LUXEMBOURG AS A KNOWLEDGE CAPITAL AND TESTING GROUND FOR THE CIRCULAR ECONOMY

NATIONAL ROADMAP TO POSITIVE IMPACTS
Tradition, Transition, Transformation

December 18, 2014

Colophon

Title
LUXEMBOURG AS A KNOWLEDGE CAPITAL AND TESTING GROUND FOR THE CIRCULAR ECONOMY.
National Roadmap for Positive Impacts. Tradition, Transition, Transformation.

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About the title

Luxembourg due to its diversity, size, and positioning is a powerful testing ground for circular economy methods. It has the knowledge and know-how to initiate and implement a successful circular economy.

To achieve positive impacts, the study balances three overlapping spheres of progress; *Tradition, Transition* and *Transformation,* so stakeholders benefit from a win-win scenario.

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Prior to publishing the study, some quotes of interviewees will have to be approved by them although most gave permission during interviews.

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Glossary

A range of glossaries is found in reports and studies on the circular economy, containing diverse definitions for the same terms. For the purposes of the present study here are few core terms and definitions;

Biosphere and Technosphere

The circular economy focuses on systems, products, components, materials and ingredients designed for two main pathways: consumption pathways in the *Biosphere* where products are designed to safely enter biological systems, and service pathways in the *Technosphere* where products safely enter technical systems to be part of new future product generations, and are often offered as services.

Biosphere Products for consumption are designed so that degradation by-products generated during their use (e.g. abrasion or dilution in air, water or soil) support the biological systems they enter in the Biosphere. Those resources can be renewed through agriculture, reforestation, aquaculture or other ecosystem processes, each leading to next generations of products.

Examples of consumption products are: biodegradable textiles, cosmetics, or vehicle brake pads that wear out. However consumption products also contain inert materials like sand, which do not biodegrade but support bio-processes like soil formation. As well, metals like zinc and magnesium are usable in the Biosphere if designed for compatibility with biosystems.

Technosphere Products for service are designed to be chemically stable during use and get dismantled into Technosphere resources, known as ́nutrients ́ after they fulfill their function. The ingredients in these renewed technical nutrients are carefully defined as resources for next generations of service products. These accelerate the transition from owning materials to using them for the services they provide.

Examples of technical nutrients are found in electronic appliances, although these might sometimes contain biosphere products like coatings, which are designed to wear off into the environment during use. Technosphere products also often contain bio-based materials. Those are designed for continuous use instead of being consumed at once.

Certified for Circular Economy Cycles

The term 'certified for circular economy cycles' is used throughout the present study, and here is a definition and background;

The European Commission, World Economic Forum, and Ellen MacArthur Foundation cite the Biosphere & Technosphere as the basis for circular economy materials flows. Products and materials certified for compatibility with the Biosphere & Technosphere are the de facto standard for circular materials. The recognised independent standard for certifying products for the Biosphere and Technosphere is governed by the non-profit Cradle to Cradle Product Innovation Institute (C2CPII), based in San Francisco and The Netherlands.

The C2CPII publishes on its website transparent methodologies for certifying products for the Biosphere & Technosphere, http://www.c2ccertified.org/resources/collection-page/cradle-to-cradle-certified-resources

However, certification is only a step on the way to circularity. Products certified this way are required to describe a roadmap for continuous improvement with defined timeframes. As with everything else in the circular economy, it is a process of continuous improvement.

Circular Economy

There are many definitions for the circular economy in more than 28,000 scholarly publications. For the present study, which is more narrowly focused than broader approaches taken by others, the CE is defined as;

The restorative use of materials and products in renewably powered cycles where everything is a resource for something else, generating positive economic, social and ecological impacts through improved quality and resource productivity.

Cradle to cradle design protocol. See annex E.

Near-shoring also known as in-shoring or re-shoring

Relocating production close to the point of final product use. Near-shoring is significant for circular economies because it often shortens supplier and user networks so makes them easier to optimise. Near-shoring is being made more affordable by new technologies which are quicker, cheaper and cleaner. Implications are large-scale relocation of or creation of cleaner manufacturing jobs and capital investment to Europe e.g. to Luxembourg.

Positively defined material

A positively defined material is one where the contents are defined to be nutrients in a technical or biological cycle. Inert materials are also potentially consaidered as nutrients if they structurally support those cycles. e.g. sand in soil. Definition of contents to 100 ppm is normally required in order for material to be evaluated for its potential to be a positively defined material.

Reverse Logistics

The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of use to the point of origin for the purpose of recapturing value. (Ref. Source Rogers et al.)

Service Concept

The service concept for circularity, also referred to as a leasing concept, transforms linear ownership of materials, components and products into circular services through leasing or renting instead of selling them. Variations on the service concept include takeback schemes and product return incentives. The concept is described in many publications since the 1990s.

Upcycling

Upcycling is the improvement of materials quality for circular economy Biosphere and Technosphere cycles. It occurs in these ways;

- *Improving on Tradition.* Improving systems for reprocessing materials. For example, methods for separating plastics from organics as with Aikan technology, or systems for improving return rates of returnable glass bottles as with the Carlsberg Circular Community. Those improve quality, save costs, and are often more profitable than other traditional methods.
- Facilitating Transition. Redesigning components, ingredients or additives in products, to improve the quality of recycling. For example, when coatings or inks are compatible with paper recycling as with Gugler inks, or when systems are redesigned for rapid maintenance, replacement, repair, removable and disassembly as with Vanderlande Industries conveyor systems used in airports and warehouses. Other examples include upcycling at the molecular level by e.g. chain extenders for polymers.
- *Accelerating Transformation*. Material is transformed when it is given added functionality to support biosystems. For example; designing packaging labels or cardboard so they are safe to be composted to topsoil. Floor and wall coverings that actively clean the air.

List of Acronyms

BIM	Building Information Modelling
C2C	Cradle to Cradle
CE	Circular Economy
EC	European Commission
EPEA	EPEA Internationale Umweltforschung GmbH
EU	European Union
FMCG	Fast Moving Consumer Goods
IEA	International Energy Agency
LCA	Life Cycle Analysis also known as Life Cycle Assessment
LCCE	Luxembourg Center for the Circular Economy
LIST	Luxembourg Institute of Science and Technology.
MBDC	McDonough Braungart Design Chemistry LLC
MDDI	Ministère du Développement durable et des Infrastructures, Luxembourg
PPA	Power Purchase Agreement
SDK	Superdreckskescht

Where to Find What in the Study

The present study is divided into three parts after the Highlights; the first part describes circular economy enabling mechanisms, the second looks at commercial applications, and the third examines potential Roadmaps for Luxembourg, based on practical projects.

- Examples of companies working on circularity in Luxembourg are described in Chapter 10 *Sectorial Snapshots*. As well, 100+ products certified-for-circularity cycles and sold in the Greater Region, and 15+ circularity service concepts operating in the Benelux, are described in Annex B.
- Materials flows and impacts in Luxembourg are described in the Highlights segment entitled *Materials Flows and Assets,* Figure X.
- Economic impacts of circularity for Luxembourg are described in Chapter 4 entitled *Raising Competitiveness*.
- The role of the Greater Region is described in Chapter 13.
- Potential gains for Luxembourg from circularity, are described in Figure XIII.
- The potential Mission to achieve those gains is described on the page preceding Table III.
- Objectives, Big Wins, & Quick Wins to support the Mission are described in Highlights Table III. The Objectives are divided into two main sections; service sector enablers and industrial implementation projects.
- *National Circularity Initiative* to implement the Objectives is described by organogram Figure XVII.
- Selected examples of potential inspirational Light-house projects are in Table 14.5 near the back of the study.
- *Primary stakeholders* in the present study are described in Annex A. *Multi-stakeholder platforms* are described throughout the study as primary tools for implementing circularity. Examples are in Annex B.

Where to find related aspects

A main aim of the Ministry of the Economy is for the present study to identify how to further diversify Luxembourg's economy in comparison to the financial industry. Due to this, finance is covered briefly in the Sectorial Snapshots chapter and Figure 10.21 *Where finance & circularity meet,* but principally finance is a parallel activity organised by the EcoInnovation Cluster, so a secondary focus of the Ministry for the present study.

STUDY HIGHLIGHTS

The circular economy is more than a potential model for Luxembourg; it is an economic imperative.

Terms of Reference in Brief

Describe the pros and cons of why and how Luxembourg uses and might use materials productivity and quality in the circular economy to raise employment, competitiveness and savings, and improve environmental impacts.

The Diversity Imperative

The circular economy is more than a potential model for Luxembourg; it is an economic imperative.

At a December 11, 2014 Cluster Forum, the dynamic achievements of Luxembourg's Innovation Clusters were presented, and in describing those the Secretary of State for the Economy as well as Cluster Presidents and Managers made one thing exceptionally clear; it is a priority for Luxembourg to diversify its economy. The circular economy was described as one way to support that diversification.

In that context it is no accident that the Ministry of the Economy requested the present study to focus on describing how to use materials in the circular economy to diversify Luxembourg's economy so it is still more resilient.

BREAKING NEWS – A NEW OPPORTUNITY FOR LUXEMBOURG ?

In the week the present study was being submitted, European Commission President Jean-Claude Juncker and Vice President Vice-President Frans Timmermans announced the EU legislative package on the Circular Economy was being withdrawn and would be re-tabled in 6 months.

Is it good news or bad news for the Circular Economy? According to Mr. Timmermans;

> *"We want to make sure the Circular Economy is approached in a circular way and not just half a way."*
>
> Source Circular Economy package to be ditched and re-tabled. Euractive.com 17/12/14

While the outcome is unclear at the time of writing, one thing remains certain; the circular economy as described in the present study is an economic mechanism to achieve positive economic, social and environmental impacts. It is not a sustainability mechanism to create extra costs. Companies who use the positive impacts approach as a basis for their business already achieved considerable success.

In that way, the re-tabling of Circular Economy legislation presents an unexpected opportunity for Luxembourg, which takes over the EU Presidency later in 2015. The opportunity is to focus legislation on creating positive impacts, which are already driving circularity successes. By emphasising positive impacts instead of reducing negative impacts, Luxembourg might guide a new EC package to successful passage and implementation.

The main messages

Circularity is already an economic imperative for Luxembourg and is being used to generate employment and stay competitive. Businesses use it but don't call it the circular economy. As a result the positive impacts are under-stated.

The potential in Luxembourg is great for value creation at the scale of;

- *Systems & Services*. Supplier communities, logistics, ICT, buildings.
- *Products*. Automotive, construction, food, glass, household goods, metal.
- *Components*. Re-using, remanufacturing & recycling.
- *Materials*. Paper, metal, polymers, biochemicals, biomass, secondary raw materials & composites.
- *Additives & Ingredients*. For composites, glass, metals, polymers, & wood.

Government leadership with a low-cost enabling platform will be a catalyst for the private sector to seize opportunities offered by the circular economy to generate positive impacts and add value through innovation.

Business Opportunities Identified

Already-operating and candidates for scaling up;

- Increase local product sales with buy-local co-branding.
- Valorise secondary materials for cost savings & EU compliance.
- Raise metal manufacturing margins with Greater Region suppliers community.
- Preserve & generate jobs with improved materials sourcing in Greater Region.
- Partnering manufacturers with Tarkett for additives quality & materials sourcing.
- Replicate building savings by City of Venlo using goal-setting & residual value.
- Improve construction packaging savings with reusable containers.
- Savings from improving quality and separation of high quality office paper.
- Savings from substitutions to conform with new EU regulations on HFCs.
- Recover high value additives from specialty glass.
- Modular conveyor systems for logistics operating savings.
- B2B is the main potential except for local B2C grocery retailing.

Business Opportunities Identified

Short road to implement from existing platforms;

- Quality assurance & savings on duplication with national coordination.
- Use spare capacity for reverse logistics with the post office.
- Capture value from truck repairs through legal enabling mechanisms.
- Develop a new consulting business with standards for secondary raw materials.
- Sharing & re-use websites for e.g. equipment, vehicles, & excavation residues.

Mid-term perspectives with big win potential;

- Evaluate converting excavation waste dumps into recreation areas.
- Quantify positive impacts with an improved LCA tool.
- Develop reversible biobased composites with Greater Region R&D project.

Government Actions

Leadership on enabling platforms and light-house actions;

- Working Group to start stakeholder task forces & track existing actions.
- National quality co-branding with pilot.
- Education modules & hands-on skills-for-circularity training.
- R&D positive criteria for materials & legislation. Investment matchmaking.
- Initiate Light-House Actions e.g.
    - Facilitate Greater Region actions on materials banking.
    - Quality & valorisation standard & compliance for secondary raw materials.
    - Logistics. Facilitate Paper, Post Office, Repairing.
    - Circular buildings; defined, modular, healthy, savings, added value.

Potential CE Initiating Actions to Align with Existing Activities

December 2014 - March 2015
Working group created from the present study steering committee to;

- Analyse the study in-depth & get feedback from steering committee members.
- Organise consultation with 45+ study interviewees to get feedback and recruit implementers & initiators to be on stakeholder task forces.
- Do stakeholder goal-setting & find capable coordinators for quick-win pilot projects.
- Identify CE leadership group candidates to catalyze government & business.
- Start organising a practical stakeholder workshop to celebrate & accelerate where Luxembourg is already doing the right thing the right way.
- Identify upcoming events & what to announce where & when e.g.
  Participate in and integrate February finance symposium results.
- Generate a compelling narrative based on stakeholder selection of priorities.

Introduction

The circular economy is more than a potential model for Luxembourg; it is an economic imperative.

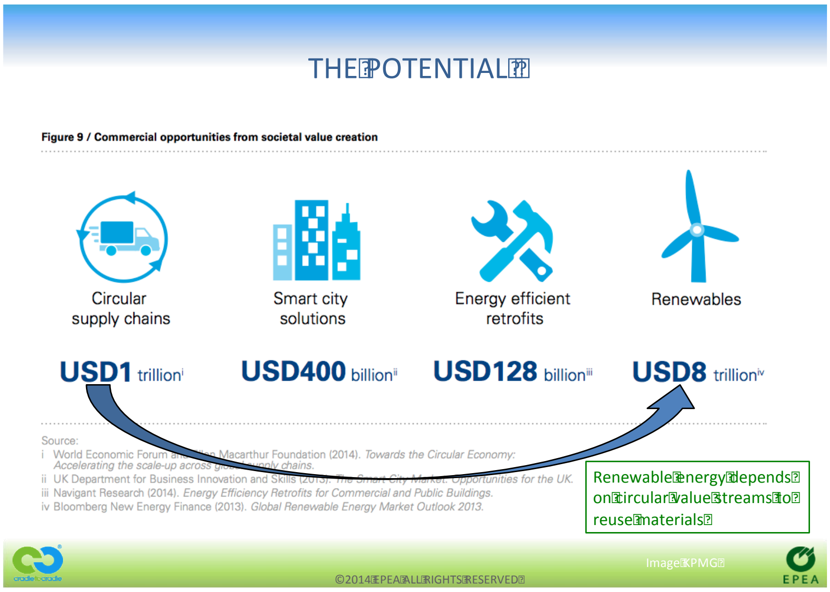
Due to its history of exhausting resources then finding substitutes, Luxembourg is already a testing ground for circularity methods. For example its steel, aluminum, glass, and other industries are experts at re-using secondary raw materials. The re-use of those materials is core to their economic survival. It is a competitive necessity to sharpen their capacities in those areas.

Because Luxembourg's exemplary European society is based on equity, cultural tolerance, economic stability, responsive government and manageable size, the country is a powerful proving ground for circularity. Its heritage of quality and its service-based economy allow leveraging of skills to take advantage of the embedded growth potential. The likely benefits for Luxembourg are considerable. The starting position is excellent. The capabilities and motivation seem to be in place. It is now only a question of providing a nucleus and initial catalyst to accelerate the transition towards a circular economy at scale. The Grand Duchy of Luxembourg and the Ministry of the Economy in particular have powerful roles to play as catalysts for circularity.

In the present situation where knowledge of circular economy potential is low but know-how for supporting technology and services is high, the government has a special brief opportunity to seize the initiative by delivering powerful messages about circularity through initiating and coordinating actions, as well as supporting those with a solid foundation of education, training and national co-branding.

By leveraging those mechanisms the government will provide the enabling framework for its stakeholders to implement a circular economy with innovative lighthouse initiatives.

The Size of the Prize



Highlights Figure I: Total value creation potential relating to circularity. Source image KPMG

How big is the economic prize for circularity?

Estimates vary, but most agree it is large. The estimation of 1 Trillion USD on the left is from a report for the World Economic Forum by Ellen MacArthur Foundation and McKinsey with participation by EPEA. Another 8 Trillion USD estimated from renewable energy is calculated by Bloomberg New Energy. The arrow connecting those results from studies (Gordon et al) suggesting strategic materials supplies for renewables might be problematic, and substitution of those materials on its own might not be sufficient to meet intermediate demand. A restorative paradigm integrating high quality materials with innovative substitution is a main mechanism to avoid shortages. The mechanism is working today. For example logistics equipment companies like Vanderlande Industries and Luxembourg-based companies like Tontarelli, Ecoparc Windhof and Tarkett are generating materials and energy savings for shareholders and customers.

Big Wins from circularity are in materials recovery and materials for renewable energy, with total size of the prize; 9 Trillion USD. How much of that might Luxembourg gain? Up to €3 Trillion in assets resides in Luxembourg financial institutions. Might those funds be invested for circularity?

Estimating Circularity Benefits for Luxembourg

Circularity supports 7,000 – 15,000 jobs as well as more than €1 billion annually in economic activities in Luxemburg primarily in manufacturing but also in buildings, retailing and other areas. Companies using circular service concepts and other mechanisms include some of the largest manufacturers; ArcelorMittal, Eurofoil, Guardian Industries, Norsk, Tarkett, Tontarelli, building developments like Ecoparc Windhof and building equipment leasing and sharing like Floow2 and Loxam, as well as retailers Oikopolis, Pall Center and Cactus. Automotive suppliers have a returnable packaging network for components while Luxembourg leads Europe in automotive leasing and is starting car sharing.

Compared to most of Europe, Luxembourg, the Greater Region & Benelux enjoy a proportionately large share of circularity-designed products, services and systems. According to information compiled as Annexes for the present study, more than 100 products certified for circularity cycles are being offered by local outlets in the Greater Region and at least 15 circular supplier communities are applying service concepts in the Benelux and Germany. Those products and services are driving millions of tonnes of circular materials flows. The proportionately large share of circular activities in the Benelux derives from two complementary catalysts; a survival imperative created by dependence on secondary raw materials, and frontrunner activities utilising the cradle-to-cradle innovation approach.

However, presently statistics are often unavailable or not presented in the right framework to accurately estimate the economic and jobs aspects of circularity in Luxembourg. The following figures and tables provide qualitative and quantitative estimates of the existing and potential benefits based on best available information, summarising types of circularity benefits and potential gains for diverse economic sectors in Luxembourg in accordance with the main focuses of the study; *describe how to improve competitiveness, employment, savings, and environmental impacts.*

Highlights Table I: Benefits & potential gains in the circular economy for Luxembourg

Economic Activity	Competitiveness	Job Preservation & Creation	Savings / value creation	Improving Environmental Impacts
Primary & secondary manufacturing **Steel, Aluminium, Specialty glass, polymers.**	Steel, Aluminium, Specialty glass manufacturing rely on secondary raw materials to stay competitive. e.g. ArcelorMittal, Eurofoil, Guardian. Offering performance based contracting options and service concepts improves customer lock in and value capture due to quality gains.	Ensuring stable volume flows controlled by Luxembourg entities. Improved separation, potentially improved volumes through supplier communities. Offering additional performance based services.	Matching scrap quality with output quality improves margins. Examples ArcelorMittal, Norsk, Eurofoil. Improve re-use and recycling yield. Improve operating, maintenance savings. Example Vanderlande Industries.	Secondary raw materials content saves up to 90% of energy & emissions compared to primary extraction. Examples ArcelorMittal, Norsk, Eurofoil.
Architecture, Engineering, Construction	Staying competitive with Designs for prefabrication and modularization, improved construction techniques. Creating buildings that are more attractive for customers because they are healthier and more cost effective to occupy.	New policies & standards requiring architects, engineers, construction companies to be responsible for REACH compliance. Systems for Improved separation & reuse of residues, on-site recycling, deconstructing instead of demolishing. Improving market share coverage within Greater Region.	Reducing waste management costs & improving residual value through innovative designs & product use. Example; Venlo City Hall.	Reducing emissions from transporting & landfilling waste. Reclaiming excavation waste sites as useable areas. Eliminating incineration.
Professional trades	As prefabrication, modularity & deconstruction enter markets, trades need related skills to stay competitive.	Maintain quality leadership and offset higher labour costs with higher resource productivity. New skills for refurbishment, disassembly, redesigning.	Refurbishment, repair, disassembly generate savings for customers and extend usage period of current stock.	Contributing to materials recovery & revalorization supports positive environmental impacts. Delays externalities of new production.

Economic Activity	Competitiveness	Job Preservation & Creation	Savings / value creation	Improving Environmental Impacts
Finance	Investments in systems with greater residual value, known materials &improved functionality are more reliable.	Protecting against surprises from REACH non-compliance on investments. Across the spectrum. Table 10.21 in the main study describes *Where Finance and Circularity Meet*.	Buildings and systems, which have high residual value instead of demolition liabilities are more cost effective. Example; Venlo City Hall.	Investments into defined circular activities have overall positive impacts which vary by project. Example; Improved ROI for Desso & Tarkett shareholders.
Real Estate	Level the playing field as owners won't be able to dump excavation waste offsite and build with undefined materials in the future.	Competitive cost-effective renovation of older buildings. Gaining expertise in building healthy mixed use developments with greater marketing value. Leasing office interiors.	Assets gain value and have lower maintenance costs if designed for total life cycle costing, higher reuse rate offset re-investment needs. Example Park2020.	Buildings have the greatest environmental impacts so improvements have substantial positive impacts. Example Ecoparc Windhof.
Reverse Logistics	Improving efficiencies of existing assets and building re-commerce platforms ahead of competition.	Keeping up with competitors who offer an extra reverse logistics service to your customers. Using spare capacity of physical assets for reverse logistics. Build out new services, i.e. including separation and re-configuration of shipments.	Energy savings, materials savings from reusing existing assets. Improved load factors by re-balancing flows.	Energy savings, materials savings. Reduced emissions due to higher load factor, i.e. fewer trips.
Retailing	Meeting demands of customers for local products, achieve higher margins on local products.	Keeping customers with a local quality label and maintain sales presence. Attracting more customers with a local quality label and create job in upstream product handling (e.g. packaging).	Improve yield and margin on locally sourced products leveraging higher quality and proximity. Examples Oikopolis, Pall Center.	Locally produced, marketed & consumed food is environmentally friendlier. Example Rosport.

Economic Activity	Competitiveness	Job Preservation & Creation	Savings / value creation	Improving Environmental Impacts
Small farms	Staying in business in the face of high costs by quality differentiation	Stay profitable with locally grown label & retailer communities Improve sales through customer communities, increase share of biological agriculture with higher share of labour than mass-production agriculture	Integrating energy production with nutrient recycling generates savings if done effectively. Example; Palaterra.	Locally produced, marketed & consumed food is environmentally friendlier. Improve quality of local soils Example Oikopolis
R&D	Improving functionality, residual value, eliminating fossil fuel use.	Maintaining competitiveness in materials R&D Near-shoring with High-tech has large job creation potential. Creating new materials designed for reversibility and high residual value.	Savings form improved materials quality. Examples Tarkett, Desso, Steelcase. Speeding disassembly through automation.	Potential for very large positive impacts from new materials and sources.
Industrial design	Improving functionality of materials	Improved risk management by avoiding REACH violations. Designs for disassembly to improve residual value, additional work required to re-design products and processes for circular economy (FabLab, GoodYear tires)	Systems designed for offline maintenance, disassembly, less weight and energy use generate savings. Example. Vanderlande Industries.	Systems with easily recoverable materials generate large environmental savings by avoiding primary extraction.
Waste management	Waste management companies compete against each other for business and customers are demanding improvements. Example Pall Center.	Use regional customer supplier networks to prevent loss of business to distant traders. Specialty technologies e.g. food grade upcycling for polymers, recovering rare elements from waste.	Reducing transport, separation & processing costs. Examples; SDK, Ecoparc Windhof.	Replacing incineration with recycling generates large environmental savings.

Economic Activity	Competitiveness	Job Preservation & Creation	Savings / value creation	Improving Environmental Impacts
Accounting & legal	Keeping ahead of the competition on accounting for internalization of external costs; one of the most significant factors for business today.	Improve risk management. New Balance Sheet for measuring economic value of positive impacts New types of contracts for materials banking & leasing, high demand for improved reporting and auditing	Industries wanting to know how much they are saving require economic indicators and KPI verification.	Increased transparency on leakage and improve measurement allows avoidance/re-capture of emissions and externalities
ICT	ICT providers are competing to provide services for cataloguing materials in products & buildings, integrating renewables with lighting systems.	As tax benefits disappear, offer safe haven for data against agency snooping. Developing sharing websites & backbone architecture. Reverse logistics data management.	ICT generates cost-savings by supporting reverse logistics, valorisation of materials, validating data for KPIs. Example; Equipment sharing websites.	By improving use of existing assets, environmental costs are reduced.

Note: The above table is not repeated in the main body of the study.

Defining Circularity

The study found high motivation to learn about circularity, a high level of competence about some tools used for circularity, but a low level of knowledge about the circularity framework. .

To account for those, the following section provides a basic introduction more extensive than normally in a study summary.

Context. EU and EC approaches to the circular economy

On December 16, 2014, the President and Vice-President of the European Commission announced the EC was withdrawing its Circular Economy legislative package and re-tabling it in 2015. The new development represents an unexpected opportunity for Luxembourg to co-develop a positively defined approach to the circular economy in preparation for its EU Presidency.

On its Environment website, the European Commission describes the circular economy package. However, given the withdrawal of the package by the EC, the following information is only a baseline for further preparation by Luxembourg rather than a framework for action;

The circular economy package (package withdrawn Dec 16, 2014)

'The European Commission adopted the Communication "Towards a circular economy: a zero waste programme for Europe" and annex to establish a common and coherent EU framework to promote the circular economy. Turning Europe into a more circular economy means:

- *boosting recycling and preventing the loss of valuable materials;*
- *creating jobs and economic growth;*
- *showing how new business models, eco-design and industrial symbiosis can move us towards zero-waste;*
- *reducing greenhouse emissions and environmental impacts.*

As part of the circular economy package, the Commission also adopted a legislative proposal to review recycling and other waste-related targets in the EU and annex. Achieving the new waste targets would create 180 000 new jobs, while making Europe more competitive and reducing demand for costly scarce resources.'

(Source http://ec.europa.eu/environment/ circular-economy/)

As a basis for Luxembourg to prepare actions on the circular economy, the EU and EC communications and studies as well as new political developments are reviewed here briefly;

- The published EC interpretation of the circular economy on its website is still anchored in the environment Directorate General rather than in the economic and financial affairs DG. As a result, the CE initiative comes from the environmental perspective despite significant emphasis on economic incentives, and despite significant support for CE approaches in the business community.
- The potential for using the circular economy to generate *Positive Impacts* is described in an August 2014 EC Scoping Study of the circular economy. See chapter 3.2.2 of the present study.
- *However, those positive impacts are not emphasized as much in the EU communication on the circular economy*. For example the term 'positive impact' is used only once in the framework publication.

A review of circular economy literature and practice suggests that the potential for generating and capturing value through positive impacts offers wider benefits for Luxembourg than just reducing waste. The potential for positive impacts is explored here, in the context of new developments at the EU, and the wider recommendations of the EC Scoping study.

The historical context of circularity

The term 'circular economy' is published in scholarly literature since the 1950s to describe e.g. the positive economic potential of nutrient recycling for integrated agriculture and aquaculture in China. On the other hand, in Germany the term 'Circular Economy' or 'Kreislaufwirtschaft' is used in waste legislation since the 1990s, so it has a different meaning in Europe's largest economy than in China or as presently used by circularity proponents.

In Europe at least 18 NGOs and consultancies focus mainly on circular economy and each has its own version of circularity. Among the 9 Benelux-based organisations, all except one were created in the past 5 years. Those examples show why the term 'Circular Economy' is still a work in progress.

Defining circularity in the context of the present study

As the core topic of the study is to assess the starting position and potential of a circular economy for Luxembourg, it is important to describe what is understood by the term, as it is still evolving and is subject to different interpretations and focuses. In order to know what is involved in circularity quality assurance, a basic knowledge of the circular economy is a first step.

For the present study focusing on materials, the circular economy is defined as follows, which is less of an all-encompassing definition and more in conformity with the boundaries set for the study;

Circular Economy

The restorative use of materials and products in renewably powered cycles where everything is a resource for something else, generating positive economic, social and ecological impacts through improved quality and resource productivity.

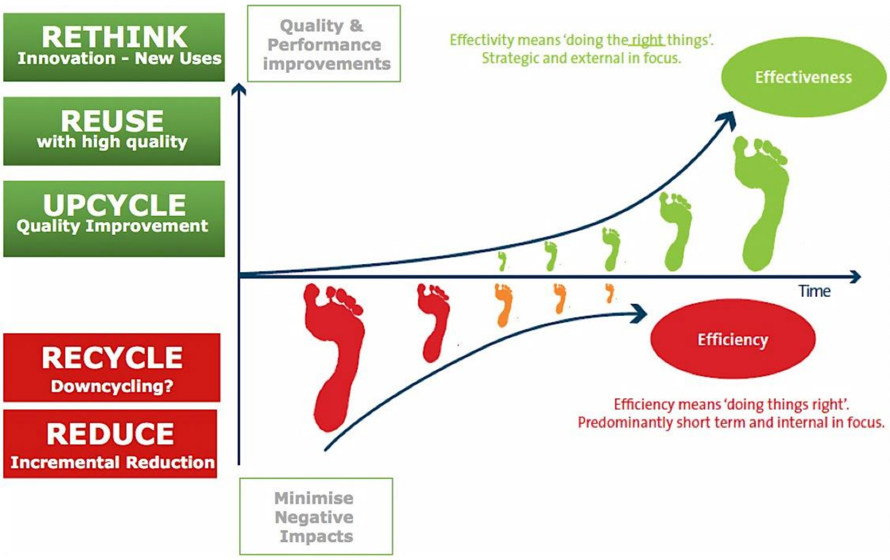
A common notion connected to that definition is the decoupling of economic activity from linear material throughput by replacing the linear 'take-make-waste' paradigm with high-quality material, component and product reuse cycles in a holistic and service-oriented framework.

Scale

- On a descending scale and although definitions of the following terms vary, the circular economy occurs at the level of;
  - Systems & services ranging from taxation to logistics, buildings, agricultural topsoils and emissions re-use,
  - Processes ranging from manufacturing to biodigestion and deconstruction,
  - Products and components ranging from automobiles and paper clips to circuit boards and connectors,
  - Materials ranging from composites to wool,
  - Additives, chemicals and elements ranging from gallium to chlorophyll.
- In Luxembourg examples of circularity are found at each of those levels

Quality and positive impacts

Environmental regulatory approaches focus on *reducing negative impacts*. Circularity focuses on *improving quality* and *generating positive impacts*. The following diagram illustrates the pathway from less negative to more positive.



Highlights Figure II: The road from less negative to more positive. Source EPEA.

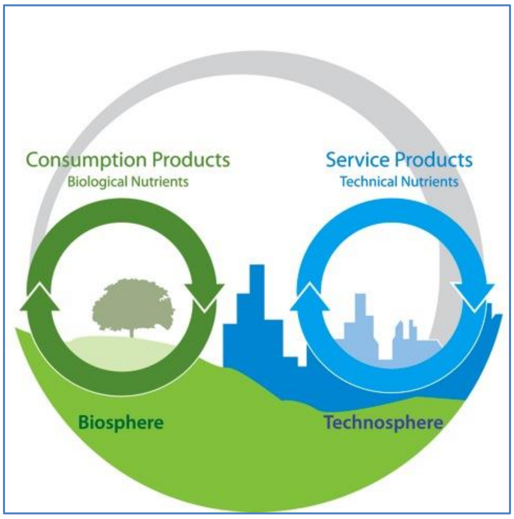
For example,

- The red-coloured section focuses on reducing negative impacts. Under most regulations using the reduction approach a sustainable floor covering has to minimise resource use and emissions.
- However in the green-coloured section, positive impacts are a value-added feature. For example a circularity floor covering *maximises resource re-use* and *actively cleans the air*.

The Benelux is a frontrunner in creating those types of positive impacts. Products certified for circularity cycles have improved the quality of billions of Euros worth of products for Benelux companies like DSM, Desso, Vanderlande Industries, Mosa, and others.

Those frontrunners make products, systems and buildings that do good things and have high residual value. Designing things that are actively positive for the environment, practical and healthy for users, and profitable for manufacturers is an art and a science. Benelux companies are achieving it.

Technosphere and Biosphere



Highlights Figure III: Basis for materials flows in the circular economy (Source EPEA)

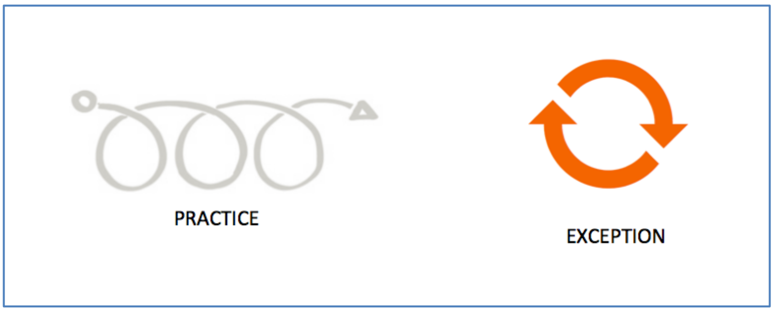
The Technosphere and Biosphere cycles, also referred to as technical and biological cycles, are a scientific and economic foundation for circular ingredients, materials, components, products and systems.

- Figure III describes a broadly acknowledged basis for materials flows in the circular economy; the **Biosphere** where products are designed to be *consumed* then dispersed into the environment, and the **Technosphere** where products are designed to perform a *service* and be kept in technical cycles. The methodology was published in 1992 by Braungart et al and is described more completely in peer-reviewed publications like the Journal of Cleaner Production (Cradle-to-cradle design: creating healthy emissions, 2006).
- Materials in the circular economy are <u>defined by their use in those cycles, rather than if they are biological or non-biological materials</u>. For example, a non-biological element like magnesium is used in the Biosphere as a nutritional supplement, and in the Technosphere as a coating or alloy component. Its toxicity levels and functionalities are significantly different for the Biosphere than they are for Technosphere. In the Biosphere it is designed to be consumed by people and in the Technosphere it is designed to be used and reused. The use defines the materials.
- For products designed for the Technosphere, the circular set-up allows economic arbitrage potential by preserving the embedded material, labour

and capital costs longer in the system. Extending usage periods by maintaining products, components and materials in the inner loops, using them in cascaded value chains and avoiding dilution of quality of feedstock achieves positive economic returns compared to linear take-make-dispose value chains. The resulting increase in resource productivity accelerates de-coupling of economic growth from primary raw materials intake.

Systems are central to circularity

- In the circular economy, systems and services concepts are modelled on the Biosphere and Technosphere for sourcing, manufacturing, distributing, using, collecting, repairing, remanufacturing, recovering, recycling, and regenerating materials, components and products.
- Businesses operating in the Benelux designing products and systems on that basis are doing well, for example: architectural tiles (Mosa), floor coverings (Desso & Tarkett), furniture (Steelcase, Ahrend, Herman Miller), lighting (BB-Lightconcepts & Philips), logistics (Vanderlande Industries), paper (Steinbeis), printing (Gugler), and textiles materials (DSM). For those companies, the thousands of substances that give their products functionality are usually not kept in closed loops. Under circularity they are often designed to be released into the environment, or recovered for other processes & products. In this way, *everything is a resource for something else.*
- For example, a USB memory stick rarely becomes a memory stick again. Instead its materials are recovered and used for other purposes. As well, phosphate migrates from soil to plants to products and back again in a wide-ranging cascade. Those spheres and cascades provide innovation opportunities for businesses due to the diversity of potential customers for their products.



Highlights Figure IV: Continuous and closed material flows.

- *Circular supplier communities.* In order to connect those systems across value streams, circular supplier communities link customers with suppliers in new ways in multi-stakeholder platforms by supporting innovation and economy of scale. Those communities exist for everything from textiles to buildings and paper. For example, the largest circular supplier community to date is the Carlsberg Circular Community involving customers & suppliers with combined revenues exceeding €30 billion. The community was started in 2013 to optimise packaging ingredients and packaging returns systems used in dozens of countries for the leading packaging streams including paper, glass, cardboard, metal and plastics.

Highlights Figure V: Illustration describes some Carlsberg circular community participants Source Carlsberg

The role of additives in circularity systems and services

Systems and services are based on products. Products are based on components. Components are based on materials, and materials get their functionality from thousands of additives.

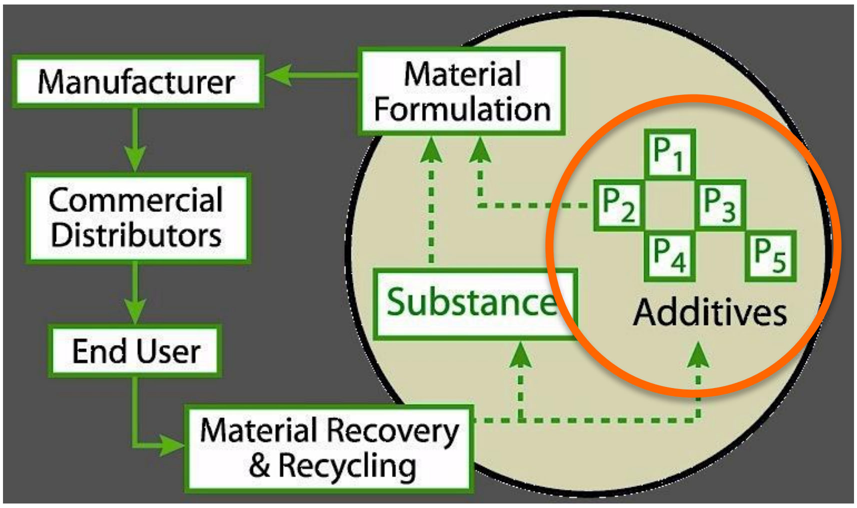
<u>Why are additives so significant for Luxembourg? The leading materials on the EU Critical Raw Materials list are additives rather than bulk materials.</u> Among the 14 most critical raw materials identified by the EU as critical, about 95% are used as additives to give materials functionality; *Antimony, Beryllium, Cobalt, Fluorspar, Gallium, Germanium, Graphite, Indium, Magnesium, Niobium, Platinum Group Metals, Rare earths, Tantalum and Tung*sten. (Source http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm)

Products like automotive components, floor coverings and speciality glass, manufactured in Luxembourg rely on additives to be functional. Additives are also essential for remanufacturing, repairing and recycling.

Designing additives for safe use & re-use in circular systems is paramount for those systems to work effectively. How to be sure additives are safe and effective as well as available for use in circular systems?

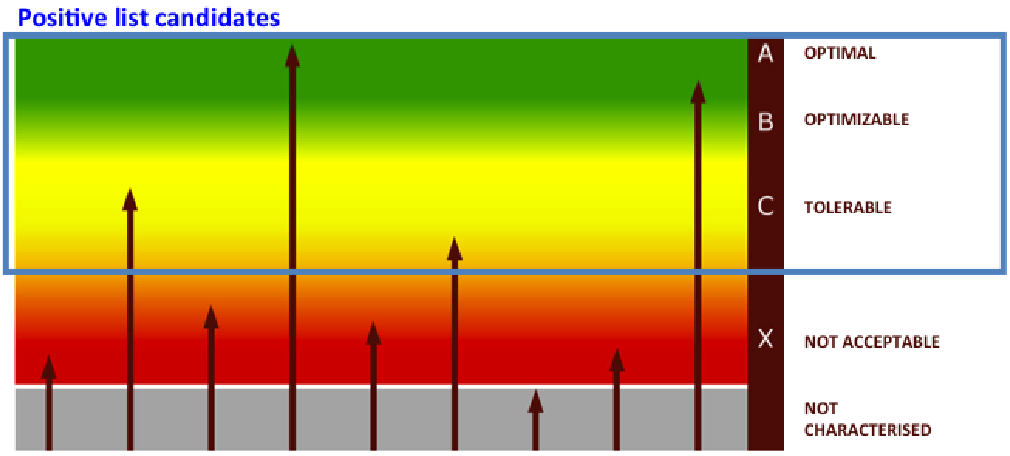
Positively defined additives

Usually, bulk substances like plastics, glass, or metals are easy to evaluate. It is additives that pose the challenge. For example, in Luxembourg's flooring industry large quantities of chemical substances are used in production, from processing of polymers to dying the fibres to the final touch of the finished article. In the textiles industry more generally, approximately ten percent of the 2,400 textile-related substances identified in a recent EC analysis are considered to be of potential concern for human health (Source https://osha.europa.eu/en/news/se-chemicals-in-textiles). The good news is that hundreds of chemicals, ingredients and materials already are suitable for uses in the circular economy. The still better news is that Luxembourg with The Greater Region has competencies for integrating positively defined additives into products, and this is already done through innovative companies like Tarkett with their R&D centers in Luxembourg. Those companies use circularity powered by cradle to cradle methods to take a new approach to additives; Considering the extensive list of chemicals that are bad for us, it makes more economic and health sense to focus on the ones that are good for us.



Highlights Figure VI: It's the additives that matter. Materials cycle describing how additives determine functionality. Source EPEA.

The following diagram describes the process for assessing positive potential of additives used in materials for products. Ingredients in the upper zones make a Positive List. The EU is starting to use positive lists in its legislation.



Highlights Figure VII: Illustration of assessing ingredients for positive potential. Source EPEA.

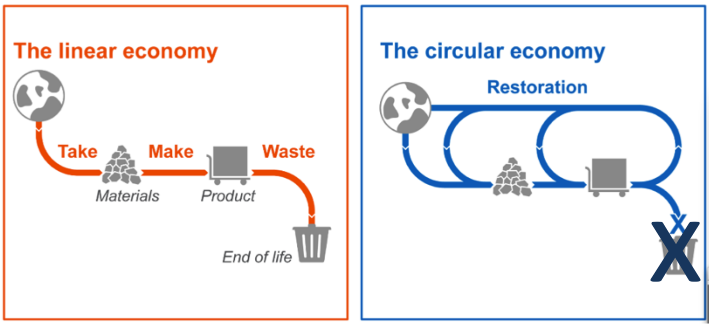
Managing complexity

Due to the complexities of systems, services, products, materials and additives, the main challenge of describing the circular economy is being clear without being simplistic. The basic concept is easy but implementation is challenging because it integrates science with economics.

The challenge is managing complexity.

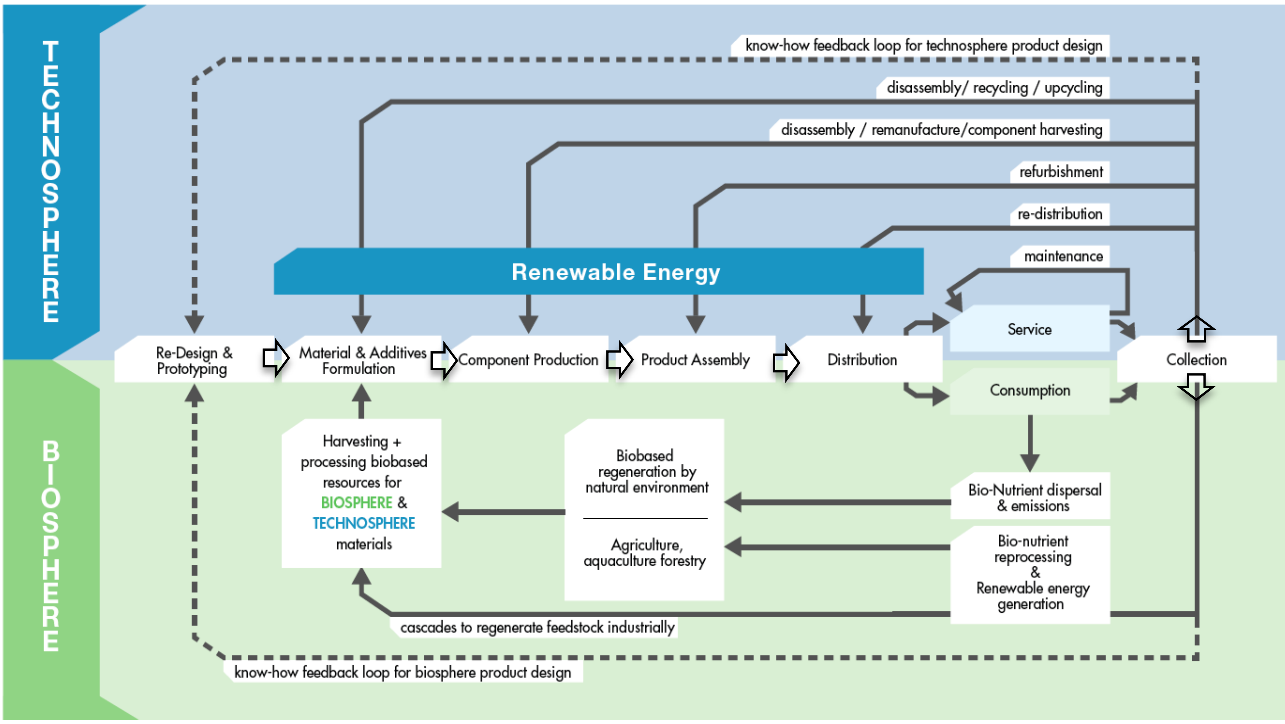
The illustration on the following page describes circularity in simplest terms. The diagram after that describes a framework for managing the more challenging technical flows which comprise a circular economy.;

In simplest terms…



Highlights Figure VIII: Diagram Desso.

In economic and scientific terms…



Highlights Figure IX: Circular economy material flows powered by Cradle to Cradle (Source C2CBizz Guide to C2C-Inspired Business Sites. Diagram EPEA & Returnity Partners)

The diagram describes the following features, which are significant for Luxembourg's economy;

- *Value capture is possible across the cycles*, including design, prototyping, formulation, manufacturing, assembly, distribution, collection, repair, remanufacturing, disassembly, recycling, reprocessing, regeneration, and re-use. Luxembourg has know-how for most parts of the cycle.
- Designing and prototyping of materials, components and products are value propositions for the circular economy. Designing and prototyping are also strengths of Luxembourg companies, especially R&D divisions.
- *Designing and prototyping are improved when know-how from the back-end is used to optimise circularity at the front end*. Luxembourg companies at the back-end like Superdreckskescht (SDK) and Valorlux have the know-how to support designers and prototypers at the front end.
- *Additives, coatings and trace ingredients* determine the functionality of materials and products. Companies like Tarkett are pioneering new approaches to healthier additives and coatings in Luxembourg.
- *Bio-based resources are* utilized to manufacture materials for the Biosphere and Technosphere. The Technosphere opens a door to new markets for Luxembourg's biobased materials R&D.
- *Dispersion of bionutrients* into the environment supports new feedstock for the circular economy. Designing for dispersion is a competitive advantage. Luxembourg's bio-based materials initiative will gain markets from designing materials in that way for the Biosphere.
- *Renewable energy* is generated by and used to manufacture Technosphere products. It is a tool for companies to capture the 8 Trillion USD projected from renewables as described in the chapter entitled Why Do It?

The Present Situation in Luxembourg

Luxembourg is still predominantly a linear economy. It is running out of local stocks of construction materials like stones for drainage, aggregate for roads, and perhaps sand for high quality concrete. Those scarcities are warning signs.

The opportunity is to adapt successful circularity models to improve materials security by improving resource productivity. The good news is that many of those models exist in and near Luxembourg, as summarized in the following pages.

As well, according to the findings of the present study, and as described in Table 2.1 of the Context chapter, more than 20 commercial planning and research activities are happening across Luxembourg with the potential to accelerate and benefit from circularity. Those activities span diverse sectors and players, making a compelling case for national alignment.

Existing platforms in Luxembourg, the Greater Region and Benelux

- Luxembourg has already a range of circular-oriented mechanisms including steel renting and take-back by ArcelorMittal, automotive leasing by various companies, intellectual property for car sharing through e.g. ArrivalStar, equipment sharing & leasing through Floow2 & Loxam, redesigning flooring materials for circularity through Tarkett, supporting regional biodiversity with a bee biodiverse campaign, reverse logistics management at Amazon and Kuehne & Nagel, R&D on biobased materials, and robotics for disassembly through the CRPs. Circular-oriented customer supplier community networks are operating in and near the Greater Region for; retailing through Oikopolis, Cactus and Pall Center, facilities management though W-Solve, logistics technologies through Vanderlande Industries, paper with Steinbeis, textiles with I-Collect and Climatex, steel with ArcelorMittal, aluminium with Eurofoil and Norsk, specialty glass with Guardian Industries, and others.
- Diverse products designed or certified for circular Biosphere and Technosphere cycles are available for purchase or lease in Luxembourg, the Greater Region or the Benelux and are inventoried for the present study. For example some buildings like Ecoparc Windhof, Venlo City Hall and Park2020 contain dozens of construction products and systems designed for circularity.

Those platforms still require optimisation, but they are a good place to start for launching education and training as well as test marketing of circular B2B and B2C products and systems.

Circular economy knowledge & capacities in Luxembourg today

Knowledge & motivation. Among the 45+ individuals interviewed, and according to their own perceptions of the situation in Luxembourg, there is a generally high motivation to learn about the circular economy but currently only few practitioners are familiar with the concept or have practical experience from applying circular practices. The combination presents a special opportunity and risk; the opportunity to set the right direction, and the risk of missing a competitive potential if nothing is done to craft the approach while it is fresh.

- *The financial industry* is motivated to learn about the circular economy and wants to know the details of implications for each type of business activity. An October 2014 workshop with selected finance industry representatives was well attended and generated a range of questions, which are summarized in Annex I (Results from circular economy finance workshop) to the present study. Due to this the government has a special and brief window of opportunity to fulfil that information demand to take a frontrunner position on circularity.
- *The construction and manufacturing industrie*s understand the potential quickly and embrace the concept. For them the question is how to find the right partners along the value chains and to pool enough critical volume to develop profitable business models. The government can be an important catalyst to bring the relevant stakeholders together.

Capacity.

- Luxembourg has the beginnings of an educational and training capacity due especially to commercial experience of companies like Tarkett & Ecoparc Windhof applying cradle-to-cradle (C2C) in buildings and manufacturing. See Defining the circular economy for C2C relevance.
- Among those with some knowledge of the circular economy there is a concern Luxembourg can't do much because it is too small to have the whole cycle in its borders. However, the study found Luxembourg has circularity mechanisms in manufacturing, agriculture, construction, finance, retailing, and education. In R&D, Luxembourg and the Greater Region have diverse capacities for circularity research.
- Measuring Environmental Impacts. Luxembourg companies are already improving their environmental impacts with circular mechanisms but the

tools to accurately measure some of those improvements and reductions are missing.

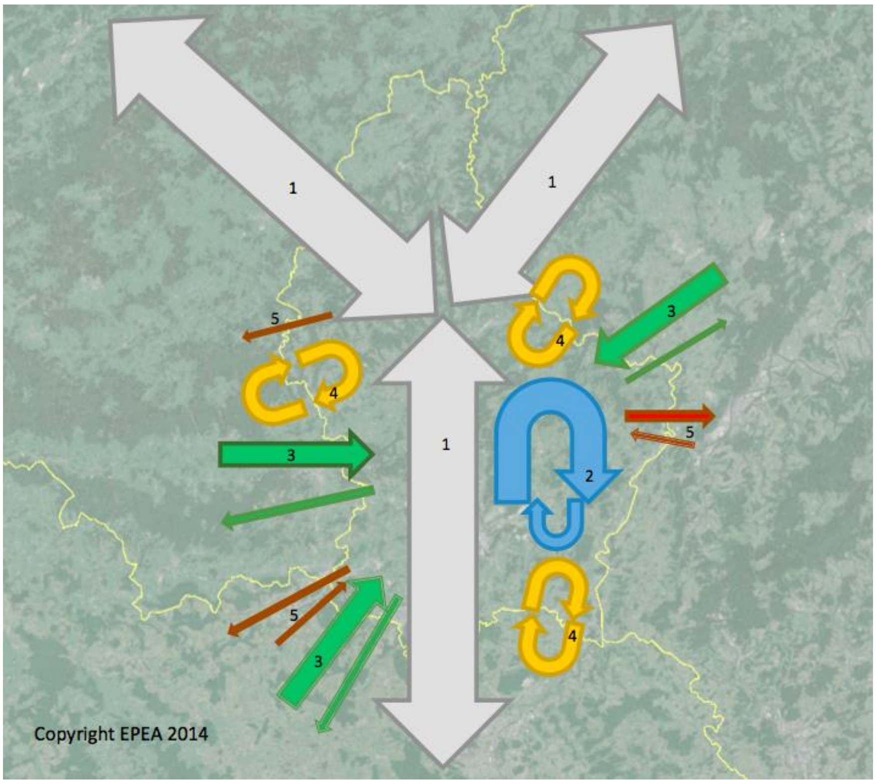
In conclusion Luxembourg enjoys the presence of a number of relevant, circular economy approaches, which can be a robust platform for further growth. While awareness of the opportunity, is low, motivation and potential reward to act is high. Now it is important to select and further drive initiatives, which play to the strength of Luxembourg's S.W.O.T profile discussed later.

Materials flows & materials assets

As in financial accounting, there are materials flows and materials assets.

Among the largest human-generated materials flows in Luxembourg are;

- *Logistics*. 50 million tonnes per year transported through hubs.
- *Excavation, inert waste*. ~10 million tonnes per year. In the CE it might also be considered an asset.
- CO_2 emissions ~6.2 - 10 million tonnes per year but skewed by 'tank tourism'.
- *Fossil Fuel combustion.* ~3.9 million tonnes per year.
- Steel & Aluminium from recycled sources ~2.1 million tonnes per year.
- Waste exports 800,000 tonnes per year.
- Incineration 120,000 tonnes per year.



Highlights Figure X: Material flows in and out of Luxembourg.

Number + Colour codes;

1 GREY	**Freight:** 50 million tonnes transiting through Luxembourg hubs. (Luxembourrg Logistics Cluster 2013)
2 BLUE	**Inert waste** incl. excavation 10.5 million tonnes (EEA, 2010)
3 GREEN	**Fuel:** Imports ~3.9 million tonnes (IEA 2013)
4 YELLOW	**Steel and Aluminium:** import/export 2. million tonnes (Arcelor Mittal & EPEA)
5 RED	**Waste**: 823,000 tonnes exported (Statec 2013)

Exclusions;

- 6.2 -10 million tonnes CO_2 emissions (IEA).
- Freight transiting through Lux which does not pass through hubs.
- Wastewater, manure, Forestry products.

[Flows to individual countries are illustrative only.]

Materials assets in the infrastructure

There is no reliable estimate on the size of Luxembourg's materials bank represented by buildings, logistics infrastructure, and power generating and transmission infrastructure, but it is certainly in the hundreds of millions of tonnes representing tens of billions of Euros.

Due to fragmentation of the assets, there seems to be no systematic evaluation of the present or residual value of that materials bank.

As materials security becomes more of an issue, it might be productive for the government to develop a reliable way of estimating the total value of Luxembourg's private and public sector materials assets.

How to determine impacts?

Quantities alone do not determine impacts of materials. Although no scientific assessment was found which compares these flows in Luxembourg, and while differing Life Cycle Assessments will result in differing ranking, the same list adjusted for negative environmental impacts like e.g. materials quality/integrity, reducing dependence on externalities, might look quite different.

Criteria for ranking impacts are shown in the main body of the study, but in general terms those considerations include factors described in the following Table II;

Highlights Table II: Considerations for evaluating impacts of materials flows in Luxembourg

Material Flow	Positives	Negatives
Incineration **120,000 tones**	• Marginal energy recovery 5 – 10% of embedded energy • Potential for repurposing	• Most embedded energy is lost • Materials integrity destroyed • Slag & ash contain contaminated mixed content hard to separate • Recycling investment discouraged • Toxic emissions
Fossil Fuel combustion. **~3.7 million tonnes.**	• Revenues for government • Technical potential for CO_2 recovery from points sources • Energy for society	• CO_2 & Toxic emissions • Non renewable • Requires military infrastructure to secure oil reserves
CO_2 emissions ***~6.2 -10 million tonnes but skewed by 'tank tourism'.***	• Potential for point source re-use	• Climate change risks
Logistics. Transporting 50 million tonnes through hubs.	• Large revenues • Large reverse logistics potential • Potential large materials banking infrastructure	• Traffic noise • Land degradation • Large CO_2 emissions
Excavating and transporting, excavation& inert waste. ***~10 million tonnes.***	• Potentially materials asset. • Landscape & recreation potential • Re-use potential on sites	• Large fossil fuel emissions from extraction & transport • Landslides • Land use • Costs
Waste exports ***800,000 tonnes destined for valorisation or incineration.***	• Revalorisation	• Incineration (see incineration previously) • Transport costs & emissions
Steel & Aluminium from recycled sources ***~2.1 million tonnes.***	• Revenues • Saves emissions from primary extraction • CO_2 reuse potential • Practical products • Materials banking potential	• Still has emissions.

Statistics and calculating ecological footprint

While some positive and negatives from that table are obvious and do not require extensive analysis to determine the right or wrong thing to do, still there is no statistical inventory classifying materials flows in those ways, and so there is only a rough basis for evaluating the potential.

For example, extensive studies are done on ecological footprint impacts of some of those materials. A 2010 study by CRP Henri Tudor identified imports and exports having the most impacts on carbon footprinting.

However, the question is; how might those footprint calculations be affected if, for example, purchase of renewable energy by ArcelorMittal electric arc furnaces, or the net energy savings of reprocessing scrap were considered? In a circular economy calculation, the figures might look quite different, but at the moment it is not known how different because the statistics are not gathered or calculated in ways that might allow the calculation. Because Life Cycle Assessment (LCA) is not designed to evaluate the positive potential connected with those materials flows it is also challenging to do a comparative assessment of benefits. In Chapter 8.6 of the present study on LCA the potential to solve the problem is described.

Table 23: Imported products impacting the Footprint of the carbon uptake land category most

Name	EFi	Impact on the total EFi
	[gha]	[%]
Iron & steel scrap	2,669,963	24%
Blooms, billets, slabs, etc. of iron or steel	724,211	6%
Products of polymerization and copolymerization	603,691	5%
Aluminum and aluminum alloys, unwrought	431,159	4%
Machinery and mechanical appliances, nes	412,021	4%
Plates etc. of iron or steel uncoated	367,511	3%
Prods of condensation, poly-condensation & poly-addition	345,885	3%
Builder's woodwork & prefab. Buildings of wood	277,358	2%
Medium plates etc. of iron or steel, 3 4.75mm	248,164	2%
Articles of artificial plastic materials, nes	218,518	2%
Chemical products and preparations, nes.	218,201	2%
Wood simply shaped or worked, nes	212,040	2%
Materials of rubber	179,137	2%
Sum	**6,907,859**	**61%**
Total EFi	**11,302,544**	

Highlights Figure XI: Calculation of leading carbon footprint impacts for imports in Luxembourg. In the tables 'Efi' is Ecological Footprint Imports and 'Efe' is Ecological Footprint Exports. (Source The Ecological Footprint of Luxembourg Technical Report CRP Henri Tudor 2010)

Table 24: Exported products impacting the Footprint in the carbon uptake land category most

Name	EFe [gha]	Impact on the total EFe [%]
Angles etc. of iron or steel, 80 mm or more	1,643,767	17%
Aluminum and aluminum alloys, unwrought	1,180,016	12%
Other coated iron or steel plates	765,116	8%
Products of polymerization and copolymerization	490,565	5%
Rubber tires & tubes for vehicles and aircraft	489,825	5%
Bars and rods of iron or steel, ex wire rod	443,680	5%
Wire rod of iron or steel	364,403	4%
Aluminum and aluminum alloys, worked	355,067	4%
Iron & steel scrap	303,939	3%
Articles of artificial plastic materials, nes	296,700	3%
Fabrics, woven, of synthetic fibers	235,430	2%
Prods of condensation, poly-condensation & poly-addition	222,002	2%
Chemical products and preparations, nes	213,816	2%
Paper and paperboard in rolls or sheets nes	193,091	2%
Sum	**7,197,415**	**73%**
Total EFe	**9,854,422**	

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Highlights Figure XII: Calculation of leading carbon footprint impacts for exports in Luxembourg. In the tables 'Efi' is Ecological Footprint Imports and 'Efe' is Ecological Footprint Exports. (Source The Ecological Footprint of Luxembourg Technical Report CRP Henri Tudor 2010)

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S.W.O.T. Summary

In performing the S.W.O.T. analysis the present study accounted for S.W.O.Ts done by the Haut Comité as well as by surveys of Luxembourg's economy and environment in global competitiveness reports (e.g. Report on Global Environmental Competitiveness of Luxembourg). As well, S.W.O.Ts by the 2014 EC scoping study on the circular economy, and the U.K. All-Party Parliamentary study on remanufacturing, were considered.

A traditional S.W.O.T analysis structure is not the most practical for Luxembourg because with circularity often weaknesses are also strengths and threats are opportunities. In the main body of the study S.W.O.T was organized by topic to describe challenges and solutions along thematic observations.

However, for the purposes of the summary, here are highlights according to a traditional S.W.O.T structure;

Strengths:

- Excellent geographic location and multi-cultural capabilities with an already extremely high share of transit volume and business relationships.
- Excellent R&D and piloting capabilities across wide spectrum of CE-relevant topics (from material intensive applications (i.e. construction, agriculture, heavy industry) to high-end service provisioning.
- Diversified economy encapsulated in a focused geographic location with strong personal and professional ties to effect cross-sectorial change with a government with clear commitment to guide economic development according to strategic objectives.

Weaknesses:

- Little awareness about CE-opportunity in business community. Potential for confusion about circularity theory and practice.
- For some fractions sub-scale volumes (e.g. for own re-valorization activities) and limited value chain coverage (i.e. only R&D or logistics handling, but no own core manufacturing activities).
- Lack of economic indicators, statistics and LCA scoping parameters to measure progress.

Opportunities

- Become the pre-eminent initiator, orchestrator and enabler of CE-activities by combining design, material flow/logistics and enabling competencies (i.e. financing, planning).

- Become an important CE showroom and test-lab for CE-applications (i.e. CE-construction, CE-consumer product test lab, …).
- Define CE innovation and R&D frontier by aligning already existing initiatives at Luxembourg level with CE as core vision (i.e. Luxinnovation clusters).
- Identify competent partners with aligned incentives & diverse capabilities in specific value streams, jurisdictions, regional boundaries.

Threats:

- Substantial risk of misunderstanding CE science based on popular misconceptions about materials and cycles, which in turn might lead to misallocated investments.
- Traditional forces blocking innovation and systems redesign (e.g. investments locked up in linear processes with little appetite to sacrifice return of investment, when moving to competing CE-set-ups, e.g. automotive sector's customer base).
- Potential lack of quick tangible results in some CE areas as Luxembourg's opportunity-rich environment could yield mega-trend opportunities which take more time to develop (e.g. biotechnology for aging population, big data investments, ….)
- Inability to start circularity initiatives;
  - Perceived absence of decision-makers
  - Materials not designed for healthy use or high residual value.
  - Overlapping jurisdictions on waste and water especially in agriculture.
  - Licensing requirements for companies to handle secondary raw materials.

→ Overall, the CE fits extremely well to Luxembourg's S.W.O.T profile because it will favour locally available sub-systems and play to the specific strengths of Luxembourg. So a fantastic opportunity.

Barriers and how to overcome them

Earlier studies on the circular economy identified barriers to circularity at EU, regulatory and other levels, and proposed solutions. Rather than re-invent the wheel, the present study points to where those studies are relevant for Luxembourg. See Annex G.

The Near-Term Potential Summarized

If Warren Buffett owns it we must be doing something right.

MBDC CEO Ken MBDC CEO Ken Alston referring to Warren Buffett's ownership of Shaw Industries which pioneered circularity designs for carpets (Source C2CBizz event Antwerp Nov. 20, 2014).

Acceleration of circular economic practices in Luxembourg at scale is estimated with the potential to generate €300 million to €1 billion EUR annual net-material cost savings and more than 2.200 jobs especially for young unemployed in the next years, if robustly applied in the construction, automotive, manufacturing, financial, logistics, R&D, and administrative sectors.

Improved material productivity as well as innovation to obtain those savings will strengthen Luxembourg's resilience and support new employment *especially in the high-unemployed youth category where the government has established priorities*.

In order to capitalise on those potentials, it is advantageous to craft a Mission, Strategy and Objectives with measurable Goals and Milestones supported by quick and mid-term wins.

Special note. Refer to the main text of the study in order to appreciate the preconditions and scope of work to achieve those gains. For example, a precondition is that the Ministry as well as frontrunner companies and R&D institutes in Luxembourg adopt circularity as a development approach, and implement circularity education, training, supplier communities and other enabling tools in order to capture savings and realise added value. These are often low-cost mechanisms but nonetheless pivotal for achieving gains.

Indicative rough estimate of potential job creation*

ROUGH ESTIMATE

In number of employees (salaries)

INDICATIVE SENSITIVITY ANALYSIS

Activity		CE-share Savings %	CE-share Total	Main lever for job creation: Growth of activity %	Growth labor intensity %	Add additional activities %	Local value chain coverage %	Potential %	Total	Comment
Financial / real estate / renting (J + K)	44,108	5	2,205	10	3	2	2	17	375	More component harvesting, redesign
Wholesale / retail / transport/ communication (G - I)	41,854	5	2,093	10	-	5	-	15	314	Increase offerings of CE-based services (e.g. leasing)
Public administration	40,602	2	812	-	-	3	-	3	24	Build out CE-based programs
Construction	38,796	5	1,940	25	3	2	-	32	621	More separation, material recycling
Manufacturing industries	32,117	10	3,212	3	2	5	-	10	321	Add re-manufacturing capabilities
Health and social services	29,253	0	-	-	-	-	-	0	-	-
Scientific, research, technical	27,609	5	1,380	10	-	-	2	10	138	Increase research around CE topics
Trasnport and logistics	26,330	5	1,317	10	-	2	2	14	184	Increase in reverse logistics
Administrative services	22,603	5	1,130	5	-	5	-	12	136	Reverse supply chain management
Hotels and restaurants	15,935	0	-	-	-	-	-	0	-	-
IT and communication services	15,752	5	788	5	3	-	-	8	63	Redistribution, repair services
Other services	5,450	0	-	-	-	-	-	0	-	-
Household productions undifferentiated	3,252	0	-	-	-	-	-	0	-	-
Education and training	3,127	2	63	10	-	-	-	10	6	Build out CE-based trainings
Teal estate	2,063	5	103	10	-	-	-	10	10	Increase in revalorization of building components
Arts and entertainment	1,716	0	-	-	-	-	-	0	-	-
Not classified	1,593	0	-	-	-	-	-	0	-	-
Water distribution and management	1,470	50	735	10	-	3	-	13	96	Increase sludge processing, nutrient extraction
Agriculture	1,399	10	140	30	2	-	-	32	45	Grow bio-based share of total agriculture
Energy generation and distribution	1,193	10	119	10	-	-	-	10	12	More alternative energy installations
Extra-territorial activities	538	0	-	-	-	-	-	0	-	-
Extracting industries	282	0	-	-	-	-	-	0	-	-
Total	**359,042**		**16,036**						**2,345**	

* Not exhaustive, based on signature activities, 3 year projection
Source: Rapport annuel 2012 agence pour le dévelopment de l'emploi

Highlights Figure XIII: Estimate of potential job creation in 3 years if national programme implemented

As expected the opportunity for job creation is highest in those labour intensive and manufacturing based industries and construction. This is fully in line with the findings derived in the sectorial deep dives discussed in this study.

Moreover as these jobs will require more artisans than white collar professionals, it also highlights the opportunity for growing and establishing CE-activities to address the structural needs of the local labour and employment market.

Overview on material input and potential cost savings

INDICATIVE ESTIMATE

Use and supply

FOR DISCUSSION

2012 in base prices

						Net material cost savings in EUR millions			
	Use in EUR millions			Savings in %		Output industries		Total	
Activity/sector	**Output**	**Industry imports**	**Total**	**Transition**	**Advanced**	**Transition**	**Advanced**	**Transition**	**Advanced**
Manufacture of computer, electronic and optical products (26_28)	1,320	2,334	**3,654**	13	21	172	277	475	767
Manufacture of transport equipment (29_30)	141	3,492	**3,633**	13	21	18	30	472	763
Manufacture of furniture; other manufacturing (31_32)	88	487	**575**	13	21	11	18	75	121
Total	**1,549**	**6,313**	**7,862**			**201**	**325**	**1,022**	**1,651**

Source: Statec Luxembourg, ESA95 Questionnaire 1500 – Supply table at basic prices, including a transformation into purchaser's prices (2012), relative savings from Ellen Mac Arthur Foundation – Towards the circular economy report I (2012)

Highlights Figure XIV: Estimate of potential savings in 3 years if national programme implemented

It is important to note, that this potential quantifies the size of the overall opportunity but does not account directly for the potential of Luxembourg to fully capture it, as Luxembourg frequently only covers a relatively small portion of the associated value streams in the respective industries (frequently in activities upstream (e.g. design) and down-stream of the main manufacturing activities (esp. distribution)). For this reason the potential is likely to represent an upper limit (for the contribution from these specific activities).

Added potential for economic gains

While the above estimates solely focus on the manufacturing part of the economy there are two more sectors, construction & services, which stand to provide sources for further economic growth leveraging CE-practices. As for these a solid bottom-up validated estimate on potential net-material savings is not available (esp. for construction) or not meaningful (esp. for services).

However, based on anecdotal information provided in interviews with the steel, aluminium, specialty glass, plastics and flooring industries in Luxembourg, there is a near-universal agreement that margins will be improved by improving the quality of secondary raw materials feedstock, and in some cases it was estimated by interviewees that the improvements might make the difference between profit and loss. As well, similar estimations are possible for the construction industry and these are described in section 4.3.2 in Chapter on Raising Industry Competitiveness.

Potential Visionary Mission for Luxembourg

Luxembourg aspires to be **A Knowledge Capital and Testing Ground for the Circular Economy,** to generate positive impacts, diversify its economy further, and improve the quality of life for citizens, partners and visitors.

Luxembourg will achieve the Mission by creating **Circular Economy Services** to improve productivity and resource quality across diverse sectors, for example, construction, education, finance, ICT, logistics, manufacturing, retailing, training, and R&D.

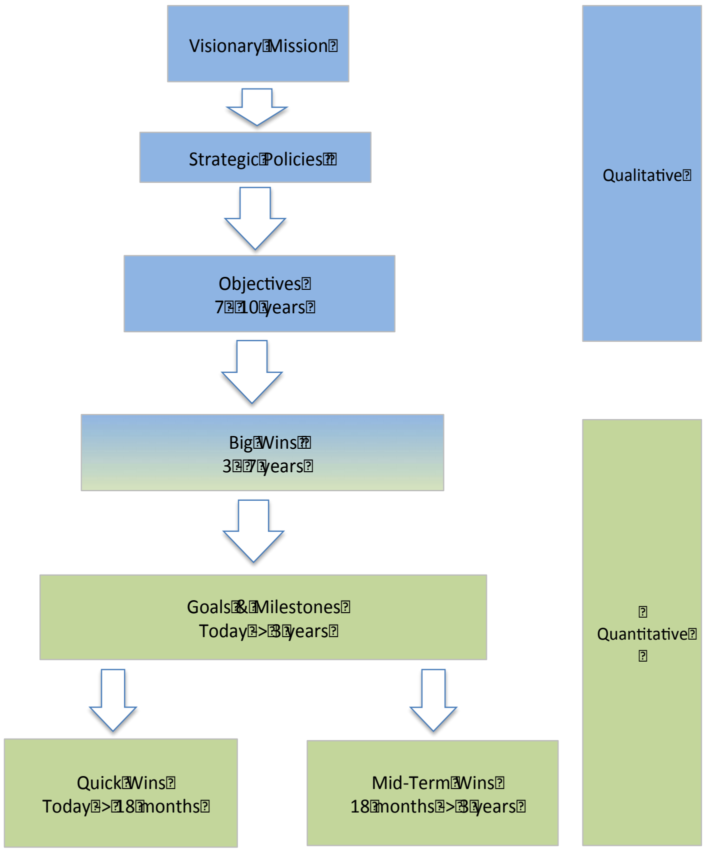
Luxembourg will implement the Mission with measurable objectives, goals and quick wins to accelerate employment, improve competitiveness and increase value creation.

In order to implement circularity, a Roadmap was requested in the study terms of reference. However, it is EPEA's experience that implementing circularity at a national level across diverse sectors, calls for more than a single roadmap. It involves diverse roadmaps developed with diverse stakeholders.

- The framework for Circularity Roadmaps is organised as follows and described in Figure XV on the following page;
  - Mission, Strategic Thrusts and Objectives. These are qualitative.
  - Big Wins, Goals, Milestones, Mid-term Wins and Quick Wins. These are quantitative.
- The Roadmap framework on the next page describes a systematic process for achieving the overall Mission.
- The framework is accompanies by Strategic Policies, which the government might use to support the circularity transition.

Special Note

Normally, roadmaps are developed through a goal-setting process, which EPEA co-develops with stakeholders. In this case, the Ministry requested EPEA to describe what the roadmaps might look like. It is emphasised strongly that in order to reach final roadmaps, a goal-setting process be undertaken for each of the described Objectives.



Highlights Figure XV: Roadmap structure

The following Highlights Table III comprises 7-10 year Objectives, 3 – 7 year Big Wins, and immediate-to-3-year Short-to-Mid-term Wins arising from the present study. The Objectives are divided into two main sections; enabling framework & services, and economic implementation projects.

Highlights Table III: Objectives, big wins & low cost quick wins

Overall Objectives supported by strategic thrusts 7 – 10 Years	Potential Big Wins on the road to Objectives 3 - 7 years	Potential Low-Cost Quick Wins & Mid-Term Wins 1 – 3 years
CIRCULARITY ENABLERS		
National Objective Implement a *National Circularity Roadmap for Resource Quality & Productivity*.	*Implement enabling mechanisms, which empower diverse stakeholders to implement the circular economy by raising competitiveness, accelerating job creation, saving costs and improving environmental impacts.*	Establish a *National Circularity Initiative for Resource Quality & Productivity* (NCC) Announce *Circularity Training Initiative* for the EU Presidency. Announce *National Quality Co-Brand for Circularity* to improve sales and support existing Luxembourg quality labels.
Education & Training Luxembourg with the Greater Region will be Europe's leading education & training hub for creating new jobs and improving competitiveness using circularity skills and technologies.	*Luxembourg creates thousands of new jobs for youth through remanufacturing, repairing, disassembly, deconstruction & logistics.*	*Circularity Training Initiative* for hands-on training of unemployed youth for circularity skills.
Marketing & Messaging National quality co-brand for circularity-inspired products & services by leveraging existing Luxembourg labels to increase sales & competitiveness of products.	*Luxembourg increases sales of local agricultural products and manufactured goods by integrating a national quality co-brand with circularity.*	*National Quality Co-Brand for Circularity* to complement existing Luxembourg labeling, piloted with local grocery retailers & growers, supported by a government 'buy local' campaign.
Economic Indicators Luxembourg is recognized as an authority for quality assurance and measurement of present and potential value of circular materials.	*Luxembourg creates a new industry for circular economy quality assurance and measurement by pioneering a New Balance Sheet for Circularity*	Announce plan to establish a *New Balance Sheet for Circularity* To start, announce Pilot for Measuring Positive Impacts by adapting LCA Announce a *National Materials Banking Valorization Inventory* for materials in Luxembourg's infrastructures.
Regulation Luxembourg be a leading partner with the EU to establish regulation and incentives for safely and equitably implementing circularity, with a focus on supporting R&D incentives and removing licensing barriers.	*Luxembourg is a consulting services hub for advising governments & companies on circularity legislation, regulation, & incentives.*	Optimize & embed already-developed *CE positive criteria* into new legislation, regulation and investment guidelines. To conform with new EU regulations announce a CO_2 *Phase-In programme for replacing Hydrochlorofluorocarbons HFCs* with economical & energy-saving closed loop CO_2 systems.

Overall Objectives supported by strategic thrusts 7 – 10 Years	Potential Big Wins on the road to Objectives 3 - 7 years	Potential Low-Cost Quick Wins & Mid-Term Wins 1 – 3 years
	ECONOMIC SECTORS	
Manufacturing Luxembourg with the Greater Region will be a European R&D frontrunner for recovering & using secondary raw materials for primary manufacturing to support its existing industries. Luxembourg will be the technology frontrunner in IT, robotics and additive manufacturing for near-shoring circularity.	*Luxembourg & Greater Region achieve substantive resource security and improve margins by 10% with smart specialization in secondary raw materials.* *Luxembourg integrates high-technologies to be a significant participant in the repatriation of millions of near-shoring jobs to Europe, i.e. bringing jobs back to where the markets are.*	Accelerate *Circular Supplier Communities* for improving secondary raw materials productivity & quality. Upcycle scrap & cullet trading into a *Materials Banking* service to improve margins for Luxembourg's manufacturers. Initiate *Positively Defined Materials* with manufacturers, anchored by years of successful R&D at Tarkett in Luxembourg.
Construction National materials management for circularity in construction & building management fully operational. The plan to be developed in the near-term.	*Luxembourg and the Greater Region save hundreds of millions in costs annually and increase the real value of the new & renovated building stock amounting to billions of Euros in gains, by converting demolition liabilities into bankable materials assets.*	Announce *National Materials Management Plan* for construction headlined by *Upcycling Construction Residues* to reduce excavation and construction waste 30% by re-using it. Pilot a *Circularity Light-house* in Luxembourg with 100% defined materials to improve residual value.
Investment, Banking, Insurance Luxembourg will be the leading financial center for circularity investment & banking, including new mechanisms for integrating Greater Region R&D with industry and finance, & best practices	*Luxembourg becomes the Trillion-Euro circularity banking hub for revenue-generating banking services, investment, materials leasing, and insurance.*	Quality-Assured *Circular Matchmaking* with Greater Region R&D innovators. Pilot *Secondary Raw Materials Valorization Service* with municipal governments and builders, vetted by the financial community.
Logistics Luxembourg will be a European reverse logistics hub, leveraging its existing assets to provide new services.	*Increase the share of logistics revenues for reverse network activities and re-distribution in the Greater Region.*	*Circular Logistics Service* with La Poste Investigate feasibility of *Circular Vehicle Repairing & Leasing.*
R&D Luxembourg with the Greater Region and supported by the investment industry will be an R&D frontrunner for introducing positively defined chemicals, composites, nanomaterials and biomaterials to existing and new industries.	*Luxembourg and the Greater Region lead near-shoring of industry with 3D and automated circular manufacturing to repatriate millions of jobs .* *Luxembourg is the IP capital for licensing circular materials, generating billions of Euros in licensing fees.*	Pilot 3DRD; *3D & Robotic De-construction Initiative* based on existing R&D. Announce The New BBC. Biobased Biocompatible Composites

Highlights Table IV: Secondary objectives*

*These items are described as potentially secondary due to considerations described under Methodology in Annex M. However, it is emphasized that the Ministry and the Stakeholders will ultimately determine priorities. The table is provisional only.

Category	Objective
ENABLING MECHANISMS	
ICT & advanced technology systems	Luxembourg will be the technology frontrunner in ICT, robotics and additive manufacturing for circularity.
ECONOMIC SECTORS	
Agriculture	Establish a national circular agriculture programme focused on improving local marketability of Luxembourg agricultural products and restoring soil quality with advanced methods.
Automotive	Investigate the feasibility of circular supplier communities through pilot projects based on increasing secondary raw materials use, remanufacturing, tracking systems for returnable packaging.
Water	Luxembourg will be a circularity leader in value-added water recycling to meet and exceed its EU water quality goals.

Strategic Policies to Achieve the Mission and Objectives

Ultimately materials re-use might drive the Greater Region.

Laurent Federspiel
Head of Department, Technology & Business Development Luxinnovation

Circularity for materials might be Luxembourg's answer to the EU's demands for smart specialization by regions.

CE study interviewee

Companies achieved cost savings of more than 40% easily by re-thinking their value streams in a circular set-up

Valorlux interview

There is a universe of potential opening up. However, we have never looked systematically yet to capture these opportunities.

FabLab interview

When we think Circular Economy we don't think just end-of-use but also the quality during use.

Anne-Christine Ayed, Vice-President, Tarkett

Resource productivity supported by materials quality and systems efficiencies is taking its place alongside energy transformation as a priority for Europe to achieve a dual mission of well-being and economic prosperity. The circular economy supported by cradle-to-cradle methods is a defined and practical framework for achieving it.

A Core Strategy for Integrating Circularity into Government Policies

In the circular economy, materials, components and products are used to develop new services, as well as sales. The strategic thrust is to leverage Luxembourg's service-oriented capacities to optimise and scale up those knowledge assets.

Luxembourg has the opportunity to use materials quality as an innovation platform for resource productivity and security. For example, materials know-how is a platform for partnering with the Greater Region in a Smart Specialization strategy to establish Luxembourg as A Knowledge Capital and Testing Ground for the Circular Economy

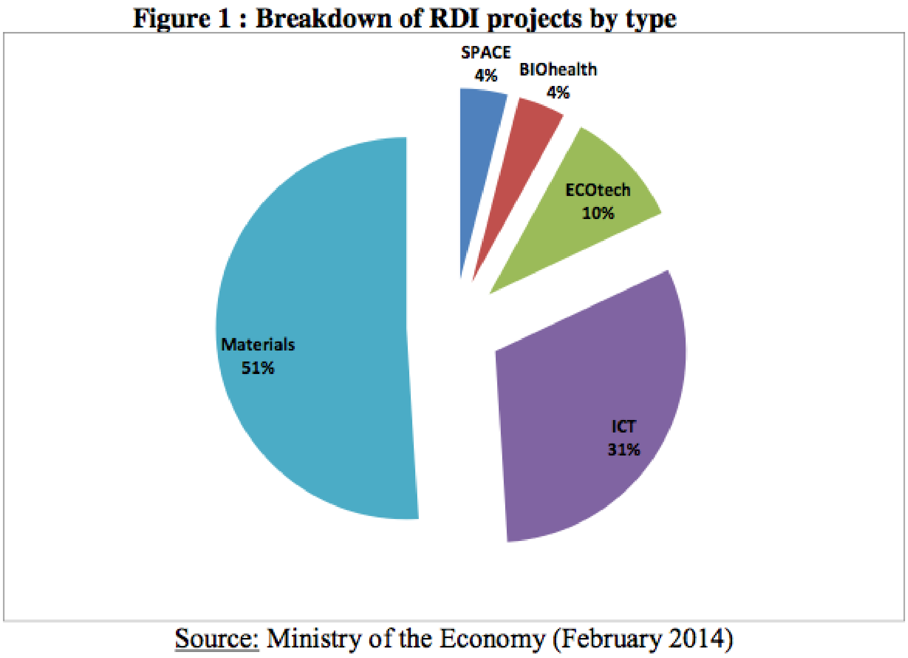
Luxembourg is superbly positioned to claim leadership as a Knowledge Capital and Testing Ground for the Circular Economy, to accelerate job creation, improve competitiveness and increase cost savings while reducing environmental impacts. Luxembourg and the Greater Region enjoy a powerful starting base as they already use circularity for thousands of jobs and billions of Euros worth of materials, products, & services. Companies are using those platforms to achieve prosperity.

To support Luxembourg to achieve the status of Knowledge Capital and Testing Ground for the Circular Economy, the following section is divided into Sectorial, Regional and Enabling strategies.

Why focus on materials resources as a strategy?

Materials are the designated focus for the present study, but factors other than the terms of reference justify materials quality as a circular economy focus for Luxembourg.

For example, the following diagram taken from the *2014 National plan for smart, sustainable and inclusive growth Luxembourg 2020* illustrates the current breakdown of public R&D funding to companies in Luxembourg;



Highlights Figure XVI: Funding proportions for Luxembourg R&D

As well, effective use of materials and resources is one of the 3 themes relevant to the Europe 2020 strategy selected for the INTERREG North-West Europe trans-national programme with a FEDER budget of €396 million, and is also the focus of an EU Interreg project INTERMAT involving the Greater Region.

Secondary raw materials are core to the survival of some of Luxembourg's leading primary industries. It is a competitive priority to sharpen and scale up Luxembourg's capacities for reusing secondary raw materials.

As well, in the circular economy materials and products are used to provide services, and services are the greatest strength of Luxembourg's economy.

Sectorial Strategies

Use materials & resource productivity to improve competitiveness & employment

Potential CE Big Wins for Luxembourg cut across traditional, transitional and transformational sectors, but each requires training;

- Traditional sectors; Reverse logistics, Construction methods, Retailing agricultural products. Support traditional industries by optimising scrap and cullet streams.
- Transitional approaches. Adapt approaches for capturing new value streams with reverse logistics, designs for disassembly, phosphate capture. Develop positively defined biobased ingredients and materials.
- Transformational approaches. Near-shoring with transformative technologies like ICT-based 3D additive manufacturing and systematic introduction of performance-based usage models

Circularity has the potential to support resources of the past, present and future. Luxembourg will benefit from solutions for each;

- *The past*; Upgrading waste management technologies to better deal with brownfields, excavation waste, old PVC, old concrete, demolishing old buildings etc.
- *The present;* upgrading industrial sourcing and recycling of secondary raw materials for steel, specialty glass, aluminium, plastics, reusable packaging.
- *The future*; composites, bio-carbon fibres, nanomaterials, biobased materials, new ways of assembling and disassembling e.g. additive manufacturing and robotic/human interaction for disassembly.

B2B vs. B2C. Gains are largely but not entirely in the B2B rather than B2C segments; for example, primary & secondary manufacturing, agriculture, construction, finance. Exceptions include B2C retailing and ICT for sharing websites.

Luxembourg's consumers have shown a willingness to pay premium for local products and to be supporting re-use models (e.g. re-usable bags introduced by Valorlux and local retailers like Cactus), once presented with a circular economy choice.

Improve resource productivity in selected sectors with customer supplier communities.

Scale up Customer Supplier Communities in construction, recycling, and retailing to improve value and quality. Profitable examples are working today in & near Luxembourg and are available to be scaled up.

One of the most effective marketplace mechanisms for achieving buy-in to circularity is customer supplier communities. These re-align the traditional customer supplier relationship to amplify win-win scenarios.

Customer/supplier communities are core mechanisms for achieving materials quality. Those exist across a range of activities in Luxembourg including;

- for steel & aluminium between manufacturers & scrap dealers,
- for paper between customers and collectors,
- for retailing between agricultural producers, wholesalers & retailers,
- for flooring between materials designers and marketers.

The challenge is to optimise and scale up.

Support mixed use in the Plan Sectorial

The government recently completed a long-awaited Plan Sectorial for development across Luxembourg. Builders and developers as well as MDDI expressed universal agreement about the importance of promoting mixed-use developments which integrate business, residential, institutional, and commercial to replace the single-use strategies which in past resulted in substantial commuting. A move to creative, socially responsible increased density including healthy materials and buildings is also seen as a way to avoid further generation of excavation waste by going slightly up instead of down, while improving affordability which in turn encourages diversity required for circularity.

Optimise procurement

Customer supplier communities are closely connected to procurement. Procurement cuts across every government and large company department so seems a natural way to accelerate competitiveness, but practice shows there are barriers to overcome. Central purchasing rules, anti-competition, confusion over circular vs. sustainable, traditionalism and other factors have to be overcome. Especially perceived conflict between supplier communities and anti-competition legislation is a priority to address. Procurement quick wins might be in the non-publicly listed private sector where the rules are less stringent. However there might be exception with government owned companies. As well customer/supplier communities are central for educating purchasers & suppliers in the public and publicly traded sectors.

Regional Strategy

The Greater Region as a circular community for R&D & education on materials quality & resource productivity

- Unify efforts of the Greater Region around the EU Smart Specialisation programme by establishing a 'Materials Quality' Specialty.
- In the strategic field of technology R&D the Greater Region is already a strong partner with Luxembourg, due to Luxembourg's traditional leveraging of regional resources to compensate for its size and limited accreditations. Leveraging those partnerships is central.
- An example is the IntermatGR consortium of universities working on materials research. The following is excerpted from a description by Luxinnovation;
- The Luxembourg Materials Cluster set up a cross-border Cluster based on materials in the Greater Region, "INTERMAT". The establishment of the Cluster is financed through an INTERREG project with a duration of 18 months. The project aims at fostering knowledge exchange, identifying synergies between partners and creating a Materials Competence Centre. This company-focused project provides:
  - Companies and especially SMEs with access to existing competences in the Greater Region through joint networking events, such as lab days, meetings and seminars, creativity sessions and open innovation networks.
  - One-stop-shop services to create a common platform for the exchange of know-how and expertise as well as for transnational problem solving.
  - In fact, materials are a common topic in the five regions involved in this project: Luxembourg, Wallonia, Saarland, Lorraine and Rhineland-Palatinate. All regions share a common industrial past and common excellence in materials research. Previous INTERREG initiatives have already created close links between academics in the region.

- A range of Greater Region programmes and institutes specializing in materials and especially in bringing those materials from the lab to the marketplace are dynamically active in the Greater Region, for example the Leibniz Institute for New Materials http://www.inm-gmbh.de/en/. The network started through Intermat might be expanded to those groups.
- Other potential focus areas for materials R&D co-operation include;
  - biobased additives and composites designed for circular cycles,
  - designs for disassembly,
  - robotics,
  - 3D additive manufacturing,
  - Life Cycle Assessment,
  - Joint progress in revalorization processing (e.g. concrete recycling)
- In Germany a few standout activities deserve mention; Moorbach energy landscape for off-grid solutions, and Palaterra, a company and methodology with a new kind of topsoil manufacturing with potential to restore Luxembourg's agricultural soils.
- In selected areas such as textiles and reverse metallurgy, regions like Wallonia announced plans to become circular economy regions, although progress to date has been delayed by regional elections. Luxembourg will gain from studying this cluster as it develops and possibly participating.
- Circularity statistics on the Greater Region as an entity are difficult to find. Information has to be gathered from individual Greater Region members. The newly-created Greater Region EcoInnovation Cluster Umweltcluster Grossregion will be a valuable mechanism for that.

Benelux strategy. The Valley at Schiphol Trade Park as a model for Luxembourg to track.

To underline the value of integrating R&D with practical pilots and enabling tools, a new circular economy hub in The Netherlands might be a model for the Ministry of the Economy as well as other Ministries and businesses in Luxembourg to track, especially regarding tax, free trade zone potential and R&D incentives. Initiated by Delta Developments who developed the C2C-inspired Park 2020 in the Netherlands, and supported by the Schiphol Airport Development Corporation (SADC), *The Valley* at the Schiphol Trade Park plans to bring circularity to a new level by creating 'materials farms', knowledge hubs and scientific networks with a range of circular economy businesses and services. It will be the largest circularity development to date, encompassing an area larger than one square kilometer next to one of Europe's busiest airports.

The Valley is being co-developed with a range of local and international stakeholders, including various universities, the World Economic Forum and the Ellen MacArthur Foundation, making it one of the largest economic circular economy activities in The Benelux.

As a starting project, the group did an inventory of the diverse residue flows around Amsterdam to identify local opportunities for upcycling it to resources and matching it with potential re-users. These fractions will be used as a basis for materials communities as described further in the present study.

Enabling Strategies

Do a few things well but empower diverse stakeholders with education & training

The study considered how Luxembourg might focus on doing a few things well but still support diverse stakeholders in its economy.

The potential solution is for the government to lead on selected priorities while empowering stakeholders with educational and training platforms to innovate on their own.

Leadership on selected priorities includes primarily supporting light-house initiatives for example;

- Hands-on education & training,
- Pilot projects for upcycling & classifying secondary raw materials,
- National quality co-brand circularity pilots
- Pilot transforming supplier chains into circular supplier communities

Improve competitiveness & employment with education & training about circularity

- The National plan for smart, sustainable and inclusive growth Luxembourg 2020 recommends;

  Step up efforts to reduce youth unemployment by improving the design and monitoring of active labour market policies. Strengthen general and vocational education to better match young people's skills with labour demand, in particular for people with migrant background. Take resolute action to increase the participation rate of older workers, including by improving their employability through lifelong learning.

- The potentials for circularity education and training for employment are;
  - *Preserving jobs* by continuing to optimise security of supply of secondary raw materials for primary and secondary industries, as well as retraining personnel for circularity.
  - *New job potential in Luxembourg.* Traditional sectors like construction, logistics, finance, retailing, but as well for transformative technologies like 3D additive manufacturing. While 3D might be seen as a job killer risk it is

actually generating new employment from manufacturing of the machines, software and feedstock, as well as releasing creativity potential for product designers. The further 3D potential for near-shoring jobs presents a significant potential for Luxembourg.

  - *New job potential in the Greater Region & beyond.* Luxembourg-based companies have the opportunity to create new jobs and competitive advantages outside Luxembourg especially for ICT, finance, logistics.

- The tools are;
  - *Hands-on training.* Those potentials might each be met with an aggressive hands-on training programme and facility. There is a potential for job preservation as well as job creation among high-unemployment groups in Luxembourg due to forecasted demands for physical disassembly and reverse logistics. To take advantage of those opportunities, hands-on training is required. The infrastructure to deliver training already exists through e.g. Chambre des Metiers, FabLab, Futurelab, Innovation clusters, IFSB & Luxbuild2020, Learning Factory, the CRPs, University of Luxembourg, as well as companies like ArcelorMittal, Cimalux, Goodyear, Pall Center, and Tarkett to mention a few. The opportunity and challenge is to align and unify those efforts around hands-on training for circularity.
  - *Circular Supplier communities* to accelerate competitiveness and education. Supplier communities are a redesign of the traditional supplier chain. Usually lowest-cost is the only driver and this often leads to lowest or unknown quality along the supply chain. By integrating cost and quality according to transparent objectives, suppliers become partners with customers in the journey to circularity. The results with projects like e.g. Ecoparc Windhof in Luxembourg include more competitive attractive buildings and workplaces which also include collective savings by eliminating redundancies.

Integrate circularity science with economics

There are knowledge gaps on the science of circularity. Those gaps represent a competitive opportunity for Luxembourg;

- *Designing*. Designs of materials, components and products have large impacts on circularity economics. Efforts to optimise recycling without optimising materials or products generate unnecessary costs. It is more cost-effective to design materials, products and revalorisation systems together.
- *Positively designed ingredients*. Materials functionality and added value come from thousands of commonly used ingredients, additives, and coatings. Most environmental regulations focus on reducing toxicity of

those ingredients, but a distinction of circularity is to define them positively. The competitive potential is for Luxembourg and Greater Region R&D groups to collaborate on *developing positive lists* of chemicals for products.

- *Biomaterials* are one of the largest potentials for the Technosphere especially for biobased chemicals as feedstock. Luxembourg & the Greater Region have powerful R&D capacities to develop biochemicals and biomaterials for the Technosphere to increase the decoupling effect by employing biological resources in the Technosphere to achieve usage periods exceeding the regeneration periods required for the present methods of growing biomass feedstock.

Aim for quality, then focus on quantity

Circularity is first about quality and embedded value. Luxembourg has the potential to use quality to its competitive advantage to be A *Knowledge Capital and Testing Ground for The Circular Economy.* The capacities, which give it the potential, are; economic & cultural diversity, stability, service orientation, high education and income level, materials research, flexible governance and geopolitical location.

Materials quality is a framework for Luxembourg and the Greater Region to meet the goals of the EU smart specialization policy and improve resource productivity for Luxembourg's secondary-raw-materials-dependent industries. The circular economy aims to increase effectiveness of systems (doing the right things) and it is thus typically more potent than the classical sustainability debate, which focuses on efficiency gains (doing things right). The question is where to start; with the installed base or with new designs? Those are each good starting points and mutually supportive, if they share a perspective on achieving higher quality standards/levels. Those perspectives include;

- *Resource effectiveness based on quality of materials recovery and economies of scale*. The value capture lies with efficiencies in the existing system by recovering materials, which are part of the established asset base.
- *Resource re-use based on quality of materials*. The fastest road to value capture is to improve the quality and residual value of materials by remaking the way they are made.

Those schools of thought are potentially complementary, but only if quality is the overall driver. In that context, Highlights Table III shows the potential quality Objectives for Luxembourg.

Promote positive impacts

A new way of doing businesses requires answers to previously unasked questions to take full advantage of the future opportunities and being able to mitigate the risks of disruptive innovation. While the shift is focusing to improve productivity of finite, physical resources, the innovation will need to span from design including material formulation, business model innovation (towards a performance based economy), reverse network capabilities to establishing enablers and platforms to foster collaboration. Current environmental regimes are not up to the challenge because they are based on regulations for reducing negative impacts and are not incentive-based. The circular economy is focused on improving positive impacts. The approach is catalyzing a new set of policies, incentives and regulations aimed at positive impacts. An example is the new set of EU product criteria based on 'positive lists' instead of 'banned lists". Luxembourg has the capacity to lead development of those enabling mechanisms by adopting policies based on positive impacts.

Promote stakeholder engagement

The ultimate focuses for circularity in Luxembourg are determined by stakeholders as a next step from the present study. The study started the consultation process by performing 45+ interviews to learn perception of stakeholders, then used those perceptions to provide a range of potential circularity objectives. Especially the study focused on where it might be feasible to get buy-in for the following ambition levels;

- Supporting incremental traditional improvements where it makes economic or cultural sense.
- Using transition as a manageable bridge from the present to the future.
- Transforming technologies & systems to stay competitive.

Customer supplier communities also play a pivotal role in leveraging stakeholder engagement.

Leverage Luxembourg's presidency for circularity

Utilise the upcoming EU-Presidency to claim the Circularity space and harness the associated energy to move towards implementation quickly. For example;

- The withdrawal and re-tabling of circular economy legislative package by the EC presents an unexpected opening for Luxembourg to drive a positive agenda in contrast to a regulation-driven agenda. See *Breaking News* section at the beginning of the Highlights section of the present study. For example introduce positive criteria for circular economy legislation.

- Announce Luxembourg's intention to focus on circularity at the highest level of government, industry & academia.
- Announce the intention to establish a quality standard for secondary raw materials.

By so doing the government will claim the territory and generate public excitement and commitment for next Presidencies like The Netherlands to follow through on.

Motivate Luxembourg's leadership through participation

Involve business, academic and government leaders in a high level mechanism to coordinate the diverse circularity-related initiatives already going on. See following section.

Potential Role for the Government of Luxembourg

Government is a big potential enabler in Luxembourg for CE, and one advantage Luxembourg has over other countries is, that its tradition for business-minded policies and its ability to align stakeholders across sectors allows to move quickly to respond to shifts in marketplace conditions

As described at the beginning of the summary, the study identified a pivotal leadership role for the Ministry of the Economy and national government to play in clarifying, optimising and scaling up the circular economy;

The government has a special brief opportunity to seize the initiative through initiating and coordinating actions, supported by powerful messages about circularity through education, training and national co-branding. By leveraging those mechanisms the government will provide the enabling framework for its stakeholders to power the circular economy with innovative lighthouse initiatives.

Potential Implementation Structure

A Framework for Circularity Actions

A National Circularity Initiative (NCI) for Resource Quality & Productivity coordinated by a results-oriented circularity working group for implementation.

The NCI is exemplified by the many initiatives described in the Roadmap of the present study, including for example a National Co-branding Label for Circularity to further distinguish the existing Luxembourg brand, improve sales of Luxembourg products & services, and inspire national participation. The co-brand is itself a type of quality assurance to build understanding of the circular economy.

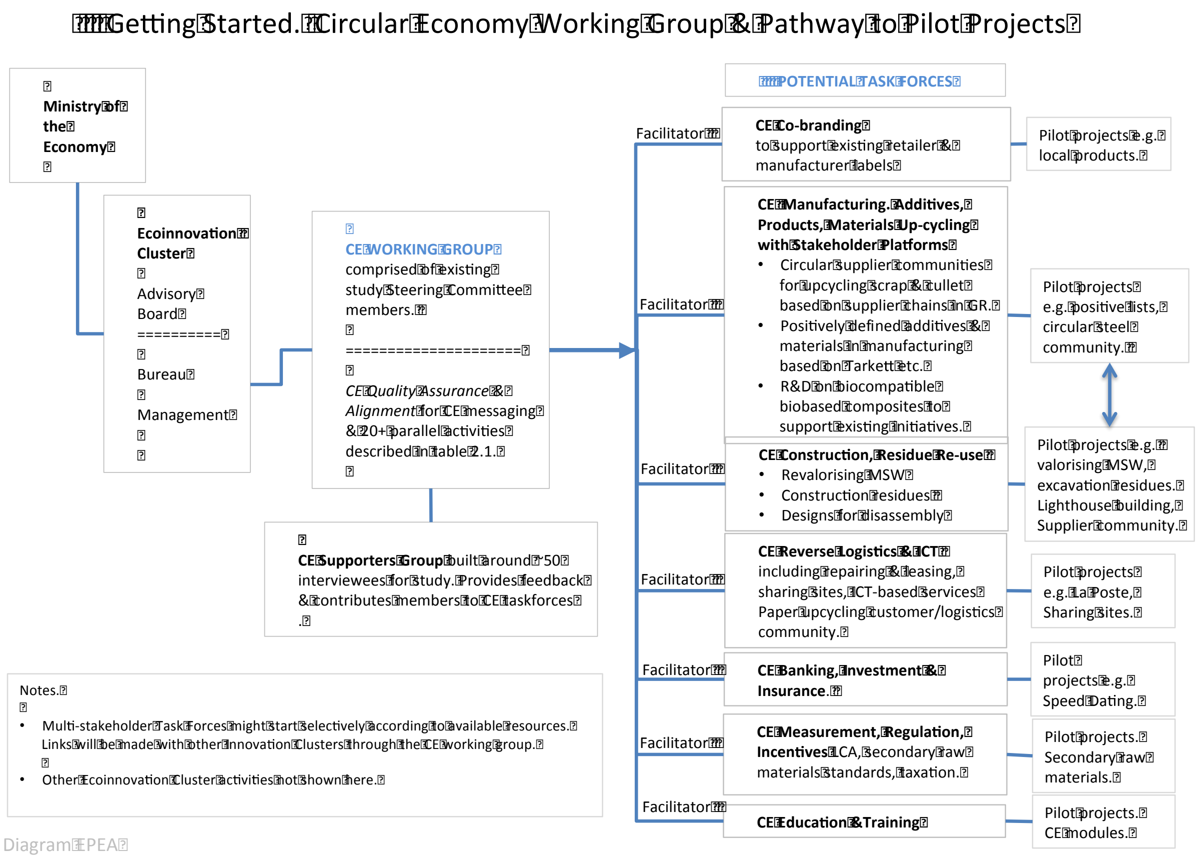
Working Group Composition. The initial working group is intended as a practical activist and catalyst for circularity instead of a committee catch-all for every ministry and industry association.

Coordinate work through the Innovation Clusters

Innovation is at the core of circularity. Participation and leadership by the Ministry of the Economy via the Innovation Clusters and initially the Ecoinnovation Cluster seems a practical place to base the programme described here, especially because the Innovation Clusters already integrate stakeholders from the private and public sectors, so there is no need to re-invent this structure.

> The working group for the NCI might play a function additional to aligning circularity activities; It might allow the government to more closely integrate 20+ parallel initiatives described in Table 2.1 in Chapter 2 Context. The diversity and number of activities occurring in 2014 is remarkable and displays a proactive attitude but also a potential for duplication.

For more information on the potential terms of reference and composition of the working group see; chapter entitled Potential Circularity Roadmap for Luxembourg, under Objective #1, as well as Quick Win #1, which contain the main sections describing those activities.



Highlights Figure XVII: Organogram for National Circularity Initiative and associated stakeholder platforms. (Lines indicate communication rather than authority.)
For more information on structure & functions refer to Quick Win #1 under Roadmap chapter.

SECTION I

OVERVIEWS

1. WHY DO IT?

The size of the prize

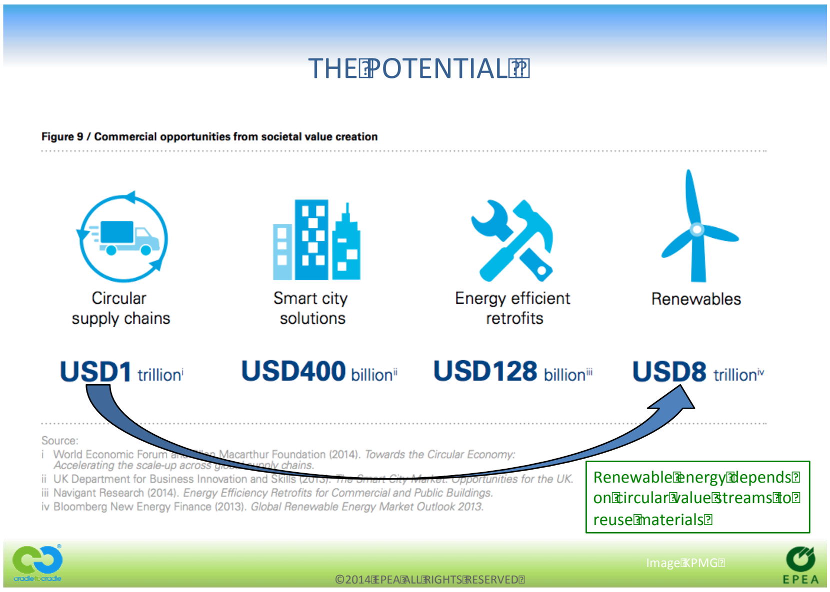


Figure 1.1: Total value creation potential relating to circularity. Source image KPMG

How big is the economic prize for circularity? As the present study describes, estimates vary, but each seems to agree it is large. The estimation of 1 Trillion USD in the left of the image came from a report for the World Economic Forum by Ellen MacArthur Foundation and McKinsey with participation by EPEA. However a more compelling number is on the right; 8 Trillion USD from renewable energy calculated by Bloomberg New Energy.

Why is the study focused on materials and how does it connect to that large number?

The arrow connecting those results from studies (Gordon et al) suggesting the continued supply of strategic materials required for renewables might be problematic. Substitution of those materials on its own might not be sufficient to meet intermediate demand. Circularity of high quality materials combined with innovative substitution are among the main mechanisms for success in order to prevent unnecessary shortages. The implications are; the Big Win from circularity is in materials recovery but also materials for renewable energy.

The total size of the prize; 9 Trillion USD. How much of that might Luxembourg gain? At least €3 Trillion in assets resides in Luxembourg financial institutions. Might those funds be invested for circularity?

Other motivators

- Luxembourg's leading primary industries, billions of Euros in revenues, and thousands of jobs rely heavily on secondary raw materials.
- Materials security is already a national security focus for Germany, the EU, the U.S. and China. Circularity will accelerate the use of secondary raw materials to achieve materials productivity, and through productivity materials security as well as energy security are achievable.
- The potential of circularity is high for supporting Luxembourg's climate change goals for;
    - Positive environmental and energy impacts of secondary raw materials
    - HFC substitution to meet new phase-out EU regulations
    - CO_2 re-use to economically use climate change gases in closed loops.
- The EU asked all the countries and regions to focus on smart specialisation. Luxembourg is still considering what to do. The vacuum offers a potential for using circularity as a smart specialisation and being first mover.
- Circularity is a major contributor to biodiversity & biodiversity is a major contributor to the economy. Luxembourg's agricultural sector stands to benefit from using it.
- Marketplace experience demonstrates that improving materials improves performance & productivity.
- Internalizing environmental and social externalities is becoming an increasing pressure on industries, as described in the present study. The circular economy empowers companies to use savings, revenues, and quality to internalize those externalities.

Synopsis of significant numbers

$9 Trillion USD. The estimated potential of commercial opportunities globally from circular-related and renewables activities.

€30+ billion. Combined revenues of companies participating in one of the largest circularity communities; Carlsberg Circular Community.

~€1 billion. Estimated revenues supported by circular activities in Luxembourg, excluding R&D-generated revenues.

€325 million. Estimated minimum near-term cost savings from circularity in Luxembourg.

10 million. Tonnes of excavation and inert residues generated annually in Luxembourg.

2 million. Tonnes of steel manufactured in Luxembourg, which relies entirely on circular supplies of secondary raw materials..

~1,400,000 Scholarly publications containing the term *sustainable development*.

~27,000 Scholarly publications containing the term *circular economy*.

15+ Eco-economy terms competing with 'Circular Economy'.

~15,000 Upper estimate of jobs which rely on circularity in Luxembourg

~5,000 Additives commonly used to give products their functionality.

1 Mentions of additives in the 2014 EC scoping study of circular economy.

~2,200 Estimated jobs, which might be created short-term with circularity in Luxembourg.

108+ Products certified for circular cycles, which have a market presence in the Greater Region.

20+% Increase in Benelux market share attributed by Desso's CEO to C2C-based circularity during the financial crisis.

15+ Circular-oriented service systems and customer/supplier networks operating in the Benelux involving circularity products used in the marketplace today.

9+ Circular economy-focused organisations in the Benelux.

5% Estimated margin increase companies like ArcelorMittal say might be achieved by matching scrap quality more closely to steel quality; a potential difference between profit and loss

~1 year. Delay in constructing University of Luxembourg laboratories due to excavation waste landslide.

#1 Position products certified for circularity cycles hold in sales of Ahrend, Desso, Herman Miller, & Steelcase products.

0 The number of people who refused to be interviewed for the present study.

2. CONTEXT, TERMS OF REFERENCE, STUDY APPROACH

2.1. Context. Why Is National Alignment On Circularity A Priority?

A surge of activities with links to circularity is happening in Luxembourg. See Table 2.1 for overview of 25+ activities occurring in 2014 with relevance for the present study. Those point to an imperative for national alignment. The activities contain important data and recommendations about the Luxembourg economy, which are valuable re-enforcement for the study.

For example; The 2014 National Plan For Smart, Sustainable And Inclusive Growth Luxembourg 2020, makes recommendations on Optimisation of circulation and transfer of scientific knowledge on intelligent & recyclable materials (p. 31) as well as effective use of Materials and Resources. The Plan especially focuses on Education & Training to solve the youth unemployment challenge, and gives examples of e.g. installing insulation for energy efficiency (p. 23), also covered in the present study.

As well the 2014 Plan Sectorial designates areas of the country where Mixed Use developments might be used to accelerate circularity.

The present study might be a vehicle for supporting and implementing National Plans.

Example

The draft 2014 report of the *Haut Comité pout L'industrie Groupe de Travail Developpement industriel Plan d'action pour donner de nouvelles perspectives a l'industrie luxembourgeoise* makes the following recommendations which significantly align with the findings of the present study;

- Recommendation; Strengthen links between industry and R&D, and between industry and the financial community.
    - The present study describes similar potential for circularity.

- Recommendation; Further develop technological competencies.
  - The present study describes similar potential in similar areas.
- Recommendation; Improve the perception of Luxembourg industry by the general public at home and abroad.
  - The present study describes a vehicle to achieve the approach; a national quality label based on circularity.

Because the primary stakeholder for the present study is the Ministry of the Economy, and the Ministry has diverse reports in its hands, it was not necessary to repeat the many excellent statistical and sectorial overviews done in those reports. For example, the Haut Comité report contains overviews on;

- Strengths, weakness, opportunities and threats for Luxembourg industry, which are not exactly the same as for circularity but have crossovers.
- Overview of the globalized directions towards e.g. additive manufacturing, nanotechnology, composites, robotics; each which are focuses of the present study as potential circularity enablers.
- Emphasis on the importance of access to Germany's liquid energy markets, which has important implications for circularity due to Germany having the largest percentage of renewable energy generation.
- Emphasis on the role of Luxembourg as a Data-Highway. The present study explores the role of ICT in enabling circularity.
- Focus on continuing to accelerate R&D, also covered in the present study.
- Focus on diversifying the economy to reduce dependence on the financial sector. The present study describes ways of utilising the financial sector to drive that diversification.
- Recognition of the increasing demand for products by a growing middle class globally. The present study emphasises the risks and opportunities of increased competition for materials occasioned by the increasing demands.
- Recognition of the transfer of environmental externalities to internalities in industry, resulting in new demands on industry.
- Recognition of the trend to re-shoring, which in the present study is identified as a leading potential for circularity to drive the re-shoring.
- Recognition of service-driven business models. Service concepts are central to the circular economy.

Table 2.1 describes parallel activities and their potential relevance to the circular economy, as well as who might be responsible for aligning those with circularity initiatives in Luxembourg, It is advised that the Ministry of the Economy earmark the following activities for alignment through coordinating mechanisms proposed in the Roadmap chapter.

Table 2.1: Activities in Luxembourg with potential links to the circular economy; parallel to the present study for the Ministry of the Economy

SECTOR	ACTIVITY	RELEVANCE TO THE CIRCULAR ECONOMY	POTENTIAL ACTIONS, RESPONSIBILITY
National Planning	*2014 National Plan For Smart, Sustainable And Inclusive Growth Luxembourg 2020*	Includes materials in financing priorities, and especially social inclusion through training.	Align recommendations of the Plan with the Objectives and Quick wins described in the present study. *Responsible; Luxinnovation*.
Sectorial Planning	Les plans directeurs sectoriels primaires published April 2014	Identify candidate areas for mixed use to integrate circular economy materials flows and efficiencies with quality of life. Focus on mixed use.	Prioritise pilot projects described in Table 14.5 of the present study. Appoint a Task Force of the *National Circularity Initiative* to support those.
Industry **Planning**	*Haut Comité pout L'industrie Groupe de Travail Developpement industriel Plan d'action pour donner de nouvelles perspectives a l'industrie luxembourgeoise*. 2014	Recommendations relating to CE potential	Align recommendations of the plan with the present study. Provide the present study to the High Committee. *Responsible Ministry of the Economy.*
Procurement & Construction	*Centre de compétences* en *construction durable*	Training	Align with e.g. the Institut de Formation Sectoriel du Bâtiment to support and follow pilot projects. *Responsible Luxinnovation.*

SECTOR	ACTIVITY	RELEVANCE TO THE CIRCULAR ECONOMY	POTENTIAL ACTIONS, RESPONSIBILITY
Procurement & Construction	Systèmes de certification pour quartiers urbains durable**s.** June 2014	Workshops on sustainable construction certifications are vehicles for evaluating green certifications compared to sometimes differing requirements of circularity.	Consider future workshops linking materials circularity to the standards being set by certification systems. *Responsible Luxinnovation?* http://www.eukn.org/Policy_Labs/Certification_Systems_for_Sustainable_Urban_Neighbourhoods_June_30th_2014_Luxembourg
Procurement & Construction	New EU procurement regulations published June 2014. Process of national adopting starting in Luxembourg.	Procurement is one of the leading mechanisms for implementing circularity but perceived & real barriers prevent implementation.	Use CE procurement templates described in the present study as a basis for CE procurement. Check those against the new EU regulations for compliance.
Construction & Planning	EC C2CBizz Guide November 2014	Potential application tools for CE in area developments	Provide the Guide to sustainable construction groups. If a construction Task Force is developed for circularity refer participants to the C2CBizz tools for educational potential. *Responsible Ecoparc Windhof & CRP Henri Tudor who participated in the Guide.*
Construction	Conseil National pour la Construction Durable. Announced 2013, created 2014.	Priorities for sustainable buildings	Align with circularity pilot projects and training programme described in the present study. See Construction and Education sections of Table III Objectives. Align with e.g. the Institut de Formation Sectoriel du Bâtiment to support and follow pilot projects. *Responsible; Still to be determined which organisation might best coordinate the construction approach..*
Construction	Potential pilots for demolition. European Parliament and EIB refurbishment?	Potential pilot for CE materials.	Develop a construction Task Force of the *National Circularity Initiative* in collaboration with e.g. the Institut de Formation Sectoriel du Bâtiment to support and follow pilot projects. *Responsible Luxinnovation with LuxBuild2020?*

SECTOR	ACTIVITY	RELEVANCE TO THE CIRCULAR ECONOMY	POTENTIAL ACTIONS, RESPONSIBILITY
Construction	Closure & rehabilitation of excavation waste landslide site.	Potential innovation pilot for re-using excavation waste	Potential for excavation waste re-use and conversion to recreational facility? *Responsible MDDI & EcoInnovation Cluster.*
Construction	Ernst & Young constructing new building in Kirchberg. Lighting, some interiors and facilities management contracts might still have room for innovation.	Potential quick win for CE savings on interiors	*Responsible; Luxinnovation contacts E&Y?*
Agriculture & Water	New pesticide testing rehabilitation resulting from agricultural pesticide spills.	Use as a platform for initiating a circular water management pilot including recovery of nutrients from water.	See Chapters on agriculture (10.1) & water quality (10.9) *Responsible Ministry of Agriculture & MDDI.*
Tax	VAT for data centres starts to go down 2015.	Potential CE models to maintain Luxembourg position as preferred location for data centres. Connection to reverse logistics zones?	Use Luxembourg's confidentiality reputation as leverage for privacy on sharing websites for circularity. *Responsible ICT Cluster.*
Finance	CE EcoInnovation Cluster/KPMG workshop for finance sector October 2014 & symposium planned March 2015.	Educating and achieving buy-in from the financial sector.	A range of questions & mechanisms was identified at an October 2014 workshop. Follow-up is underway to be tracked. *Responsible EcoInnovation Cluster.*
Logistics	Earlier study on future of Luxembourg logistics?	Logistics S.W.O.T	Important for reverse logistics. *Responsible Logistics Cluster?*
Logistics	Container transfer tax-free terminal open July 2014	Potential for integrating reverse logistics	Evaluate potential for reverse logistics. *Responsible Logistic Cluster?*

SECTOR	ACTIVITY	RELEVANCE TO THE CIRCULAR ECONOMY	POTENTIAL ACTIONS, RESPONSIBILITY
Materials R&D	*IntermatGR.* Materials R&D consortium established under the EU Interreg programme and scheduled for completion in 2015.	Potential basis for circular materials R&D across the Greater Region. Pivotal platform for co-operation between Luxembourg and the Greater Region.	Align results with R&D on circular materials and use the network as a platform for scaling up R&D for circular materials. *Responsible Luxinnovation.*
R&D	Environmental R&D Incentives laws & regulations by Jan 1/15.	Potential to positively guide incentives.	Draft principles for the laws & regulations are provided in the present study. Verify if and how those will be included, and how they might be applied for other legislation & regulation. *Responsible ?*
R&D	Luxembourg Institute of Science and Technology (LIST) Created 2015.	Potential for coordinating circularity R&D	Consider as coordinating mechanism for R&D on circularity. *Responsible Luxembourg Institute of Science and Technology (LIST)*
R&D	Environmental R&D Incentives laws & regulations by Jan 1/15.	Potential to positively guide incentives.	Draft principles for the laws & regulations were provided as part of the present study. Verify if and how those were included, and how they might be applied for other legislation & regulation. *Responsible Minister of the Economy*.
R&D **Materials**	Composites survey for potential sub-cluster in materials cluster August/September 2014?	Focus for R&D.	*Responsible. Materials Cluster ?*
R&D	National fund on research has been advised to rewrite the Luxembourg smart specialization report.	Potential contribution based on CE	Consider the present study when doing the rewrite. *Responsible ?*
Materials R&D	Biomaterials Roadmap 1st draft due in early 2015	Scale-up potential but where to focus?	See biomaterials section of R&D and Objectives & Roadmap. *Responsible LIST ?*

SECTOR	ACTIVITY	RELEVANCE TO THE CIRCULAR ECONOMY	POTENTIAL ACTIONS, RESPONSIBILITY
Greater Region Statistics Research	Luxembourg Greater Region EcoInnovation coordinating group started 2014	Gathering hard-to-find statistics Later implementation of recommendations	Continue acquiring answers to inventory questions provided by EPEA to the group July 14/14 to assemble a more complete picture of material flows in the Greater Region. *Responsible EcoInnovation Cluster.*
Recycling	Towards cradle to cradle waste management A case study of Ecoparc Windhof September 2014	Excellent data on volumes, costs and types of waste collected in Luxembourg	Use as case study for waste management and paper recycling savings in business parks. *Responsible Luxinnovation ?*
Chemicals	July 2014 HFC study by Environmental Investigation Agency	Closed loop systems to replace climate change gases	Replacement of HFC's in Luxembourg. *Responsible; MDDI?*
Energy	IEA 5 year updates on energy July 16/14	Statistics on Energy for Luxembourg	Use the study to evaluate how Luxembourg might solve its leading materials leakage; fuel. *Responsible; Energy Dept. of Ministry of the Economy*
Circularity - Specialised Organisations	Luxembourg Centre for the Circular Economy LCCE	New private sector organisation in Luxembourg for circularity	Ministry of the Economy to consider LCCE potential role for interfacing with the circularity organisations outside Luxembourg?

2.2. Terms Of Reference & Study Approach In Brief

At a December 11, 2014 Cluster Forum, the dynamic achievements of Luxembourg's Innovation Clusters were presented, and in describing those the Secretary of State for the Economy as well as Cluster Presidents and Managers made one thing abundantly clear; it is a priority for Luxembourg to use knowledge, innovation, and know-how to diversify its economy.

In that context it is no accident that the Ministry of the Economy requested the present study to focus on how to use materials in the circular economy to diversify Luxembourg's economy so it is more resilient and balanced in comparison to the financial industry.

The mandate of this study has been to perform an initial scan of existing circular economy practices in Luxembourg and to identify further opportunities to accelerate the transition towards a circular economy.

In the context of wide-ranging terms of reference described in Annex A, the Study Steering Committee guided the study authors to focus on *present and potential roles of circular materials relating to employment, competitiveness, cost savings and reducing environmental impacts*.

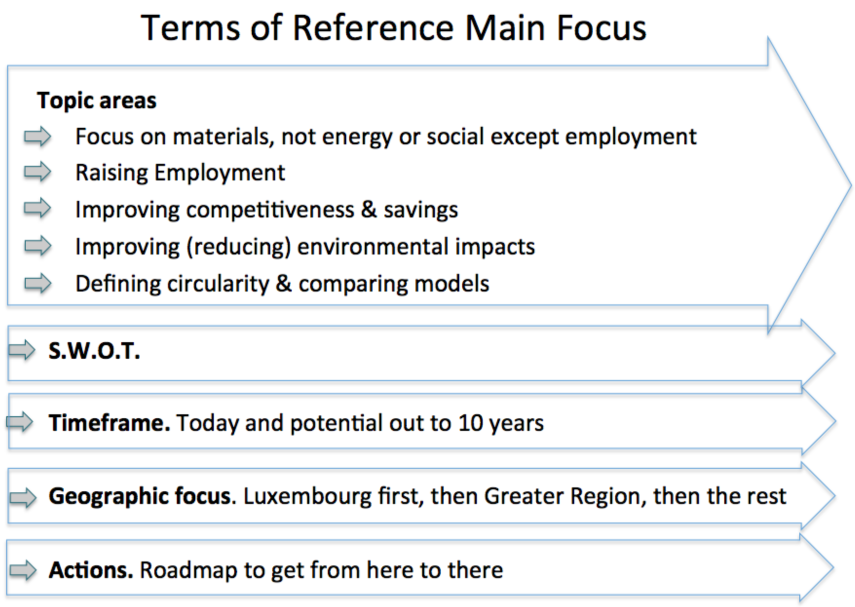


Figure 2.1: Terms of reference main focus.

As the field has not been surveyed before for Luxembourg and systematic data on this topic is scarce, the study results were compiled by conducting 45+ interviews with stakeholders covering most sectors of the economy, different functions and comprising public and private sector stakeholders. In addition more than 150 reports on Circular Economy related topics or Luxembourg specific industry and economic reports were reviewed.

The derived rough estimates on economic potential and job creation opportunity are based on indicative assumptions on future potential and aim to size the economic potential at an order of magnitude level. As a basis to explore the feasibility of the underlying business models a list with more than 100 case examples of existing products certified for circularity cycles as well as 15 examples of circular economy systems has been compiled in Annex B. As well the study drew from a wide-ranging group of studies selected from the Bibliography of Bibliographies shown in Annex C.

3. THE CIRCULAR ECONOMY & COMPARING THE MODELS

Overview

- On a descending scale and although definitions of the following terms vary, the circular economy occurs at the level of;
  - Systems & services ranging from taxation to logistics, buildings, agricultural topsoils and emissions re-use,
  - Processes ranging from manufacturing to biodigestion and deconstruction,
  - Products and components ranging from automobiles and paper clips to circuit boards and connectors,
  - Materials ranging from composites to wool,
  - Additives, chemicals and elements ranging from gallium to chlorophyll.
- In Luxembourg examples of circularity are found at each of those levels.
- *Quality* and *positive impacts* are the main value propositions that distinguish the circular economy from traditional sustainable regulatory approaches of *reducing negative impacts*. Business likes the new approach.
- Luxembourg is superbly positioned to benefit from those positive impacts due to its tradition of quality, and its diversified economy connected to most parts of the circularity cycle. The circular economy offers Luxembourg the potential for further diversification.
- The term *circular economy* is not new. It was used in 1955 in a similar way to how it is used today. However, because about 28,000 scholarly publications use the term, arriving at a common definition is a challenge.
  - The term is not new but many specialist organizations are. Among the 9 Benelux organisations focusing on circularity, all except 1 were created in the past 5 years. There is no quality assurance group for circularity. Luxembourg has an opportunity to fill that gap.
- Circularity and Materials
  - The circular economy is often not circular. Instead, its main principle is; *Everything is a resource for something else.* Businesses that focus on designing products and materials as resources are doing well.

- The focus of many CE activities is on bulk materials like plastics, glass, and commodity metals, but most of the materials on the EU Critical Raw Materials list are additives. Materials and products rely on those additives to be functional. For circularity, a sharp focus on designing additives for safe use & re-use is paramount. Luxembourg with The Greater Region has the competencies to do it.
- Materials in the circular economy are defined by their use, not by their source. The principle of defined use opens new potential for business.

- Managing complexity
  - The main challenge in describing the CE is being clear without being simplistic. The basic concept is easy but implementation is complex because it involves integrating science with economics.
  - At the risk of seeming too simplistic, the following diagram Figure 3.1 describes the overall intentions of circularity;

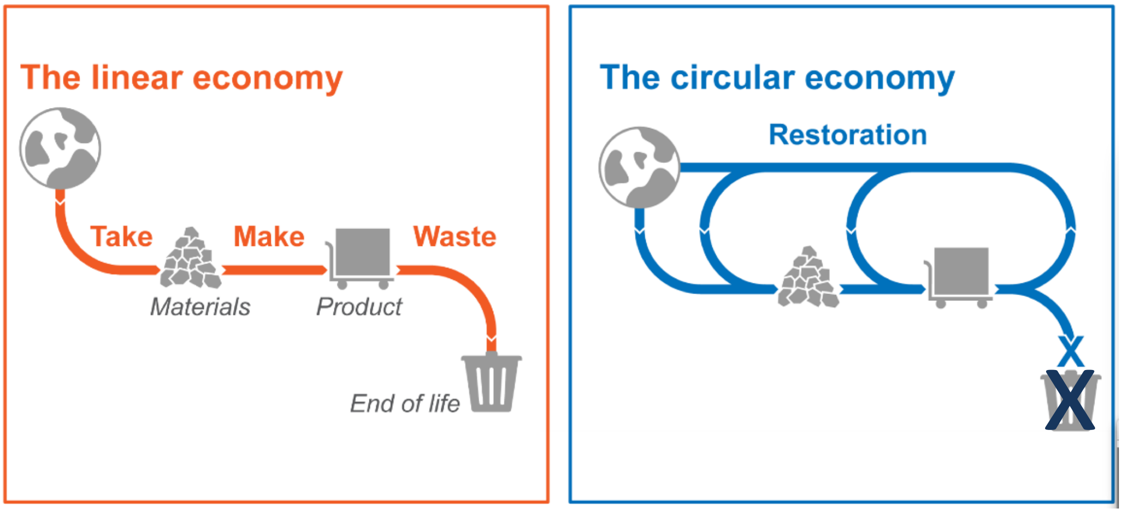


Figure 3.1: Linear and circular economy. Source Desso

However, at the scientific and economic level things become more complex. The challenge is to describe that complexity in a clear way without being overly simplistic. The following illustration Figure 3.2 describes the significant materials flows for the circular economy.

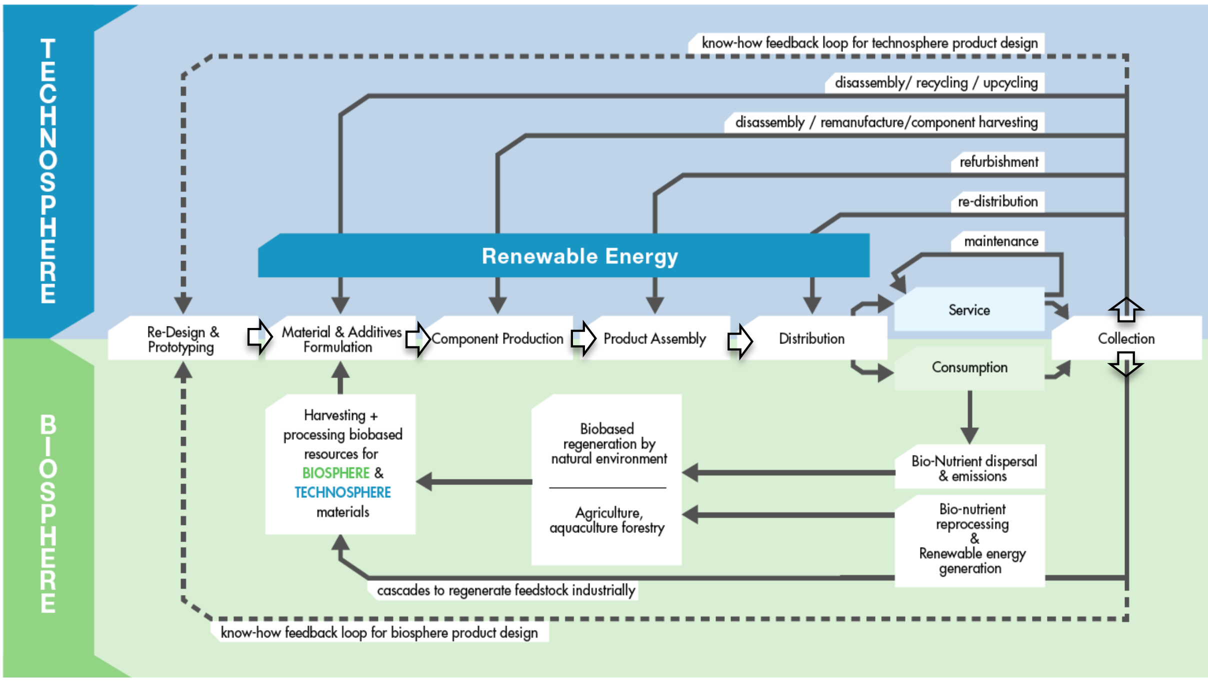


Figure 3.2: Circular economy material flows powered by Cradle to Cradle. Source C2CBizz Guide to C2C-Inspired Business Sites. Diagram EPEA & Returnity Partners.

3.1. Context For Circularity

EU and EC approaches to the circular economy

On December 16, 2014, the President and Vice-President of the European Commission announced the EC was withdrawing its Circular Economy legislative package and re-tabling it in 2015. The new development represents an unexpected opportunity for Luxembourg to co-develop a positively defined approach to the circular economy in preparation for its EU Presidency.

On its Environment website, the European Commission describes the circular economy package. However, given the withdrawl of the following described package by the EC, the following information is only a baseline for further preparation by Luxembourg rather than a framework for action;

> As a basis for Luxembourg to prepare actions on the circular economy, the EU and EC communications and studies as well as new political developments are reviewed here briefly;

- The published EC interpretation of the circular economy on its website is still anchored in the environment Directorate General rather than in the economic and financial affairs DG. As a result, the CE initiative comes from the environmental perspective despite significant emphasis on economic incentives, and despite significant support for CE approaches in the business community.
- The potential for using the circular economy to generate *Positive Impacts* is described in an August 2014 EC Scoping Study of the circular economy. See chapter 3.2.2 of the present study.
- *However, those positive impacts are not emphasized as much in the EU communication on the circular economy*. For example the term 'positive impact' is used only once in the framework publication.

A review of circular economy literature and practice suggests that the potential for generating and capturing value through positive impacts offers wider benefits for Luxembourg than just reducing waste. The potential for positive impacts is explored here, in the context of new developments at the EU, and the wider recommendations of the EC Scoping study.

The circular economy package (package withdrawn Dec 16, 2014)

The European Commission adopted the Communication "Towards a circular economy: a zero waste programme for Europe" and annex to establish a common and coherent EU framework to promote the circular economy. Turning Europe into a more circular economy means:

- *boosting recycling and preventing the loss of valuable materials;*
- *creating jobs and economic growth;*
- *showing how new business models, eco-design and industrial symbiosis can move us towards zero-waste;*
- *reducing greenhouse emissions and environmental impacts.*

As part of the circular economy package, the Commission also adopted a legislative proposal to review recycling and other waste-related targets in the EU and annex. Achieving the new waste targets would create 180 000 new jobs, while making Europe more competitive and reducing demand for costly scarce resources. The proposal aims to:

- *Increase recycling/re-use of municipal waste to 70% in 2030;*

- *Increase packaging waste recycling/re-use to 80% in 2030 with material-specific targets set to gradually increase between 2020 and 2030 (to reach 90 % for paper by 2025 and 60% for plastics, 80% for wood, 90% of ferrous metal, aluminium and glass by the end of 2030);*

- *Phase out landfilling by 2025 for recyclable (including plastics, paper, metals, glass and bio-waste) waste in non hazardous waste landfills – corresponding to a maximum landfilling rate of 25%;*

- *Reduce food waste generation by 30% by 2025;*

- *Introduce an early warning system to anticipate and avoid possible compliance difficulties;*

- *Ensure full traceability of hazardous waste;*

- *Increase the cost-effectiveness of Extended Producer Responsibility schemes by defining minimum conditions;*

- *Simplify the reporting obligations and lighten obligations affecting SMEs;*

- *Harmonise and streamline the calculation of the targets and improve the reliability of key statistics;*

- *Improve the overall coherence by aligning definitions and removing obsolete legal requirements.*

(Source http://ec.europa.eu/environment/circular-economy/)

The term 'circular economy' has diverse interpretations

The term 'circular economy' is published in scholarly literature since the 1950s to describe e.g. nutrient recycling for integrated agriculture and aquaculture in China. In Germany the term 'Circular Economy' or 'Kreislaufwirtschaft' is used in waste legislation since the 1990s, so it has a different meaning in Europe's largest economy than the term popularized by e.g. the World Economic Forum.

About 28,000 scholarly publications use the term circular economy. At least 15 eco-economic terms with the term 'economy' in their title compete with ‘circular economy’, and more than 800 certifications and green labels compete with products certified for circularity cycles (Source MBDC).

Those examples show why the term ‘Circular Economy’ is not consistently interpreted. The EC recently made efforts to define circularity, as described previously in this section. Luxembourg has much to gain from adapting rather than only adopting the EU definitions as described at the beginning of this chapter and in Figure 3.7, to reflect the state-of-the-science described here.

3.1.1. Where circularity and sustainability meet

There is some uncertainty in the marketplace about the connection between the CE and sustainability, and Table 3.1 shows why. The following citations of competing terms are found in the literature; (in alphabetical order)

Table 3.1: Mentions of types of eco-economies in published scholarly literature (Accessed 12.11.2014)

Popular term	~Mentions in the scholarly literature (Source Google Scholar)
Bio-based economy	1.700
Blue economy	1.100
Carbon economy Carbon-neutral economy, Carbon-based economy	~34.200 244 394
Circular economy	~28.000
Closed Loop economy	350
CO_2 economy	85
Eco-economy	4.300
Green economy	~21.000
Passive economy	46
Performance economy	2.250

Popular term	~Mentions in the scholarly literature (Source Google Scholar)
Sustainable economy	~16.500
Sustainable development	~1.400.000
Zero Emissions economy	54

The question arising from those diverse systems is; what are the differences and similarities between those and the circular economy?

The question is a PhD thesis on its own.

Economics experts say the distinction is simple; the CE is the economic part. However other organisations like Circle Economy define the CE more broadly to include social responsibility and other factors, which go beyond economy (Source Circle Economy http://www.circle-economy.com/circular-economy/). As well, the EC description cited previously in this chapter leans more towards an environmental impacts reduction emphasis than just economy.

In that context and because there is no internationally accepted standard framework for sustainability or green or circular economy, the present study took the approach of describing 'the state of the trend' based on a review of the literature as well as EPEA own background experience in the field.

The trend seems to be as follows;

- In recent years a diagram commonly used to describe the Ecology, Equity, Economy triad of sustainability is the fractal triangle fig. 3.3. The Circular Economy is often described a falling into the lower right fractals, with ecology and social equity having less emphasis.
- As the CE evolves, there are signs it is moving closer to the centre of the sustainability core. The question from this is whether in a few years there will be any distinction between sustainability, circularity and the green economy? One possibility is the differences will be indistinguishable as circularity is adapted to be more generic. However this is only speculation. In the end, public perception will dictate.

For the present study the interpretation used relies on the perspective that the circular economy is primarily an economic framework aiming to structure opportunities from reusing and returning ingredients, materials, components and products into continued cycles of use. By doing this typically a positive impact will be expected e.g. via healthier products, increased renewable energy use coupled with reduced energy consumption through preserving embedded energy and by stimulating employment and hence social benefits.

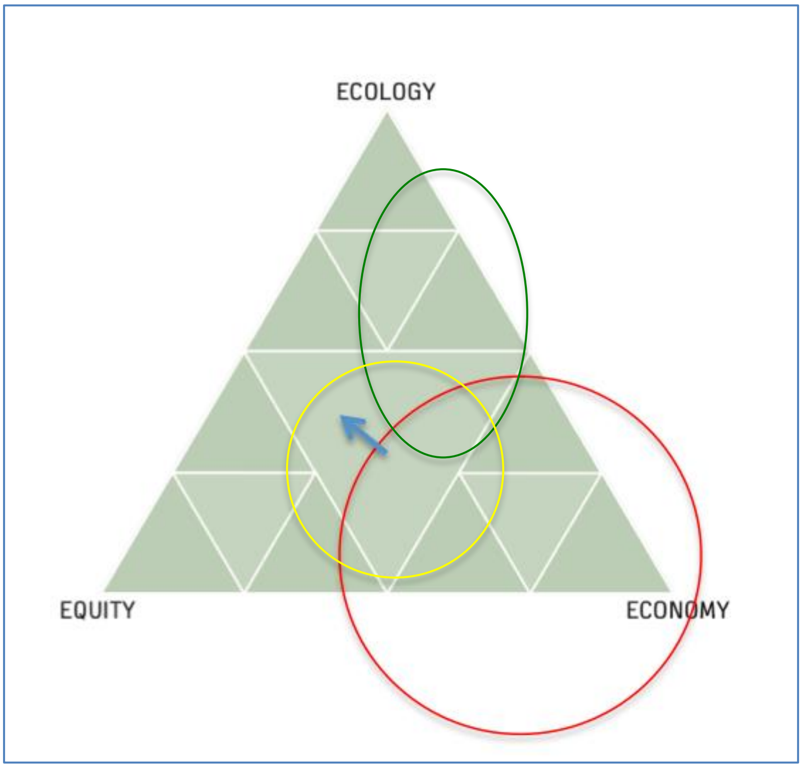


Figure 3.3: Diverse interpretations of the CE in relation to fractal diagram used often for describing sustainability. Fractal Source Braungart & McDonough

Red circle shows the generally interpreted position of Circular Economy presently by diverse companies and CE organisations, with arrow indicating trending direction. The EU interpretation, denoted by the green oval, tends more towards the ecology quadrant due to emphasis on waste. The EC scoping study interpretation which tends to be more holistic than the official EC and EU interpretations, is described by the yellow circle. As well, more than a few publications e.g. Product Life Institute emphasize the importance of using the CE to support new labour-intensive models which lean more to the social equity quadrant.

3.1.2. Practical significance for Luxembourg of circularity compared to sustainability

Technical significance

The present study is not primarily concerned with those differences or similarities because the terms of reference are specific; focus on materials and their impacts on competitiveness & jobs, cost savings and reducing environmental impacts. In effect, the terms of reference supported by guidance from the study Steering Committee defined circularity boundaries for the study compared to the wider boundaries of sustainability.

Political significance

However at another level, circularity has taken on political tones relevant for Luxembourg. The effect of the circularity wave resonating globally has been to breathe new life into sustainability through a positive agenda, at a time when climate talks are deadlocked and emerging and developed economies don't seem to agree on how to reduce their footprints. Circularity is a meeting place for government, business and NGOs to look at old problems in new ways. It represents a new impetus to tackle old problems, but with a positive outlook, which might regenerate political will for progress. For example, Luxembourg might seize the opportunity of its EC Presidency to align with the government of The Netherlands on the following Presidency, where The Netherlands plans to focus on being a Circularity Hotspot.

Tactical significance

Luxembourg has one of the highest collection rates for packaging in the EU and has important circularity enabling methods. However, no CE studies are published with the terms 'Circular Economy' and 'Luxembourg' in the title.

For example, the leading EC scoping study on circularity was published in Luxembourg but contains no mention of Luxembourg in relation to circularity.

> The lack of reference to Luxembourg in the literature might be an advantage because it allows Luxembourg to chart its own course and learn lessons from other examples, studies and regions.

3.1.3. Who is defining circular economy?

There are expanding numbers of for-profit and non-profit organisations with the terms 'Circle Economy' or 'Circular Economy' in their title in various languages, as well as organisations with other names who say they are focused on circularity. See Table 3.2 for an overview. As well many consultancies and organisations are re-positioning themselves as circularity experts. Regardless of their status as for-profit, non-profit, or cooperative many organisations offer overlapping and competing advisory and consulting services where they co-operate with and compete against each other at the same time. Those organizations each have their own circularity interpretations; some are similar and others are substantively different.

Table 3.2: Examples of circular economy-focused organisations.

Name & Location & approx. date of founding	Legal status	Offers consulting or advisory services in return for membership or other fees
Organisations in the Benelux		
C2C Center Venlo, The Netherlands, 2010 http://www.c2c-centre.com/	Non-Profit/quasi governmental	No
C2C Expolab Venlo, The Netherlands, 2009 http://www.c2cexpolab.eu/en/	Quasi-governmental	Yes
Circle Economy Amsterdam The Netherlands, 2009? http://www.circle-economy.com/	Co-operative	Yes
Circularity Center Rotterdam The Netherlands, 2014 http://www.circularitycenter.com/	Unclear	Unclear
De Groene Zaak, Netherlands, 2010? http://degroenezaak.com/	Non profit	Yes
EPEA Nederland 2010 www.epea.nl	Private	Yes
Implementation Center for Circular Economy Brussels 2014 http://becircular.eu/	Non-Profit	Unclear
Luxembourg Center for Circular Economy, 2014 http://www.lcce.lu/	Private	Yes
Plan C Brussels, Belgium, date ? http://www.plan-c.eu/	Non-profit?	Unclear

Name & Location & approx. date of founding	Legal status	Offers consulting or advisory services in return for membership or other fees
Turntoo Amsterdam, The Netherlands, 2011? http://turntoo.com/en/	Private	Yes
The list does not include companies who are transiting from recycling to circularity like e.g. I-Collect.		
Organisations outside the Benelux		
Cradle to Cradle Product Innovation Institute, San Francisco U.S.A. 2009? http://www.c2ccertified.org/	Non-Profit	Yes
Cradle to Cradle Verein Hamburg Germany, 2013	Non-profit	No
Economie Circulaire Paris France 2013? http://www.institut-economie-circulaire.fr/	Non Profit?	Yes
Ellen MacArthur Foundation U.K. 2010 http://www.ellenmacarthurfoundation.org/	Non-profit	Yes
EPEA Internationale Umweltforschung Hamburg Germany 1987 www.epea.com affiliated organisations by same name in various countries	For profit	Yes
Guiyang Circular Economy office Guiyang China, 2013	Governmental	No
MBDC, Virginia U.S.A. 1995?	For profit	Yes
Product Life Institute Geneva Switzerland, 1982 http://www.product-life.org/	Not for profit	Yes
Vugge til Vugge Denmark, Copenhagen Denmark, 2010? http://www.vuggetilvugge.dk/	For profit	Yes
Circularity Networks The range of circularity networks, alliances and joint projects popping up is yet another study and includes for example; Green Deal, C2CBizz, MyCircularFuture, Rohstoff Allianz and many others		

Depictions of the CE by those organisations are important, but too extensive to cover in the main body of the present study. However, some of the leading illustrations of their ideas are summarized in Annex D.

3.2. Definitions Of Circular Economy In The Literature

One of the first mentions of the term 'circular economy' describes circular systems of fish pond nutrient management in China. (Source *On the productivity of two experimental fishponds managed with traditional method of Chinese pisciculture*, Liu chien-kang - Acta Hydrobiologica Sinica, 1955). As of December 2014 about 28,000+ scholarly publications contained 'circular economy' in their text. However compared to 1,370,000 scholarly publications containing "sustainable development', there is some way to go in order for CE to take the lead.

Considering the terms of reference of the present study, here are a few examples of circular economy publications most relevant for Luxembourg due to scope, timeliness and quality;

- April 2014 the European Commission published; *Scoping study to identify potential circular economy actions, priority sectors, material flows & value chains.* (abbr. in the present study as EC scoping study). The study covers topic areas, which intersect with the present study, including reviewing circular economy definitions, barriers, drivers, impacts, value chains, material flows, sectors/ products, and case examples.
- March 2014, the The All-Party Parliamentary Sustainable Resource Group of the U.K. published *Remanufacturing: Towards a Resource Efficient Economy*, with recommendations important to Luxembourg's primary manufacturing as well as automotive and other value-added manufacturing sectors.
- January 2014 the World Economic Forum published together with the Ellen MacArthur Foundation *Towards the Circular Economy,* based on earlier studies commissioned by the Ellen MacArthur Foundation in 2012 and 2013. The publication signalled that the business community is recognising resource productivity to be just as important as energy security.
- 2013 the Netherlands Technical agency TNO published *Opportunities for a circular economy in the Netherlands,* including estimates of the potential for added value capture from e.g. appliances.
- 2011 the U.K. based Green Alliance published *Reinventing the wheel. A circular economy for resource security,* which describes the similarities between circular economy as a new catch-all definition and the green economy and sustainable economy which preceded it.

It would be counter-productive for the present study to repeat inventories already done in those studies. Instead of replicating bibliographies done for other studies, the present study provides readers with a *Bibliography of Bibliographies* (Annex C) as well as a Bibliography (Annex N) with relevance for Luxembourg. This approach leaves room here to focus on relevance for

Luxembourg, and identify missing elements or differences of interpretations from earlier studies.

Finding a universally accepted definition is as challenging as for ‘sustainability’ ‘green economy’ ‘blue economy’ ‘performance economy’ or others. For example some companies claim reprocessing nuclear waste is part of the circular economy (EDF conference 2014) whereas most CE advocates claim it is the opposite, and debates over greenwashing are frequent. However, if one goes back to the roots of circularity, there are some answers.

3.2.1. The cradle to cradle design protocol

The EC scoping study definition leaves no doubt that one of the pillars of the circular economy is the Cradle to Cradle (C2C) paradigm. The C2C methodology is open source, and is extensively described in the 2014 EU-sponsored *Guide to Cradle to Cradle-Inspired Business Sites*. The C2C Technosphere and Biosphere Cycles are cited by the EC and most other leading publications on the circular economy, including by the Ellen MacArthur Foundation and the World Economic Forum. C2C certification is governed by a non-profit institute, the Cradle to Cradle Product Innovation Institute, which is independent from the founders of the C2C methodology.

Today C2C is used in the designs of more than a thousand products as well as in hundreds of structures and systems. About 8,800 scholarly publications, mention the term ‘Cradle to Cradle’. The award-winning methodology is based on a background of published scientific investigations resulting from independent research and marketplace applications with companies across the industrial spectrum, which began in the 1990s. For more information see Annex E as well as the *C2CBizz Guide to C2C-Inspired Business Sites* (http://www.c2cbizz.com/tools/.html).

In brief, the relevance of C2C for the circular economy is as follows;

Positive impacts

C2C focuses on positive impacts rather than reducing negative impacts. The distinction from, and connection with, reducing negative impacts is depicted in Fig 3.4.

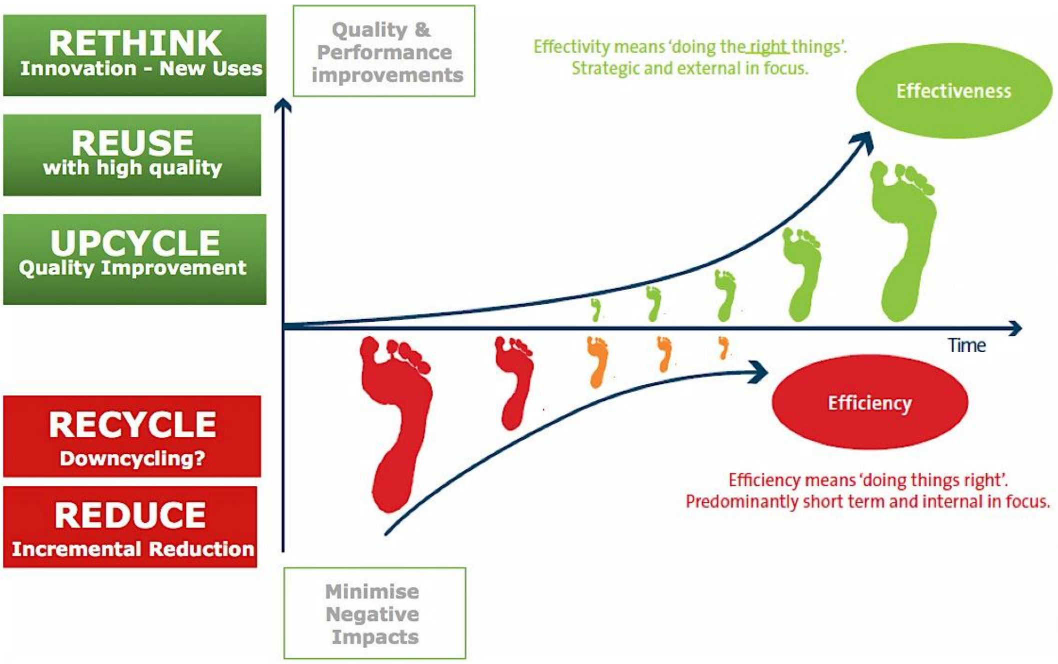


Figure 3.4: The road from less negative to more positive. Source EPEA.

For example;

- Instead of only banning certain negative chemicals, C2C focuses on positive lists of chemicals compatible with biological and technical cycles. Positive lists are being integrated into EU initiatives and recognized in legislation.
- According to most regulatory regimes a 'sustainable' floor covering is primarily one that minimises resource use and emissions. However a C2C floor covering maximises resource re-use and actively cleans the air. Positive impacts are a value-added feature.

Technosphere and Biosphere

- Materials in the circular economy are defined by their use, not by whether they are biological or non-biological. The use is defined by two types of cycle; the Technosphere and the Biosphere, see Fig 3.5.
- The Technosphere and Biosphere cycles of C2C as well as the principles governing them are the basis for circular economy materials flows. Those spheres are defined by scientific principles that have remained consistent since 1992 when they were published in the peer-reviewed Fresenius

Environmental Bulletin and in 1993 was awarded the Océ van der Grinten Prize for Economics.

- The “spheres” are central to the approach, especially for business, because these describe 3-dimensional cascades of materials rather than two dimensional closed loops. In that context, the diagram Fig. 3.5 is only a symbolic representation of a three-dimensional sphere.

Figure 3.5: Illustrative diagram of the C2C Biosphere & Technosphere cited as a basis for circularity. Source EPEA.

Principles

The Technosphere and Biosphere are governed by the following principles for C2C, which have remained constant for many years;

- Everything is a resource for something else.
- Use Current Solar Income, e.g. energy generated in the same era it is used.
- Celebrate Diversity; Conceptual, Social and Bio-diversity.

The present study focuses on the first principle, however that principle also strongly impacts materials for energy generation & use, and biodiversity.

Example of tools. Circular communities as service systems

C2C has many application tools and especially an extensive set of databases for positively defining materials. For Luxembourg among the most relevant tools are circular communities and services. Circular supplier communities link customers with suppliers in new ways to support innovation and economy of scale.

Circular communities are operating in the marketplace, some for ~15 years. These include paper supplier/customer loops, and services like chemicals leasing. See Annex B as well as Table 12.1 for examples.

- For example, the largest circular supplier community to date is the Carlsberg Circular Community involving customers & suppliers with combined revenues exceeding €30 billion (see Fig. 3.6). The community was announced in 2014 at the World Economic Forum in Davos, Switzerland with the aim of optimising packaging ingredients and packaging handling systems for paper, glass, cardboard, metal and plastics. It also extends into the retailing community, encompassing the packaging cycle from manufacturing through use, disposal and re-use.

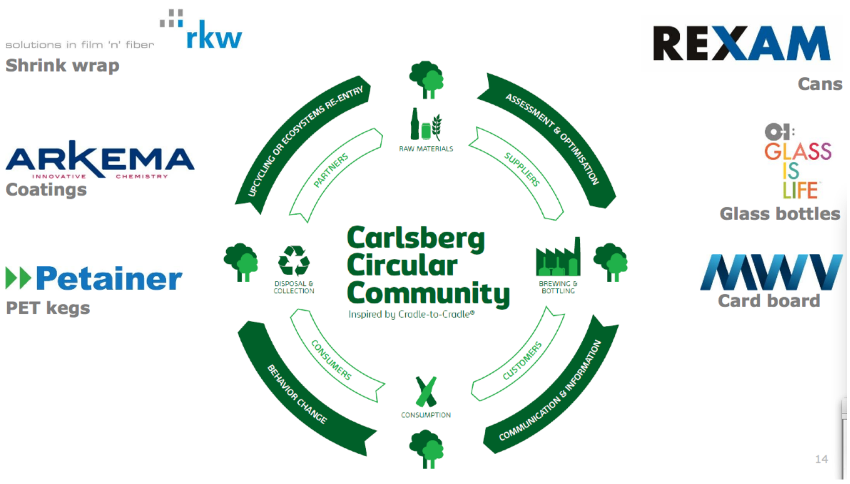


Figure 3.6: Illustration describes some Carlsberg circular community participants. Source Carlsberg

Transparency note: Carlsberg Circular Community is co-created by Carlsberg & EPEA.

3.2.2. EC and EU circularity definitions

The recently published EC scoping study condenses various circularity descriptions. See following excerpt in Figure 3.7.

2 Understanding the circular economy

2.1 A circular economy versus a linear economy

In contrast to a traditional 'take-make-use-dispose' linear economy, a circular economy represents a development strategy that enables economic growth while **optimising the consumption of natural resources**, deeply **transforming production chains and consumption patterns** and **re-designing industrial systems**. A circular economy is 'restorative or regenerative by intention and design' (Ellen MacArthur Foundation, 2012), considering the potential across entire value chains and cross-value chains, and closing 'resource loops' in all economic activities (Hislop & Hill, 2011). A circular economy goes beyond the pursuit of waste prevention and waste reduction to inspire **technological, organisational, and social innovation throughout the value chain** in order to 'design-out' (Ellen MacArthur Foundation, 2013) waste from the beginning, rather than relying solely on waste recycling at the end of the chain.

When applying circular economy concepts, resources in general can be distinguished into two categories:

1. **Technical materials** like minerals, metals, polymers, alloys and hydrocarbon derivatives (e.g. plastics), which are not biodegradable and are based on finite resources.
2. **Biological materials** from biological origin such as agricultural and forestry goods/commodities, bio-based wastes and residues, which are generally non-toxic and renewable to an extent as they are limited by the availability of land, water and nutrients and can be returned to the biosphere, where they act as nutrients.

2.2 Circular economy strategies

Circular economy strategies are schemes ensuring that upstream decisions in the value chain are coordinated with downstream activities and actors. They connect producers, distributors, consumers and recyclers, link incentives for each of these actors, with an equal distribution of costs and benefits. If circular economy aims to "design out" waste, it goes beyond the approach of waste prevention and waste reduction (Schulte, 2013). It aims to inspire innovation throughout the *whole* value chain, rather than relying solely on waste recycling at the end of value chains.

The studies which go the farthest in defining the circular economy concept (and not those which limit its definition to waste reduction and prevention) state that it is based on **two pillars**:

- **The 'cradle to cradle' principle** (McDonough & Braungart, 2002), which is twofold:
  - **Product design for durability, disassembly and refurbishment**: businesses should apply the principles of eco-design to all their products, i.e. use as little non-renewable resources, eliminate as many toxic elements and hazardous materials as possible, use renewable resources (at or below their rates of regeneration), increase the life and reuse potential of products, and facilitate, at the conception stage, the sorting and final recovery of products (IAU, 2013).
  - **"Modern circular and regenerative forms of consumption,** from anaerobic digestion of household waste to product recovery." Furthermore, models of consumption should change **from buyer to user**.
- **Industrial symbiosis :**
  - **A cross-sector approach and cooperation between actors** unaccustomed to cooperate (e.g. between product designers and recyclers), **along the whole supply chain of a product**, in order to optimise its life-cycle. It is the sharing of services (e.g., transport) (Ellen MacArthur Foundation, 2013), utility, and by-product resources among industries **in a territory**, creating synergies between businesses for economies of scale. The **spatial clustering** of collaborating companies is highly important as it makes the interconnecting of links in the supply chain and the exchange of residuals between links easier (TNO, 2013). However, in some cases exchanges are possible also at a geographical distance (e.g. implementation of the National Industrial Symbiosis Programme in the UK).

Figure 3.7: Excerpted description of the circular economy. Source EC scoping study pp. 3,6,7.

3.3. Science Meets Circularity

3.3.1. The circular economy is usually not circular

Business cases ranging from floor coverings to steel demonstrate the circular economy is usually not circular. Instead, it is characterised by spheres, loops and cascades where *everything is a resource for something else,* rather than 'everything becomes the same thing again'.

The distinction is illustrated in Figure 3.8;

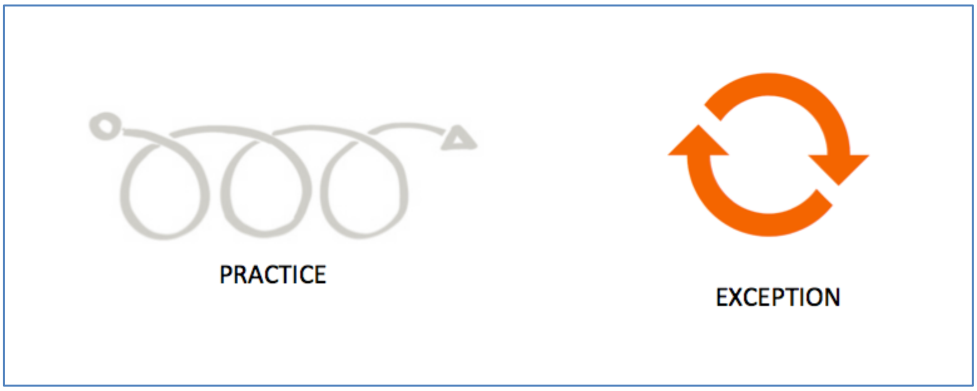


Figure 3.8: Continuous and closed loop flows. Source EPEA

In practice, as in nature, materials usually are part of spheres rather than going back to the same product in a closed loop.

For example,

- Thousands of ingredients that give materials their functionality are usually not kept in closed loops. Under circularity they are often designed to be safely combusted during recycling, released into the environment, or recovered for other processes & products. For more information on additives, see Science and Circularity under R&D Section.
- A 'circular' chair usually does not become a chair again. It might be repaired or refurbished to prolong its use, but eventually its materials are used for other products. As well, during repair and refurbishment materials are removed and used for other purposes.

There are exceptions where closed loops are used. For example;

- Climate change gases like CO_2 are increasingly used in closed loops for a range of Technosphere applications. Using chemicals in closed loops is a good example of eco-effective circular systems.
- Closed loops sometimes occur when companies want to protect valuable IP and take back products from customers in order to disassemble them and recover components for refurbishing products. However often the product is disassembled and parts de-materialized for use in other products.
- Glass bottles are reused up to 35 times. However, eventually within a few years they are remelted and become part of other glass-based products. A significant percentage of bottles break and are used for example as granulate for concrete.

In most of those cases, the integrity of materials is maintained, but those materials become part of diverse products whose materials transit through spheres and cascades.

In the end, most 'circular' materials go through continuous spheres rather than closed loops.

3.3.2. Continuous spheres and cascades are innovation platforms

For business, continuous loops, spheres and cascades provide opportunities.

- Based on a review of peer-reviewed studies e.g. Journal of Industrial Ecology and Harvard Case studies, the Biosphere and Technosphere cycles described in fig. 3.5 are innovation platforms. Those platforms give businesses the freedom to find diverse customers for their materials then organize reverse logistics in diverse ways. The practice is sometimes referred to as industrial symbiosis.
- Spheres and cascades let businesses improve rapidly obsolete products like Fast Moving Consumer Goods (FMCG). For example, personal computing devices are constantly changing in size and thickness, so why design them to last for 25 years?
- It is more practical to design component materials for easy disassembly and recovery of their materials, instead of forcing obsolete designs into a closed loop. The approach sometimes contradicts the traditional approach to 'durability', but supports one of the basic mechanisms of circularity; designing products and materials for their practical use, taking into account the speed of technology advances.

3.3.3. Circular materials are defined by their use, not whether they come from biological or non-biological sources.

In the circular economy, materials are defined by *how they are used and the cycle they are designed for.* The use of materials for circularity is <u>not</u> determined by whether those materials come from biological or non-biological sources, or if they are biodegradable.

For example;

- Biobased plastics can be designed for the Biosphere or Technosphere. For the Biosphere, they are designed to be consumed then degraded in the environment, while for the Technosphere bioplastics are designed to be used in multiple cycles before they are biodegraded.

However many studies on the circular economy describe 'biological materials' as only being used in the bio-cycle, and 'technical' materials as only used in the technical cycle. See Annex D from the EC scoping study and from the World Economic Forum as examples.

For example, sand fits the description of technical materials under the EC definition; 'not-biodegradable and based on finite resources'. However, sand is also a component of most soils so is part of the Biosphere. The EC scoping study reflects the confusion when it says;

> *The distinction between technical nutrients and biological nutrients, inspired by the literature, is not always clear…*

If the EC is confused, how to distinguish between materials suitable for the Biosphere or Technosphere? The solution is; designing for the intended use rather than the material source.

Materials cycles compared to sources

The definitions published by Braungart et al in 1992 focus on designing for cycles rather than sources.

The risk of not using the approach is; if designers are told they are only supposed to use biological materials for biological cycles, they risk missing one of the great innovation opportunities; using biobased materials for technical cycle products.

The opportunity for Luxembourg and the Greater Region is to apply the original definitions to designs for Technosphere and Biosphere cycles. In this way the innovation potential for materials will be accelerated.

3.3.4. Quality vs. quantity.

Circularity is first *qualitative* whereas regulatory sustainability is usually *quantitative*. In most regulatory regimes, sustainability focuses on reducing energy and materials or improving efficiency. By contrast, circularity focuses on high-quality use and re-use of materials.

Quality leads to economic success. For example, SDK collected data in 2008 documenting this effect, that maintaining high quality can significantly improve end-of-use value of materials and resources.

To achieve it, scientific protocols were developed to evaluate ingredients in products for their safe usability in Biosphere or Technosphere cycles. Performance by ingredients as positively defined resources is central for successful circularity economics.

3.3.5. Product design affects circular economics.

The impacts of product design on circularity economics and technologies are often under-stated, despite evidence that good design drives profitable recycling (Sources Vanderlande Industries, Steelcase, Hermann Miller & Desso and various studies in the Journal of Cleaner Production).

Redesigning materials makes them more economic for circularity. Product and materials design also prevents misallocated investments by avoiding expensive recycling technologies. For example;

- A flooring company like Desso that replaces its bitumen backing with a recyclable polyamide does not have to invest in outdated bitumen downcycling. Instead the investment goes into materials innovation. (Source Desso).
- A Steelcase chair that comes apart in 5 minutes is profitable to recycle. A competitor's chair that comes apart in 35 minutes is not. (Sources; Van Gansewinkel, HMS Import Agency, Steelcase).
- Plastic that is easily separable and re-polymerized is economical to reprocess. A plastic requiring expensive processes to separate and re-polymerize is uneconomic and requires a subsidized system of waste management (Source Tarkett).

> Current recycling systems are often expensive because they have to process products and materials not designed for recycling. As a result, taxpayer-funded subsidies such as gate fees are often required to subsidize bad designs.

Additives influence functionality and economics

About 10 - 15 polymers and 20 - 30 metals and inert elements dominate bulk products today. By comparison, thousands of additives & coatings are used to give those bulk materials functionality. Examples include smoothers, fillers, hardeners, plasticisers, fire-retardants and thousands of other substances used in products. Despite their central role, additives are mentioned only once in the EC scoping study, and are only occasionally mentioned in other CE studies described earlier. Additives are usually missing from circular diagrams. See Chapter 8.4 under R&D for more information on additives.

The distinction between circular assessment and traditional toxicity assessments is that circular assessments identify the *potential of ingredients to be positively defined*, rather than only evaluating negative toxicological impacts.

The following diagrams Figure 3.9 and 3.10 describe the positive potential of 5,000+ additives commonly used in materials that go into products.

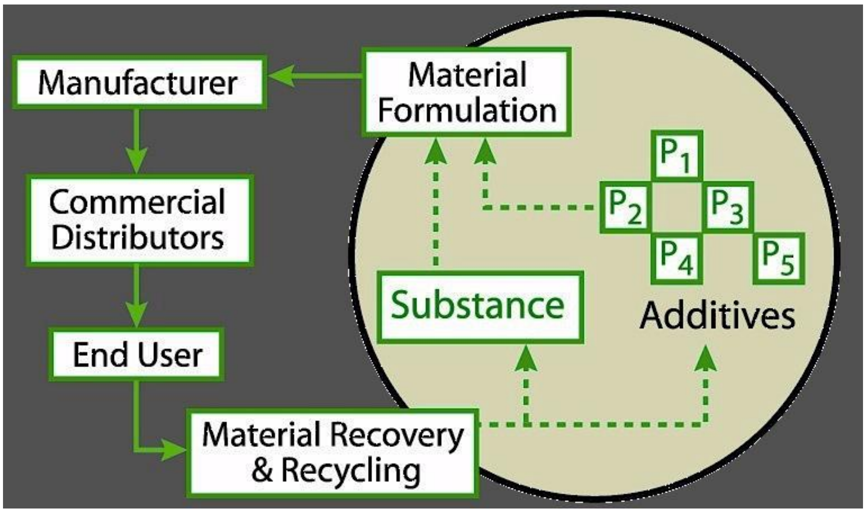


Figure 3.9: Technical materials cycle where additives determine functionality. Source EPEA.

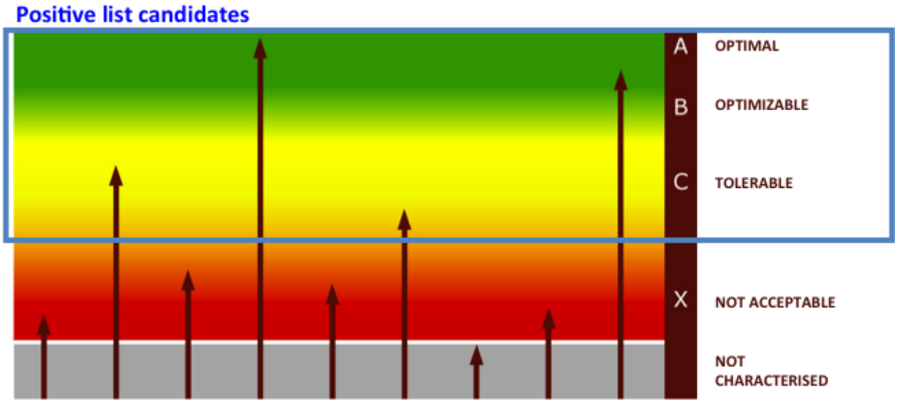


Figure 3.10: Illustration of assessing ingredients for positive potential. Source EPEA.

One of the biggest technical challenges facing the circular economy is to design additives to make them suitable for their intended use in biological or technical cycles. However the challenge is not described in most studies on circularity.

The opportunity for Luxembourg and the Greater Region is to recognise the challenge and use their considerable R&D capacities to be frontrunners in the field. This could mean initiating and orchestrating build-up of know-how, which is a valuable intangible asset for Luxembourg as the proposed Capital of Circular Economy Know-how

3.3.6. Bionutrients dispersed into the environment are significant economic resources

Emission or dispersal of materials into the environment is a major pathway for regeneration and occurs in the hundreds of billions of tones annually. Dispersal occurs for example when effluent enters rivers, tires wear off onto roads, or clothes wear out, or when materials are burned or off-gas. If materials are designed for their intended use, those emissions regenerate the environment. However, today many emissions are still harmful.

Nutrient emissions and dispersal are basic design considerations for products and play a major role in e.g. agricultural and ecosystem regeneration. However the role of nutrient dispersal is under-stated in many circular economy diagrams. Instead, most diagrams focus on collection and reprocessing of nutrients, which is only half of the story.

3.3.7. The role of the Technosphere in energy generation is greatly under-emphasized

The EC scoping study draws the following conclusion;

> *"…there is only limited focus on the management of energy. This is because most of the literature on circular economy focuses on technical and biological nutrients."*

According to a review of the literature, the statement is incorrect.

- A least 40 publications contain the terms "circular economy" and "energy" in the title, and approximately 14,000 publications contain the terms "circular economy" and "energy" in their texts. (Source Google Scholar)
- The EC scoping study overlooks that everything used to generate energy including fuel, turbines, dams, solar panels and windmills is made of materials. Those materials are part of the Technosphere and Biosphere cycles.
- The second Principle of cradle to cradle is; *Use current solar income i.e.* energy derived from currently renewable sources.

Bloomberg Energy, as described previously, reports the potential commercial opportunity from renewable energy is 8 trillion USD. Materials are essential for activating those opportunities. In those ways, energy is a core component of the circular economy.

3.4. Qualified Definition Of Circular Economy

Which definition is most relevant for Luxembourg and the present study? Factors to consider;

- The European Union definition described earlier from the EC scoping study, because Luxembourg follows EU norms. However, the EU definition is presently being rewritten.
- Scientific factors affecting the definition as described earlier in this chapter and further under 'Science meets Circularity', and 'Science and Circularity' in Chapter 8 Research and Development.

For those looking for a quick reply to the question "what is the circular economy?" here is a working definition, which condenses diverse definitions and reflects the boundaries of the present study;

Circular Economy

The restorative use of materials and products in renewably powered cycles where everything is a resource for something else, generating positive economic, social and ecological impacts through improved quality and resource productivity.

Visually depicting CE materials flows from present to future

Because CE materials flows are three dimensional as described previously, it is problematic to illustrate them in two dimensions. As well, there is the challenge of depicting existing linear materials flows in relation to circular materials flows.

Accounting for earlier diagrams as well as for the limitations of two dimensions, the present and future materials flows in the circular economy are represented in the enclosed diagram Figure 3.11. The red boxes illustrate linear flows, which the circular economy aims to displace.

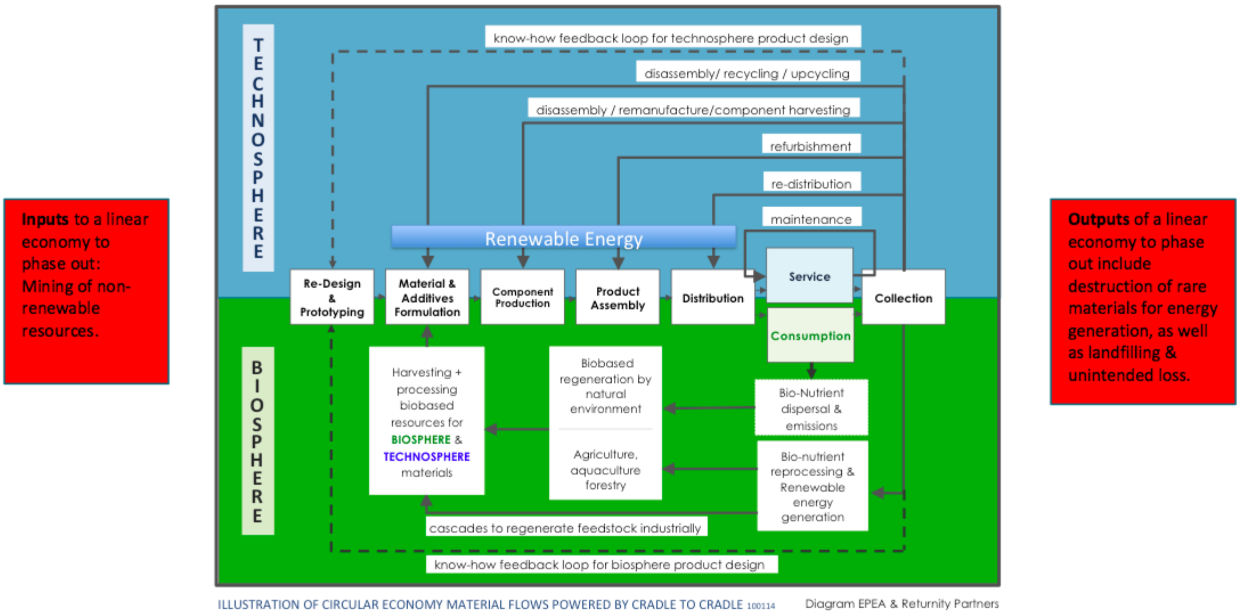


Figure 3.11: Materials flows in the circular economy. Source EPEA & Returnity Partners

The diagram includes the following features, which are significant for Luxembourg but under-represented in many circularity diagrams;

- *Designing and prototyping* materials and products is fundamental for the economic performance of circularity systems. Designing and prototyping are significant strengths of Luxembourg companies, especially R&D divisions.
- Designing and prototyping is improved with know-how from the back-end to optimise circularity at the front end. Luxembourg companies at the back-end like SDK have the know-how to support designers and prototypers.
- *Additives, coatings and trace ingredients* play a defining role in determining the functionality of materials and products. Companies like Tarkett are pioneering new approaches to healthier additives and coatings.
- *Bio-based resources are* utilized to manufacture materials for the Biosphere and Technosphere, rather than only for the Biosphere. The Technosphere opens new markets for Luxembourg biobased materials R&D. *Dispersion of bionutrients* into the environment is part of it. Designing for dispersion is a competitive advantage. Luxembourg's bio-based materials initiative will gain markets from designing materials in that way for the Biosphere.

- *Renewable energy* is generated by and used to manufacture Technosphere products. It is a tool for companies to capture some of the 8 Trillion USD projected from renewables shown in the finance and summary sections.

3.5. How Luxembourg Might Benefit From Earlier Circularity Studies

Earlier studies on the circular economy contain excellent information and data. Luxembourg has much to gain from its business, government and academic leaders reading those, especially sections relating to barriers and legislation. For this see Annex C Bibliography of Bibliographies.

> Materials know-how is a competitive advantage for reaping benefits from the circular economy, and Luxembourg has it.
>
> The perceived general lack of circularity know-how about materials globally underlines the potential for Luxembourg to fill the gap by leveraging its existing know-how as well as training scientists and managers for circularity. Luxembourg companies and CRPs have many talented chemical engineers and materials scientists who are excellent candidates for circularity scientific and technical leadership.

4. RAISING INDUSTRY COMPETITIVENESS AND JOB CREATION IN LUXEMBOURG TO STRENGTHEN ECONOMIC DIVERSITY

The Diversity Imperative

The circular economy is more than a potential model for Luxembourg; it is an economic imperative.

At a December 11, 2014 Cluster Forum, the dynamic achievements of Luxembourg's Innovation Clusters were presented, and in describing those the Secretary of State for the Economy as well as Cluster Presidents and Managers made one thing exceptionally clear; it is a priority for Luxembourg to diversify its economy. The circular economy was described as one way to support that diversification.

Context and Structure

The title of this chapter is extracted from the Cahier des Charges for the present study. The terms of reference of the study focus on the goals of raising industry competitiveness, reducing costs, reducing environmental impacts, and supporting job creation. The overall objective is to strengthen the Luxembourg economy by accelerating the transition towards a circular economy. The framework for those areas is material flows. The section here addresses each of those except environmental impacts, which are addressed in Chapter 5.

The discussion of these points is structured along the following sections

- Purpose and context of section
- Key takeaways
- Opportunity assessment and indicative, rough estimates of accelerating transition towards a circular economy;
  - Overall economic impact of reduced net-material cost savings
  - Job creation opportunities
  - Opportunities to raise industry competitiveness
- Synthesis of key thrusts to pursue in reference to selected sectors.

4.1. Purpose And Context For Estimates On Industry Competitiveness And Job Creation

The purpose of this section is to synthesize the findings of the study in terms of the overall economic potential for Luxembourg's economy stemming from improving overall industry competitiveness, supporting job creation and reducing costs by applying the circular economy at scale.

While a large set of emerging circular economy activities could be identified for Luxembourg, the overall, systematic and quantitative fact-base is sparse and highly fragmented. To this end the following discussion relies on strategic rationale, selected estimates and anecdotal bottom-up evidence as well as translating the qualitative assessment of the interviewed experts on the type and magnitude of the potential. All agree, Luxembourg has started to move on many fronts towards a circular economy, that the potential is likely to be significant and that selected (local) case examples both demonstrate feasibility and potential impact. Therefore the following section does not aim to propose concrete projections but to establish an order of magnitude, to inspire stakeholders to action.

4.2. Takeaways

- **Luxembourg enjoys a very favourable starting position** along all target dimensions as it has been displaying net employment growth, strong economic growth and a resilient competitive positioning.
- **Already a high share of jobs depends on circular business models:** The steel, aluminium, glass, and plastic products industries in Luxembourg offer a view to the future of Europe's materials-based industries; they are based often heavily on recovery and recycling of secondary raw materials and on customer/supplier relationships to support those activities. 7.000 to 15.000 jobs in Luxembourg are already based directly on circularity of resources.
- **Luxembourg's competitiveness** is already today based on critical expertise required to succeed in a circular economy at scale, as Luxembourg is home to a strong logistics, design, R&D, financial, high-tech manufacturing (esp. automotive, health care) and construction sector with a high awareness in some sectors on the value of re-using large material streams (i.e. steel, glass, aluminium). Further adoption of circular practices in Luxembourg and the Greater Region will likely further strengthen these core sectors.
- **Net material cost saving opportunities** from establishing more circular setups are estimated to be in excess of 300 mio EUR annually for the manufacturing intensive sectors (excluding construction) alone (and excluding imports).

- **Job re-classification to circularity might accelerate rapidly.** As circularity penetrates value streams from the front end and back end simultaneously, the number of jobs classified as 'circular' might rise by multiples due to synergies.
- **Further optimisation benefits.** Significant additional net-employment potential (of more than 2.000 new jobs by 2017) and competitiveness improvements are to be found by setting up, expanding and managing circular economy activities in Luxembourg and the Greater Region, where Luxembourg can play a catalysing role to increase the share of more circular activities (e.g. setting up *alliances with suppliers of secondary raw materials in the Greater Region).* There is significant potential for improving existing circularity practices in close co-operation with customer supplier communities in the Greater Region.
- **Further innovation benefits.** Big potential wins in jobs and competitiveness are to be found in innovative start-up industries with rapid scale-up potential, (e.g. additive manufacturing) but that scale-up depends as much on the subjective perception of stakeholders about future potential markets as it does on economic estimates. For this, the views reflected by the High Committee for Industry are central to understanding perceptions of priorities in Luxembourg.
- **Need to clarify definitions & data** emerges as a clear opportunity for Luxembourg to create the necessary oversight to steer, manage and control the rapid transition towards a circular economy at scale. There is no accepted definition for, or data about, a circular economy job. Definitions and data are required to establish a baseline & measure progress. Actions to achieve those are described in this study.
- **Integrating science and economics for designing CE models** The contents of primary materials have significant impacts on the quality, pricing and reprocessing costs of secondary raw materials. New regulations like REACH are bringing increased attention to the challenge of getting cleaner streams. In that context, and in order to improve competitiveness, it is a priority to integrate science with circularity economics.

4.3. Savings From Circularity

4.3.1. Opportunity assessment and indicative, rough estimates of accelerating transition towards a circular economy

Framework for economic impacts estimates

Type of estimate	Description	Data Extraction	Sources
EU-level extrapolation	• Apply mega trend methodology for Luxembourg with sector specific corrections	• Share of GDP for medium complex, medium timeframe products	• Input/Output Matrix • National statistics
Luxembourg area estimates	• Material leakage via current "waste" streams • Job creation opportunities and multiplier effects	• Current material leakage (e.g. exports, incineration, landfill • Calculation additional tasks x estimate on FTE (e.g. for sorting, services)	• Waste operator reports. Ecoparc study. • Interview waste operators, national export statistics, greater region interview • Interview with service operators, enablers (e.g. finance, logistics, education, design)
Case-specific arbitrage potential	• Material flow analysis with from-to description for priority cases • Describe scale-up of (existing) business cases for CE-enabling businesses	• Costs/value for major steps along CE flows • Description of values and volumes • Estimate of likely scale-up speed	• Interview with candidates • Statistical data from associations & Ecoparc • Detailed discussions with business, e.g.

Source Returnity Partners & EPEA

Figure 4.1: Framework for economic impacts estimates. Source Returnity Partners, EPEA

Methodology review

Considerable attention is paid in recent studies to calculating benefits from circular economy activities. The challenge with these studies is that very little data is consistently available to separate linear from circular activities (a topic discussed in more detail in Chapter 3 of the present study). To this end it is important to assess the potential from different angles.

In order to maximise the benefits of other methods and compensate for the lack of statistics on existing and potential jobs, competitiveness and cost savings, the present study considered the state of the trend and integrated the following approaches also as illustrated in Fig. 4.1;

- **Top down estimates of net-material cost savings:** analysis based on methods developed by e.g. McKinsey, Ellen MacArthur Foundation and the Dutch agency MVO employing detailed researched material savings potentials of signature products to input-output statistics for scale-up
- **Top down and bottom-up job creation estimate:** The local relevance analysis based on analysis of which jobs in which sectors seem to actually rely on circularity. Projecting likely growth in activities and share of circular activities yields job creation potential
- **Qualitative assessment of improved competitiveness:** Integrating strategic arguments on optimization and innovation benefits: The Steve Jobs approach used often at Apple, which was to encourage innovators to rely on personal perceptions instead of market surveys or statistics. Those perceptions were gathered here from 45+ interviews plus the experience of EPEA and Returnity Partners working on circularity in the marketplace for the past years (for more information on EPEA refer to Annex O).

Those methods were integrated to account for the following methodological issues identified in other studies;

Review of economic potential assessment and estimation studies for the circular economy

Moving from a linear to a circular economy requires a substantial effort to change well-entrenched linear lock-ins and to transform the modus operandi of well-established processes. This is true for individual companies but even more so for accelerating the transition at regional or national level.

For this reason the assessment of economic potential at macro scale is an important element to validate the size of the opportunity as a measuring stick for assessing how much effort and investment should or can be put into the transformation process. As a result a number of quantitative efforts have been conducted to estimate the potential at macro scale (e.g. Ellen MacArthur reports on accelerating the transition towards a circular economy; TNO study in the Netherlands).

These studies typically follow a three-step approach:

1. **Contrasting linear against circular setup:** In the first step a linear model is contrasted against a circular model by a conceptual definition of what is circular vs. linear. In most cases different reverse loops are differentiated (e.g. recycling & reuse) in order to account for different amounts of savings generated by going circular (i.e. avoiding upstream costs for virgin product manufacturing and distribution) as well as quantifying additional costs for the reverse loops (e.g. cost of collections and sorting). At this step it is important to identify the baseline of the linear situation, which frequently already exhibits circular elements (e.g. existing recycling rates) as well as defining the most representative assumed flows (e.g. recycling can be done locally in the case of e.g. steel in Luxembourg as well in some cases at global levels in the case of e.g. medical equipment, each exhibiting substantially different valorisation costs).

2. **Selective validation for specific products/components/flows:** The analysis is difficult to conduct at macro-level, because the current economic indicators group and aggregate activities are not at a sufficient level of detail (e.g. added value per activity), to allow isolating different flow-specific economics or drilling-down to individual product/component segmentation. As a result, most studies work directly with so-called signature products, which are sufficiently representative for a larger group of products or even sectors. For these selected signature products, costs are collected and frequently complemented with estimates as potentially new configurations will need to be evaluated, which cannot yet be observed in practice (e.g. in many cases not yet sufficiently large markets or material pools for remanufactured equipment components to allow for accurate costing of embedded process steps). The most significant difference in the quality of the studies lies in the level of detail and care placed into the individual costing of these reverse loops, which is frequently highly context and regional specific. In that context, transference of studies to specific situations elsewhere is a challenge.

3. **Scaling up of findings to macro-economic level**: The product-specific circular cost comparisons yield value creation opportunities stemming from material, energy, labour and capital costs savings and potential additional returns from re-valorisation. These savings are then added into the national or regional input-output statistics for the individual sectors to derive a rough estimate on overall economic potential. At this stage the question on scalability of these assumptions is a critical element of these estimates i.e. will this be applicable to all products and services or to just a fraction or will this be achievable within today's capabilities or assume further innovation or more structural changes in supply cycle configuration? .

For the current context, we chose to apply well proven, well researched signature case arbitrage savings as developed by the Ellen MacArthur

Foundation and to apply these consistently to Luxembourg's specific demand and supply tables, which are more recent than the available input-output tables. So the estimates are in the context of the specific Luxembourg starting position of being a highly open economy with a much stronger emphasis on the service sector than the European average. Those service aspects are challenging to estimate.

While the approaches chosen by different institutions follow a similar logic, the underlying estimates and assumptions on the cost- and value creating opportunities vary substantially. However, independent of these assumptions, the results of all reports consistently confirm the substantial potential of establishing more circular set-ups at national level. To this end – independently of the detailed analysis – the results should be considered a confirmation of the size of the opportunity. In a world with finite resources, regions and nations that deploy more resource productive strategies and business innovation will be much better placed to benefit from the structural shifts already under way in the global economy.

In the following we will discuss those topics in greater depth.

4.3.2. Overall economic impact of reduced net-material cost savings

Luxembourg has seen robust economic growth compared to most neighbouring countries. As an open economy with multi-lingual capabilities at its core and a strategically important geographic location at the crossroads of important material flows in Europe, Luxembourg enjoys a well diversified economy with a strong emphasis on financial institutions and services including logistics (see Figure 4.2 on GDP-make up).

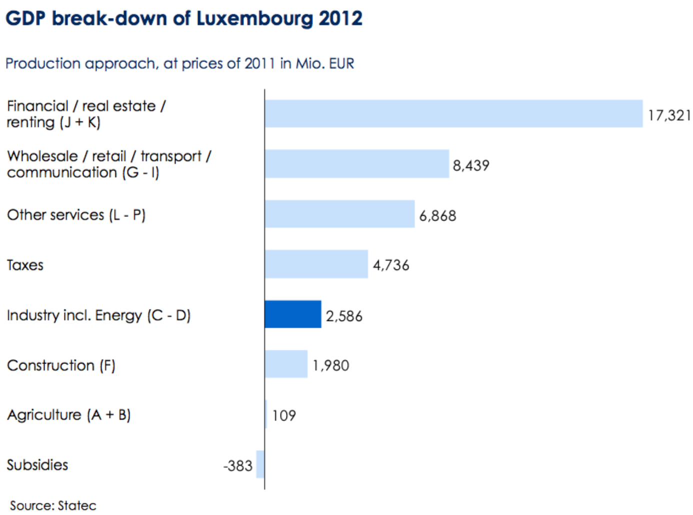


Figure 4.2: GDP break-down of Luxembourg 2012. Source Statec

To assess a rough order of magnitude of establishing and expanding circular economy practices in Luxembourg the same method was applied as in the analysis performed by the Ellen MacArthur Foundation, then applied to the local material demand and supply balance of Luxembourg. While there are many variations of this approach (see previous section) they all follow a similar logic and are robust ways to estimate potential macro-economic contribution..

Applying the average potential savings in net-material costs - as established by the Ellen MacArthur Foundation for medium-complex, medium-lived goods in their first report towards the circular economy (in 2012) - to the respective industry verticals (i.e. manufacture of computer, electronics and optical equipment, transport equipment, furniture) in Luxembourg, indicates an economic potential of 200 to 325 mio EUR p.a. for products sourced locally (in 2012 volumes at base price). This would assume an average of 13% savings for a transition scenario (with conservative assumptions and focussing on changes in product designs and reverse cycle capabilities) or an average 21% net material cost savings in a more advanced scenario (with assumptions comprising higher customer acceptance, cross-sector and cross value stream collaboration). Adding products sourced from imports the potential would increase to EUR 1 bn to 1.6 bn p.a. (valued in 2012 volumes and base price) for the selected categories (see Fig. 4.3).

This would however imply, that the economic zones from which imports would be sourced would also apply CE-methods to improve resource productivity and contribute to net-material cost savings.

Overall the identified potential from the net-material cost savings analysis would suggest roughly savings of 0.5% to 0.8% (local activities) to up to 3.9% (incl. imports) of GDP in 2012 values.

Overview on material input and potential cost savings

INDICATIVE ESTIMATE

FOR DISCUSSION

Use and supply

2012 in base prices

Activity/sector	Use in EUR millions: Output	Use in EUR millions: Industry imports	Use in EUR millions: Total	Savings in %: Transition	Savings in %: Advanced	Net material cost savings in EUR millions – Output industries: Transition	Output industries: Advanced	Total: Transition	Total: Advanced
Manufacture of computer, electronic and optical products (26_28)	1,320	2,334	**3,654**	13	21	172	277	475	767
Manufacture of transport equipment (29_30)	141	3,492	**3,633**	13	21	18	30	472	763
Manufacture of furniture; other manufacturing (31_32)	88	487	**575**	13	21	11	18	75	121
Total	**1,549**	**6,313**	**7,862**			**201**	**325**	**1,022**	**1,651**

Source: Statec Luxembourg, ESA95 Questionnaire 1500 – Supply table at basic prices, including a transformation into purchaser's prices (2012), relative savings from Ellen Mac Arthur Foundation – Towards the circular economy report I (2012)

Figure 4.3: Overview of material input and potential cost savings. Source Returnity Partners

It is important to note, that this potential quantifies the size of the overall opportunity but does not account directly to the potential of Luxembourg to fully capture it, as Luxembourg frequently only covers a relatively small portion of the associated value streams in the respective industries (frequently in activities upstream (e.g. design) and down-stream of the main manufacturing activities (esp. distribution)). For this reason the potential is likely to represent an upper limit (for the contribution from these specific activities).

While the above estimates solely focus on the manufacturing part of the economy there are two more sectors, which stand to provide sources for further economic growth leveraging CE-practices. As for these a solid bottom-up validated estimate on potential net-material savings is not available (esp. for construction) or not meaningful (esp. for services), the following section relies on exemplifying the type of contribution possible.

Construction

Construction (see also section on construction 10.3.) has been excluded from the above estimate. But it is an important sector,

1. It is a comparatively large sector,

2. with a high degree of potential from applying circular economy practices in Luxembourg (both in terms of relatively low starting base (i.e. high leakage) as well as typically large savings from CE best practices) and

3. by definition with a much higher degree of value stream control given the more localized nature of the business

To establish a rough order of magnitude we perform the following triangulation of the potential net-material costs savings:

- One can assume from the literature, that typically 30% of construction costs is material related.
- 5% net-material cost savings on construction materials and components from increased recycling and reuse (e.g. better valorisation of excavation materials, reduced costs of recycled steel, concrete and architectural glass, reduced costs for avoidable transport packaging, etc.) is feasible. The estimate is conservative. For example the City of Venlo in The Netherlands recently completed calculations based on its new city hall. Using a multi-year Cradle to Cradle process, the city forecasts 10% increase in residual materials end-value for the building which translates into €200,000 Euros back-casted potential cash flow savings per year for its mortgage on a €50 million building. (Source City of Venlo presentation Nov 20/14 at C2C Bizz Closing Conference)
- 5,5 bn EUR were recorded as total locally sourced demand by the construction service for total supplies at 2012 base prices

> This would equate to a net-material costs saving of about 80 mio EUR annually, which could be added to the economic potential above, as there is hardly any input required from the above mentioned manufacturing sectors

Services

As a large part of the Luxembourg economy is not primarily depending on material throughput the above applied methodology excludes opportunities from growing CE-related service activities. In the interviews frequently the need to complement material-based activities with an increase in supporting services highlights, that there is a relevant opportunity (see examples below, e.g. materials banking).

To put the potential in perspective an assumed one percent gain in activities of service sectors like (distribution, logistics, financing) can be estimated to potentially add more than EUR 250 mio to GDP annually. This equals the opportunity derived from net-material cost savings based on locally sourced input for the manufacturing industry

Methodological limitations

As described early the present study used three different types of estimates to quantify a rough potential of a circular economy

a) applying EMF/McKinsey typical costs savings for medium complex and medium lived technical products to the Luxembourg situation.

- Given the aggregation logic of Statec the three selected industry vertical correspond to the ones selected in the first EMF report Towards a Circular Economy. As the establishment of the potential savings requires a lot of detailed signature product specific work, which could not be duplicated in the scope of this study, the estimate was restricted to scaling up of the typical potentials to those sectors.
- The range of the savings estimate is explained by two factors
    - i) the lower vs. the upper bound of the typical net material savings as derived in the detailed case examples for the signature products
    - ii) by applying it to only the domestic inputs vs. including also the imported inputs. The difference here is, that the
- As a basis the present study used not the usually applied input-output tables but the supply and demand tables as they were more recent and more detailed than the input-output tables last compiled in the mid 90s (an updated version was announced but not available when last checked mid November)
- In that context, the estimate corresponds with the 630 bn EUR net material cost savings, which has been adopted by the European Commission as the ballpark figure for all of Europe

b) Applying estimate to construction sector

- the construction sector was excluded in the earlier EMF/McKinsey reports, as products cycle less frequently through the system and the building infrastructure varies much more significantly by region than the use of Fast-Moving Consumer Goods (FMCG). Scaling of construction is is more complex to estimate.
- To estimate the order of magnitude the study assumed conservatively;
    - 30% of construction cost to be material/component driven (it is typically greater e.g. in the mid 40%)
    - 5% savings by establishing circular practices (again limited to avoiding landfilling costs, and excluding valorization like systematic de-construction instead of current demolishing

practices. Case examples suggest that double digit savings could be possible.)

- ◦ Total domestic material supply volumes for construction (here the imports hardly matter as most bulk construction materials are procured locally (or at least as part of localised contracts, which might then have imported products and components).

c) Sensitivity analysis on 1 percentage point change in service growth due to circular economy

- There is no simple estimate-based approach to quantify growth/value creation potential for services as these are so heterogenous in nature and exhibit extremely different margins/value adds depending on local pricing levels and type of services
- For this the study considered using a 'what-if' sensitivity analysis of a conservative 1% growth in service sector to derive the proposed value in the report as additional GDP contribution.

While these estimates are derived differently they are in principle additive, assuming that a growth in services would not drastically reduce the relative material intake for the construction and industrial sectors.

We decided against the explicit adding up of these savings in the report to avoid lengthy debate about the different level of maturity of these estimates, the problems in adding up savings derived from different assumptions, etc.

Luxembourg case examples of achieved or potential net-material cost savings

The performed indicative estimates above rely heavily on the assumptions on what type of net-material saving is possible. As a detailed assessment for mapping out and quantifying product specific savings exceeded the means and scope of the present study, which focused on inventorying activities, the below list represents just an indicative collection of case examples supporting the feasibility and type of potential achievable in Luxembourg already today or potentially imaginable.

Existing cases of realized net-material savings in Luxembourg today include:

- **Packaging waste reduction:** During ValorLux's Tropheco competition a number of case examples were collected in which companies achieved substantial reduction in packaging waste by
  - **Improving weight to volume ratio:** 40% improvement for Sicos-L'0réal transport packaging of cosmetic tubes, while at the same time simplifying

the reconditioning by material simplification and due to increased stackability achieved higher load-factor of distribution vehicles

- **Shifting to renewable materials:** Boma-Ecover introduced packaging for their cleaning product on the basis of plant-based materials, which is 100% recyclable. By proposing to introduce refill packages the idea is to further de-couple usage from material intensity
- **Improving re-usability:** Sicos-L'Oréal established a closed loop concept for transportation packaging, which can be reused via a take-back scheme and fully recycled at end of use as material stock remains under full control during usage by the operator
- **Recyclability combined with Local Sourcing:** Sources Rosport established a 100% recyclable packaging for its water, which is locally sourced and hence reduces the need for CO_2 emissions and conventional fuel based transportation services. .
- **Improved separation benefits.** Analysis by Superdreckskescht conducted in 2008 shows, that the more value can be retained by improving source-separation and maintaining quality of collected feedstock. Savings of more than a factor of 2 could be achieved by those syndicates, which avoided mixed collection by separating different grades e.g. mixed glass creates cost of up to 14 EUR/ton vs. white glass as a pure fraction achieves 7 EUR/ton yield or mixed plastics fraction create costs of up to 200 EUR/ton vs. well separated fractions achieve an average of 180 EUR/tons value, as the higher quality simplifies re-valorisation of feedstock (e.g. avoiding costly sorting, degrading quality during recycling).

While the above-mentioned case examples are already achieved in today's practices in Luxembourg a number of additional ideas with a high likelihood of achieving at least similar material productivity gains were identified during the course of the study. These are however not quantified yet.

- **Interiors leasing**. An office interiors sales & service company HMS Import Agency started a Cradle to Cradle inspired office interiors leasing operation W-Solve http://www.w-solve.com/. The company is already selling C2C certified products in Luxembourg and plans to extend its leasing to Luxembourg. After 4-5 years experience, W-Solve describes savings of up to 31% on capital costs over 5 years, and describes other advantages using the model to redesign office furniture for leasing and parts recovery. For example up to 50% of furniture parts are re-usable after other parts of the chair wear out. (Source W-Solve Presentation)
- **Food-grade polymer recycling for component manufacturing.** Tontarelli operates a plastics manufacturing facility (moulding shop) and regional distribution centre in Luxemburg. They produce products out of food-grade polymers. Already today they achieve recycling rates of up to 25% from

company specific closed-loop operations. They comprise all required activities fully in-house (esp. grinding, moulding, assembly, packaging and distribution). The estimated annual costs savings amount to more than 7,5 mio EUR in net-material cost savings (i.e. more than 5%). This share could be further improved, if Tontarelli would be able to source re-grained food-grade polymers outside of the company (i.e. from a local material pool in Luxembourg, supplier community). Examples of food-grade recycled polymers are already operating in the U.K. and U.S. Technologies might be transferred to Luxembourg. For more information on Tontarelli see Construction under Sectorial Snapshots.

- **Goodyear tire re-treading, renting** Goodyear operates research and development activities in Luxembourg. While re-treading of truck-tires is a well established practice, the belief is, that this practice could be extended to passenger vehicles. Prolonging the usage period for the inner part of the tire, which does not wear off into the environment might be potent drivers for material productivity. To further capitalize on the longevity of Technosphere usage-based systems (e.g. as is already common practice for tires e.g. in the US armed forces) could be attractive for Luxembourg's fleet operators in the transportation and car leasing business. As Luxembourg also observes a high share of pass-through traffic with sufficiently long enough stand-still periods (e.g. frontaliers, legal rest-period stops for professional drives) establishing a tire-leasing pool with exchange stations could allow to grow this type of business to customer segments out of the domestic motorists. As well, under circularity there might be improvements to the model; the outer tire wears off into the environment so is designed as a biological resource, while the inner tire is a Technosphere service product for prolonged use as presently practiced. In that context, research and development could be attractive for re-defining outer tire segments as a Biosphere product. The approach is already being investigated by some bicycle tire manufacturers, and tire manufacturers in Luxembourg might adapt the concept to have a competitive edge with healthy tires.

- **Customer/supplier closed-loop high quality paper reuse.** Luxembourg's service intensive sectors consume a substantial amount of paper, resulting in the highest paper per capita ratio in Europe of 317 kg/Person (2009, www.papierwende.de). A large part of this paper is used for confidential documents, which are frequently not used for recycling but incinerated to destroy the embedded content, or at least shredded, which significantly reduces the ability to recycle the paper (on average paper can be recycled 3,5 times in Europe). With recycling rates estimated at 60% Luxembourg falls short of the EU average of around 70% (www.recyclingforpaper.eu, Statec). So the opportunity exists to improve the recycling rate and quality of paper while at the same time fulfilling the need to protect sensitive data. To counter the leakage of paper fibres the setting-up of closed-customer-loop high quality recycling, which can guarantee data protection could be set-up relatively easy in Luxembourg. Replacing office-based shredding with confidential waste bin collection. Having the collected papers transported by a trustworthy party (e.g. La Poste, document management company) to a facility specialized on recycling high quality office paper into high quality office paper at high efficiency and then returning the produced materials to the office locations would represent a very short dedicated paper loop. As all the systems already exist independently of each other (confidential waste bins, logistics, paper recycling facilities), the establishment of such a stream could be organized in relatively short period of time. See Fig. 4.4 for an example of a network already functioning in Germany and the Benelux. Given the high concentration of paper users in the financial sectors only a few participating customers would be required to likely achieve critical mass to justify a trial operation.

- Furthermore, biologically compatible inks and paper additives are already on the market which upgrade the quality of recycling by eliminating toxic sludge disposal costs. In this way the quality is upgraded and costs reduced. For more information on existing paper quality communities refer to Fig. 4-4 as well as Annex B on circularity systems.

Figure 4.4: Steinbeis paper upcycling community. Diagram EPEA

- **Concrete recycling** can take many forms. From on-site recycling of materials to component-reuse (i.e. the use of harvested sub-structures for re-use). As construction and demolition waste is an important stream for Luxembourg and in the foreseeable future the share of concrete in demolition and construction waste is likely to increase as more road-based infrastructure and concrete-buildings are likely to enter the end-of-use/ refurbishment phase, investing in capabilities to take advantage of this opportunity could improve material productivity of an important value stream, with high local control and excellent fit to Luxembourg's existing skill set. As concrete typically contains a significant share of steel components, which are also in high demand for local recycling, the share of value capture is likely to be high. However, to fully cpature value it is essential to begin designing the coatings and products which are painted onto or affixed to concrete and steel so they are safe for the Biosphere, or removable, otherwise recycled concrete might contain contaminants which e.g. contravene new REACH regulations and lead to extra costs for recycled materials users. Quality of coatings as well as designs for disassembly are fundamental to cost-effective recycling of concrete.

It is strongly recommended to collect, analyse and create more of these case examples in the near future as "lighthouse projects" to solidify input for economic estimates and create credible, local impact cases inspiring others to pursue the net-material cost savings and revenue generating opportunities of more circular business models.

4.4. Employment And Circularity

Figure 4.5 shows an overview of the current labour distribution in Luxembourg by sector.

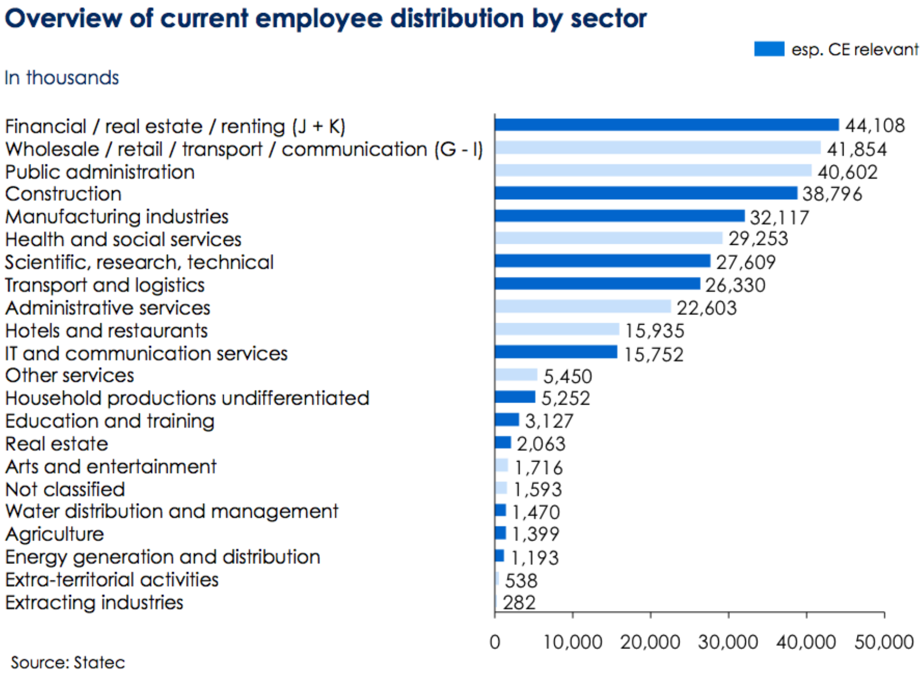


Figure 4.5: Overview of current labour distribution by sector. Source Statec

The Objectives and Targets for the study as described in the *Cahier des Charges* do not directly refer to job creation. However in its description of the present situation, the Cahiers des Charges makes it clear there is an unemployment concern to be addressed by the study.

In this context, a first task is to describe what is a circular economy job?

Defining a circular economy job

A superficial view of a circular job based on the concept of recycling might lead to the conclusion that circular economy employment is limited to back-end activities like reverse logistics and recycling.

However it would be a mistake to adopt this view.

No commonly-used definition of a green job is yet available, rendering the production of data on green jobs practically impossible, for example using the National Institute of Statistics and Economic Studies (Institut national de la statistique et des études économiques du Grand-Duché du Luxembourg) (STATEC) European statistical classification of economic activities (Nomenclature statistique des Activités économiques dans la Communauté Européenne) (NACE) codification system.

EEO Review: Promoting green jobs throughout the crisis, 2013 p. 3

The dilemma described in the study on green jobs potential in Luxembourg underlines the challenges of estimating jobs for circularity.

This is not to say 'green' and 'circular' are identical. 'Green' is a wider and more vague term. However the definitions and statistics challenges are similar and here is why they are important;

- Materials and processes for circularity reinforce each other when they enter value streams through the front and back ends simultaneously. See CE diagram figure 3.2. At the front end, circular materials designs, prototypes, manufacturing and distribution are already integrated in some industries, while increasing amounts of recycled materials enter through the back end. For example, at the front end, companies like ArcelorMittal and Eurofoil design their processes to accommodate recycled materials. As a result, every industry e.g. automotive parts, which uses those primary products depends on and participates in circularity. Likewise, at the back end of the cycle the logistics, sorting, and scrap trading associated with recovery of the steel and aluminium are essential for the re-melting furnaces, which manufacture new products. The end result; the product cycle and related jobs are depending on circular materials for their existence.
- In that dynamic, the use of defined and recycled materials has a multiplier effect on the numbers of jobs falling into the circularity value stream.
- The significance for jobs in Luxembourg is this; as more materials are designed for circularity at the front end, and more materials enter the cycle from the back end, <u>the numbers of jobs classified as circular rises by multiples due to front-end-back-end synergy driving the complete cycle.</u>
- It must be emphasized here that a process is not completely circular just because recycled materials are used. Other factors such as renewable energy use, leakage and materials quality have to be taken into account. Nonetheless, the moment an industry starts to rely on secondary raw materials, the jobs connected to it become part of the circularity cycle. It is in this context that the definition for a circular job might be established.

If the circular economy is defined for this study as *The restorative use of materials and products in renewably powered cycles where everything is a resource for something else, generating positive economic, social and ecological impacts through improved quality and resource productivity.*

…then a circular economy job might be defined as;

> An employment activity supporting the restorative use and re-use of materials and products in renewably powered cycles, generating positive economic, social and ecological impacts through improved quality and resource productivity.

Applying that definition to Luxembourg, one arrives at surprising conclusions regarding the present and potential circular economy. A significant number of jobs are already on the way to supporting circular mechanisms. For example;

Inventory of the present industrial employment situation in Luxembourg

Circular economy materials are defined by two cycles; Technosphere and Biosphere. An inventory of the leading companies in Luxembourg shows that a significant number of them rely on secondary raw materials to manufacture products for the Technosphere;

Steel

- At least one third of ArcelorMittal's sheet pile business consists of banking and renting sheet piles to customers for temporary uses. Piles are returned with reverse logistics then re-used. As well, contractors which purchase piles from ArcelorMittal themselves lease the piles to customers. Renting, banking, then recovering materials is one of the highest forms of circularity. Approximately 250 jobs at ArcelorMittal are directly connected to it and fully one-third of ArcelorMittal's steel pile business comes from renting. (Source email ArcelorMittal 241014).
- Steel manufactured in Luxembourg contains about 98 percent recycled content (Source Hoffmann email 241014). The reliance on scrap steel arose because iron ore deposits around Luxembourg became unproductive, so to maintain its competitive position in the resource constraints of the region, ArcelorMittal is focusing on steel scrap as a secondary raw material. Because of this, ArcelorMittal's 4800 jobs in Luxembourg are based on circularity as a competitive response to conditions in the marketplace. *To be clear; without recycled content ArcelorMittal's operations would be non-competitive and the facilities would probably have to close.*

- As well, third party logistics companies and scrap dealers in the Greater Region transport scrap to ArcelorMittal and other third parties transport ArcelorMittal finished recycled products out of Luxembourg. Those hundreds of logistics jobs might be classified as based on circular materials flows.
- Because recycled steel enters value streams through the front end, and is often returned through the back-end in the same geographic region where it is sold, it probably results in businesses utilizing multiple generations of recycled steel in their products, which e.g. significantly improves the CO_2 profile. However the geographic cycle estimation requires further investigation to validate.
- Regarding potential improvements for circularity, ArcelorMittal's Luxembourg smelting operations are based largely on electric arc furnaces, which are well suited to using renewable energy. So there is a potential for generating new jobs from renewables.

Aluminium

- Norsk Hydro's aluminium remelting operation in Clervaux uses aluminium scrap, saving more than 90% of energy required to make aluminium from bauxite and thereby improving the competitiveness of its operations. The facility employs 54. The Eurofoil aluminium remelting plant in Dudelange, employs 320 personnel, and Eurofoil is upgrading its capacity to deal with scrap for recycling (Source Packaging Europe 100914). Eurofoil also has an R&D centre in Luxembourg focusing on quality improvement.
- There is also an extensive logistics infrastructure for feeding scrap for the remelting facilities from outside Luxembourg. As well in Luxembourg, Valorlux and other waste companies in Luxembourg collect aluminium scrap.
- The aluminium value-added products industry in Luxembourg e.g. for automotive depends on those remelting operations for raw and primary materials.
- Altogether it might be estimates that 750+ employees are involved in aluminium circularity in Luxembourg along the value stream, and the knock-on effects apply to other companies who use recycled aluminium.

Glass

- About 20% of Guardian Industries glass is based on recycled cullet (Source Guardian interview). In that context it could be said that 20% of Guardian's 1220 jobs rely on circularity.

- As with steel and aluminium, the logistics for delivering cullet to Guardian's manufacturing facilities as well as a percentage of the logistics used to transport products with partial recycled content to customers are considered circular.
- Luxembourg has the highest percentage of glass collection for recycling in Europe.
- Although it is commonly known and sometimes taken for granted, it bears mentioning that most of the glass containers used for consumer goods in Luxembourg contain a high percentage of recycled or re-used glass. In this sense, many retail jobs rely on recycled materials for their packaging.

Leasing, renting and sharing are circular economy enabling mechanisms.

- For example more than €1 billion in automotive assets are leased, rented and shared in Luxembourg (source extrapolation from KPMG Automotive Breakfast report 2013). Although the end-of-use fate of most of those vehicles is not presently circular, the leasing mechanism is an enabler for repair, tracking and recovery of materials assets, especially for fulfilling the EU end of life directive for vehicles. In this sense, the 380+ jobs in the vehicle leasing, renting and sharing industry could be classified as on the way to circularity, as could vehicle repair and parts remanufacturing jobs connected to those activities.
- In construction, leasing and renting is used for equipment and offices. For example Loxam, one of Europe's largest construction rentals companies, has operations in Luxembourg. Thousands of workers in Luxembourg use construction rentals. Floow2 is another example as described in the chapter Sectorial Snapshots. Again, end of use fate of those materials is often still linear, but nonetheless the mechanism for circularity is in place.

Automotive components

- For Luxembourg players modularization and re-usability of expensive equipment is a key topic; and already done. Companies already re-configure their highly atomized, robotized manufacturing processes with modular machine designs (up to 80% of re-use of equipment for next generation of produced items). This is core to their cost advantage but is also a job-preserving necessity to survive in a highly competitive automotive environment. The feature is of high relevance for Luxembourg because 40,000 workers are employed in the automotive components industry, and robotics are core to their competitiveness. Modular robotics are central to job preservation and might be considered as case examples for other industries (Source interview Joost Ortjens).

Construction

- One of the more important as well as one of the most complex and challenging to quantify, the construction industry is presently a player in circularity but usually indirectly.
    - **Flooring materials.** Looking to the front end of the raw materials cycle, Tarkett devotes its R&D centre in Luxembourg to redesigning flooring materials for circularity. While the R&D involves only a few personnel, the multiplier effects apply to most of the Tarkett workforce globally because Tarkett uses the materials for its multi-billion Euro operations. Tarkett also uses secondary pre-consumer PVC in its flooring.

Reverse logistics

- If transport of scrap metal and glass cullet is defined as a reverse logistic to get materials back to where they are re-used for manufacturing, then Luxembourg already has a significant reverse logistics infrastructure. However calculating the number of jobs generated from those reverse logistics is challenging because they are not broken out in Statec or company statistics.

Waste management

- Collection, separation and transport of Technosphere and some Biosphere waste fractions by the 51+ waste management companies in Luxembourg involving 1,400+ jobs (Source Statec) could be included in the circularity jobs framework, excluding the significant portion of materials which are sent to linear activities like incineration or landfill.
    - **Concrete recycling**. A great deal of concrete is 'recycled' although under circularity definitions it is downcycling. Crushed concrete is used in roadbeds to replace scarce materials. Although not much concrete is recycled into concrete again, research and pilot projects are being done in the Greater Region. The use of crushed concrete as well as research into recycling generates a certain amount of employment.

Finance

- Connected with each of those activities are the normal financing, banking, and administrative support services, which do not show up in any statistical portal but are required to support the business of circularity. These might represent anywhere from 5 – 15% of directly generated jobs.
    - As well there is a big unknown in the finance sector. For example the EIB based in Luxembourg as well as private alternative investment funds are financing activities such as renewable energy storage, which fall into the circularity scope. Given the size of the renewable energy sector as well as

the globalized waste management industry, it is only possible to speculate how many jobs in Luxembourg's financial sector are based on funding those types of circular activities. It might range from a few dozen to hundreds of positions.

Considering those factors, it is estimated 7 - 10,000 positions rely on circularity in Luxembourg; some of them high-skilled & high-pay. It is a small but significant percentage of the overall workforce, and a good basis for learning from experience.

Employment-related inventory of the Greater Region.

If the Greater Region is included, those numbers swell. For example, many of the scrap and cullet dealers servicing the steel, glass and aluminium industry are located in the GR. As well a variety of products designed for circularity is being sold in the Greater Region as described in Annex B.. Companies in the paper, furniture, flooring, and construction sectors already sell products in the GR which are designed for circularity, and some systems are in place for recovering, repairing, remanufacturing and recycling those, also described in Annex B.

Because of this it is safe to say that tens of thousands of jobs are already supporting the move to a circular economy in Luxembourg and the GR. See Chapter 13 for more on the Greater Region.

It is encouraging to see more jobs affected by circularity, and it is important to establish a baseline for defining circular jobs, but will it lead to an increase in the real numbers of jobs and improved competitiveness?

The potential for employment growth and competitiveness powered by circularity

Job creation opportunities

In terms of employment and job creation Luxembourg has enjoyed a continuous growth of the employee base, largely to the continued increase in frontaliers. Despite the dominance of the financial sectors a large share of employees are registered into the construction and manufacturing sector, which in addition to transport and waste-treatment professionals form the basis for benefitting from local re-industrialization due to establishing circular economy practices the most (see figure 4.5 on current job distribution by activity). This would be particularly attractive as the industrial and manufacturing jobs have come under pressure due to the high labour costs in Luxembourg and the resulting decrease in competitiveness in blue-collar labour intensive sectors.

The steel, aluminium and glass industries in Luxembourg offer a view to the future of Europe's materials-based industries. In Luxembourg those industries are improving competitiveness and protecting jobs, as well as generating new jobs e.g. with aluminium foils, by transforming from primary raw materials-based to secondary raw materials based. As well, the construction industry is beginning to adapt to shortages in base commodities like sand and slag.

In each of those cases, *Luxembourg depends on the Greater Region for supplies of those secondary raw materials.* Scrap steel, aluminium, and glass cullet come largely from outside Luxembourg. Because of this, and although Luxembourg often competes with the Greater Region in other fields, *it is in the economic interests of Luxembourg to forge alliances with suppliers of secondary raw materials in the Greater Region.*

- According to ArcelorMittal, improving circularity will definitely improve competitiveness by better matching the quality of scrap inputs from the Greater Region with the quality of steel outputs. The improvement might make the differents between profit and loss in a narrow margin business, thus preserving jobs. (Source Hoffmann interview).
- According to Guardian Industries, an improvement in glass separation and logistics systems in the Greater Region would lead to a 'significant' increase in the amount of cullet usable for architectural glass, leading to energy savings and virgin raw materials savings which in turn support competitiveness. (Source Guardian interview)
- According to Tarkett, improvements to materials quality and designs for recycling as well as sourcing are already improving competitiveness, and these will become more apparent as redesigned Tarkett products begin to enter the recycling stream. (Source Anne-Christine Ayed interview)

In addition to anecdotal evidence, which suggests that due to the underlying circular material and information flows a large number of jobs is directly secured or generated by circular economy practices, the question can be posed how to grow these job opportunities further.

Job creation in a circular economy stems typically from four levers, which are all accessible to Luxembourg and for which interviewees identified tangible opportunities:

1. Growing the circular economy activity per se and the associated employment base, for example expanding the steel leasing business, growing remanufacturing activities, exporting pre-fabrication know-how and artisans in the construction industry.

2. Growing the labour intensity of a circular activity by increasing the share of labour to perform current tasks. This is frequently associated with activities in which humans outperform industrialized, automated processes in terms of quality and yield of output, rather than direct productivity. Examples of this include hand-packaging of fruits instead of machine processing to reduce process-based food waste, increased manual source separation of material streams (e.g. separation of materials at construction sites).
3. Adding new circular economy activities. Examples comprise building upcircular economy training facilities or FabLabs, adding new process-steps in the revalorization process (e.g. re-packaging, testing, re-distribution of used products, components and materials), build up of policing unit to avoid illegal material exports/collection in Luxembourg (e.g. WEEE-exports)). In addition to these direct labour effects, these activities typically increase the ability to return more products, components or materials to the value cycles and potentially at higher quality levels, which will increase value creation (i.e. better yield for pre-sorted, re-usable feedstock (e.g. pooling of food-grade polymers))

Increasing the value chain coverage within Luxembourg.

While this does not necessarily imply an overall growth of labour, it increases employment by re-locating activities into Luxembourg (at least from an employment contractual point of view). If these activities are then performed at lower labour productivity than previously, they add to total job creation. Examples of this would be for instance moving activities currently performed outside of the country into Luxembourg, e.g. polymer recycling, increasing market share in Greater Region for local construction businesses (i.e. for passive-house new-builds and energetic rehabilitation of existing structures).

In addition to these options there is the chance to re-classify an increasingly larger share of jobs as depending on circular economy activities as the share of recycled materials, refurbished, remanufactured and re-distributed products and components increases over time (e.g. as the share of recycled content grows for steel production, the more the downstream activities as logistics or trading will also continue to depend more on the robustness of the circular business streams). While in these cases the net-effect will be negligible, it still demonstrates the increased importance of circular activities to preserve jobs within Luxembourg (see steel, glass and aluminium cases from above).

The following Figure 4.6 represents a very rough estimate on what type of employment effects could stem from increasing circularity within Luxembourg for a selection of activities with high inherent connection/overlay with CE-activities. The base data reflects current job distribution of employees (salaries) in Luxembourg. The estimate of the order of magnitude of current CE share and potential growth of activities is derived from the input from the interviews. Overall this estimate is aiming to provide an indicative, top-down based approach to derive an order of magnitude for the direct job creation potential of the circular economy practices in Luxembourg. There are no assumptions added to the involved multiplier or second order effects, which frequently manufacturing jobs entail in up- and down-stream activities (i.e. for logistics and administrative functions).

Indicative rough estimate of potential job creation*

ROUGH ESTIMATE

INDICATIVE SENSITIVITY ANALYSIS

In number of employees (salaries)

Activity		CE-share Savings %	CE-share Savings Total	Main lever for job creation: Growth of activity %	Main lever for job creation: Growth labor intensity %	Main lever for job creation: Add additional activities %	Main lever for job creation: Local value chain coverage %	Potential %	Total	Comment
Financial / real estate / renting (J + K)	44,108	5	2,205	10	3	2	2	17	375	More component harvesting, redesign
Wholesale / retail / transport/ communication (G - I)	41,854	5	2,093	10	-	5	-	15	314	Increase offerings of CE-based services (e.g. leasing)
Public administration	40,602	2	812	-	-	3	-	3	24	Build out CE-based programs
Construction	38,796	5	1,940	25	3	2	-	32	621	More separation, material recycling
Manufacturing industries	32,117	10	3,212	3	2	5	-	10	321	Add re-manufacturing capabilities
Health and social services	29,253	0	-	-	-	-	-	0	-	-
Scientific, research, technical	27,609	5	1,380	10	-	-	2	10	138	Increase research around CE topics
Trasnport and logistics	26,330	5	1,317	10	-	2	2	14	184	Increase in reverse logistics
Administrative services	22,603	5	1,130	5	-	5	-	12	136	Reverse supply chain management
Hotels and restaurants	15,935	0	-	-	-	-	-	0	-	-
IT and communication services	15,752	5	788	5	3	-	-	8	63	Redistribution, repair services
Other services	5,450	0	-	-	-	-	-	0	-	-
Household productions undifferentiated	3,252	0	-	-	-	-	-	0	-	-
Education and training	3,127	2	63	10	-	-	-	10	6	Build out CE-based trainings
Teal estate	2,063	5	103	10	-	-	-	10	10	Increase in revalorization of building components
Arts and entertainment	1,716	0	-	-	-	-	-	0	-	-
Not classified	1,593	0	-	-	-	-	-	0	-	-
Water distribution and management	1,470	50	735	10	-	3	-	13	96	Increase sludge processing, nutrient extraction
Agriculture	1,399	10	140	30	2	-	-	32	45	Grow bio-based share of total agriculture
Energy generation and distribution	1,193	10	119	10	-	-	-	10	12	More alternative energy installations
Extra-territorial activities	538	0	-	-	-	-	-	0	-	-
Extracting industries	282	0	-	-	-	-	-	0	-	-
Total	**359,042**		**16,036**						**2,345**	

* Not exhaustive, based on signature activities, 3 year projection
Source: Rapport annuel 2012 agence pour le dévélopment de l'emploi

Figure 4.6: Indicative, rough estimate of potential job creation. Source Returnity Partners

As can be seen in this very rough estimate the job creation opportunity will largely stem from growing CE-activities itself or adding additional activities to enable CE-practices in the first place.

As expected the opportunity for job creation is highest in those labour intensive and more manufacturing based industries and construction. This is fully in line with the findings derived in the sectorial deep dives discussed in this study. Moreover as these jobs will be requiring more artisans than white collar professionals, it also highlights the opportunity that growing and establishing CE-activities in Luxembourg can address this particular structural need of the local labour and employment market.

Who might be losers in the circular economy transition?

In every economic paradigm shift there are winners and losers, so who might lose in a circular economy? The EC Scoping study addresses the question e.g. for automotive, bioplastics, and FMCG. However, the present study advises to critically examine assumptions underlying those scenarios. The assumptions are subject to statistical and industry-by-industry extrapolations, which as described previously are highly case-specific, thus not necessarily transferrable to Luxembourg without extensive analysis which is beyond the timeframe and budget of the present study to evaluate. As well, when some of those scenarios are considered for Luxembourg, it is conceivable that Luxembourg already experienced much of the potential loss as a result of having exhausted earlier resources. Although this is still speculative, some examples include;

- Exhaustion of traditional raw materials sources like for example iron ore. In other economies, primary raw materials extractors and processors might stand to lose, but in Luxembourg those raw materials extractors do not exist anymore, although they do exist indirectly through company head offices being based in Luxembourg. For example, Norsk and ArcelorMittal in Luxembourg rely on secondary raw materials, and rather than being losers locally they might be winners because they are ahead of other primary extractors and processors in knowing how to acquire and process secondary raw materials. It might be argued that companies like Norsk and ArcelorMittal with large primary extraction operations elsewhere, might suffer from the transition to circularity, but that is still open to speculation. If for example those companies wind down and depreciate their primary extraction operations and replace them with secondary materials processing, they might gain rather than lose, as might their workers. It is heavily dependent on how the transition is managed, and this is why the present study focuses not just on transformation, but also on tradition and tradition, as described in the title.
- Low-skilled jobs associated with traditional linear economy activities were lost in Luxembourg in the financial crisis, witnessed by unemployment increases. Those were among the motivations of the Ministry of the Economy to commission the present study. It might be that circularity eases the transition for those workers by creating reverse logistics, remanufacturing or de-construction and de-manufacturing jobs.

4.5. Competitive Opportunities

In early 2014, the High Committee for Industry developed a draft report with recommendations on how to improve competitiveness of Luxembourg industry. Later in 2014 the National Plan for Smart, Sustainable and Inclusive Growth also made recommendations. Those recommendations are taken into account in this section but also throughout the rest of the study. It might be advantageous for the High Committee to review this study. See also Chapter 2 for a description of how the study results might be integrated with other parallel activities going on in Luxembourg.

As a central definition for this chapter it is assumed that improved industry competitiveness will in consequence support the attracting, developing and retaining of economic activities in Luxembourg against potential alternative economic spheres.

The increase in competitiveness is typically routed in achieving a positive differentiation along key decision criteria, which can be synthesized and clustered along three main dimensions:

1. **Cost-leadership:** Cost leadership is routed in the ability to offer comparable products and services at better cost than potential competitors. This is typically achieved by increasing efficiency and effectiveness of activities. In the context of the circular economy this will largely be derived from improved resource productivity. Typical levers comprise for instance reduced, less volatile costs of raw materials by improving share of defined recycled content, improved scale and scope economies by creating shared and defined material pools, higher productivity in new, innovative CE-activities via faster capturing of learning-cost effects (e.g. pre-fabrication in construction)
2. **Quality-leadership:** Quality leadership is routed in the ability to provide comparable services and products at perceived higher utility than potential competitors. This is achieved for instance by increasing performance, functionality of products and services (e.g. better insulation standards for refurbished houses, better quality of locally grown bio-foods, providing of additional benefits (i.e. higher air quality by using CE-designed carpets)). While the cost-leadership can be measured objectively, quality leadership and the derived benefit for users of these products and services is more subjective and appreciation can vary by different target segment. In this case establishing standards, certification, measurement systems, independent product reviews, process audits, etc. are all good practical examples on how to proof and demonstrate the benefits of better quality. This is particularly important for Luxembourg as quality differentiation in light of the high cost environment will surely be an important aspect of any drive to boost industry competitiveness

3. **Speed/responsiveness:** Customers and users of products and services receive additional benefits or avoided costs from a supplier's ability to deliver solutions to customers without delay and in a short period of time. This allows customers to enjoy the benefits of the product, services earlier or avoid the use of less attractive alternatives. To successfully compete on this dimensions typically the agility, responsiveness and speed of the process of product manufacturing and service delivery is more decisive than the actual product/service itself. Examples of this in the context of the study could be for instance improved time to market of harvested feedstock by setting up multi-stakeholder reverse distribution activities (e.g. high quality paper recycling integrated with confidential document management orchestrated by La Poste) or avoiding stock-out of products and services by forming supplier communities and material management pools, which are more capable of absorbing demand fluctuations than individual entities could do.

As the circular economy requires the build-out of new service, solutions and product components, which typically require more intense collaboration across different players along a value cycle, Luxembourg is well positioned to achieve favourable competitive situations (esp. from quality and speed differentiators) as Luxembourg's nimbleness and resolve to action allows to configure these solutions much faster, then in the surrounding markets.

As these differentiators seldom can be improved independently of each other, the question is raised, what is the best way to now improve industry competitiveness in the context of the circular economy within Luxembourg.

Based on the discussion with the experts and the interview partners, three major thrusts emerged:

1. Strategic priorities: Luxembourg could benefit from focusing on winning activities, industries and sectors, which will be important, hard to replace cornerstones of any circular economy in the future. Good case examples would be reverse logistics, re-commercialization of harvested products, components and material streams, design and R&D activities

2. Industry resilience: Luxembourg could benefit from improving resilience against external (material) cost pressures and supply side risks. This is particularly true as Luxembourg is an open economy with a high ratio of import and export flows and requiring close collaboration and sharing of activities along the value chains (e.g. automotive industry, construction industry). By improving (local) recycling and re-usage rates economic activities can be de-coupled from material inflow (at potentially increasing and more volatile factor costs). Good examples would be the large material flows of today (i.e. steel, concrete/inerts) or energy consumption (i.e. increased usage of renewable energy sources). Further substitution and digitization of material-intensive activities would be a second avenue

for de-coupling (e.g. increased usage of document management processes)

3. CE innovation: Luxembourg could aspire to be a source and hub for disruptive innovation around CE-based activities. Examples of this could be to innovate performance-based delivery models (e.g. material banking, additive manufacturing).

The ability to be more competitive is the source also for expanding circular economy activities and to increase higher share of value chain coverage, which (as mentioned above) should then also have a positive effect on job creation opportunities.

If one considers the scientific estimates of remaining global reserves of strategic materials, which range from 7 – 50 years depending on the material (source Gordon et al), it becomes clear that if those materials continue to be used for manufacturing, most manufacturing jobs will rely on secondary raw materials. However the story goes on. Every service job, data centre, structure, fast moving consumer good relies on those materials.

4.6. Synthesis Of Potential Business Thrusts

To complement the above highly synthesized findings with more practical recommendations and ideas on how to turn them into reality the following section comprises a number of ideas for specific activities and sectors to increase economic contribution, generate jobs and/or improve Luxembourg's competitiveness

The following examples describe why perception of value is a determining factor for potential employment generators described in other sections of the study;

Furniture leasing

Scale up the W-solve model of furniture leasing described previously in this chapter, to generate capital savings and accelerate designs for residual value.

ICT & manufacturing

The ICT industry in past decades was dominated by 'black swan' events; industries, which seemingly came out of nowhere to dominate the sector. Personal computers, personal devices and internet search engines are examples;

- The example of Amazon needs no introduction for the Ministry of the Economy. The company lost money for years but today dominates online retailing. In this case Luxembourg saw the opportunity and took it using tax breaks, which generated large revenues but also an image problem.
- Why do customers pay a premium for an Apple product compared to competing products with the same capacities? After a string of near-disastrous failures Apple grew to be one the largest companies by selling concepts, not just computers. Experts generally agree Apple succeeded by learning to sell the WHY while other companies were selling the WHAT. Aided by an adaptable and stable UNIX operating system superior to its competition, Apple appealed to people's imagination about how they might use computing in their own lives. The Apple culture and brand are the core of its value creation.
- Virtually none of the management consultancies or economics experts forecasted that one of the largest companies in the world might be based on an algorithm, which helps people find information on the internet. The company, Google, disrupted the advertising industry and generated hundreds of thousands of jobs globally. It also generated enormous investments in data server capacity. As well it led to unforeseen concerns about privacy, which Luxembourg might someday benefit from due to its trustful position in markets. Today, Google is offering an autonomous car based on its proprietary navigation and mapping systems. How will it affect the Luxembourg automotive and ICT industry?

Those examples are relevant for Luxembourg because computing and data management are core to the circular economy (see Chapter 10.4 ICT under Sectorial Snapshots), as well as being important drivers for Luxembourg's present economy and drivers of its future economy.

How are those examples relevant for the circular economy?

In Luxembourg, one of the next great potential economic transformers is 3-D manufacturing, also known as rapid prototyping or additive manufacturing. 3D is the ultimate internet of things. It is based on software and data that transform digits into materials. According to some experts, 3D has the potential to re-industrialize Europe in a positive way and generate a new type of circular economy.

Luxembourg has most of the elements required to scale up 3D manufacturing, including technology, software, parts manufacturing, polymers as feedstock, and a broad customer base across Europe as well as proximity. However, who in Luxembourg might integrate those assets?

In a similar way, computer and software-guided robotics are used extensively in Luxembourg's manufacturing sector and in just one of many examples most of Guardian Industries glass handling is done robotically. However, there is a next step; adapting robotics from assembly to dis-assembly by scaling up robotic dis-assembly in collaboration with human workers to improve the efficiency of repairing, remanufacturing and recycling products. Disassembly costs are one of the leading drags on the circular economy and human/robot interaction has to potential to cut those costs.

New R&D in Luxembourg is testing this radical concept of human/robot disassembly (Popper et al), but who will adopt it?

In the cautious business culture of Luxembourg, might someone have the vision to make Luxembourg the European leader in robotic-enabled disassembly or reversible 3D printing? At this stage the debate is defined by perception of economic projections. Despite a 70% annual growth rate in 3D printing, skeptics say 3D is just a hype or a niche like the dot.com boom/bust. Optimistic thinkers say the skeptics will be out of business in a few years as the technologies pass them by.

Those radically differing opinions are drawn from the same sets of data.

The outcome of the debate will have enormous implications for 'métiers' skills in Luxembourg, which represent the largest share of the economy's jobs. Will the skilled trades welcome working with robotics and 3D or will they resist it? Who will maintain and repair a large fleet or robots and 3D manufacturing machines? Who will deliver the feedstock? Who will frame the picture of this manufacturing and de-manufacturing revolution?

Fuels

Luxembourg makes considerable revenues from 'tank tourism' where neighboring residents purchase lower priced fuel in Luxembourg. The revenues are a significant source of income..

However those same purchases are imported from distant petroleum producers, then purchased by tank tourists, then burned in a linear way. As a result, Luxembourg rates among the lowest of European nations for its CO_2 footprint due to tank tourism.

As well, those purchases represent one of the main 'leakage' of materials from a circular economy. In total, including all fuel sources, according to the IEA, Luxembourg consumes 3.9 million tones of fuel annually, which ranks as one of the greatest leakage of materials from a circular economy.

As well, according to well-established climate calculations Luxembourg would have to invest billions of Euros to compensate for the extra CO_2 being emitted.

In a circular economy, one solution would be for Luxembourg and its sizeable financial sector to invest in biofuels, which do not compete with food. The results would offset the effects of tank tourism and generate large amounts of employment.

However, from interviews conducted for this study, the thinking in some government departments today seems to be that Luxembourg is too small to lead the biofuels industry because Luxembourg lacks the land and the technology.

The perception might be based on outdated data, as new biofuel technologies suggest Luxembourg has the resources for generating biofuels internally and together with the Greater Region.

Biobased materials

See R&D for more information on this pivotal topic.

There is optimism in parts of Luxembourg's scientific community that bio-based materials are within the technological grasp of Luxembourg, regardless of its limited land capacity. The future markets for biobased materials are estimated in the hundreds of billions of Euros.

However in some interviews, skepticism was expressed due to the perception that Luxembourg lacks the investment power to do world-class R&D into biobased materials, or that the results might be a long way off.

While it might be true that Luxembourg on its own has limited R&D reach, the country has traditionally overcome that weakness by partnering with other universities in the Greater Region, and in the case of biomaterials the potential is there. As well the EU has a biomaterials initiative involving Luxembourg, which provides substantial leverage.

5. IMPROVING ENVIRONMENTAL IMPACTS WITH CIRCULARITY

One of the study terms of reference is to inventory how circular economy activities reduce environmental impacts. However, one of the circularity principles is to generate positive impacts in economically feasible ways.

The connection between positive impacts and reducing negative impacts is explored here.

The following section is relatively short because environmental impacts reductions and improvements as well as methods for measuring the impacts of circularity are covered in the following chapters & sections;

- Sectorial Snapshots. Especially Elephant #3. Fossil Fuel
- S.W.O.T. Inventorying Material Leakages
- Research & Development

Takeaways

- Luxembourg has an exponentially greater influence on environmental impacts compared to its geographic or population size. It is home to the largest steel company, as well as the R&D departments of some of the largest companies in the chemicals, flooring, tire, and other industries, and its financial sector has the potential to exercise considerable influence over environmental impacts with its investments.
- It is easier for business to reduce negative impacts with positive impacts, because it is more profitable than only incurring costs for reductions. The near-term opportunity is to optimise and scale up existing positive impacts. For example, by using circularity the steel, aluminium, glass, flooring and retail industries in and around Luxembourg are achieving savings of up to 90 percent of energy for primary extraction and processing, as well as hundreds of millions of tonnes of toxic emissions, tailings and other contaminants from primary extraction & processing.
- A big challenge remains how to compensate for high emissions of climate change gases and pollutants from fossil fuels and 'tank tourism'.

- A profitable win for Luxembourg companies as well as the quickest way to cut the most aggressive greenhouse gas emissions is a national programme for substituting HFCs. Luxembourg has a registry for reducing HFCs and this might be an easy way to work with companies to profitably substitute.
- An important quick win for workers health is to substitute petroleum-based lubricants with bio-based and bio-compatible lubricants across industries.
- Present methods used to measure environmental impacts of circularity require upgrading to be practical. Present methods often do not account for the benefits of re-manufacturing, re-use, or actively beneficial functions of materials and products. As part of the National Circular Economy described in this study, it might make sense to establish a cross-sectorial taskforce to address those challenges.

5.1. The Present Situation

Steel, aluminium, glass and paper are among some of the most energy intensive materials when manufactured from primary raw materials. The use of secondary raw materials to manufacture those products results in immediate and substantial savings of energy as well as non-renewable and renewable resources.

A large body of studies exists on the savings generated by using secondary raw materials in each of those categories. It would be non-productive to repeat those studies here. However a few outstanding features of those studies relevant for Luxembourg warrant mentioning;

- Up to 90 percent of the energy and emissions used to mine and manufacture resources for steel, aluminium and glass is saved by using recycled materials. When those calculations are applied to the 2 million tonnes of recycled steel, 30,000+ tonnes of recycled aluminium and thousands of tonnes of speciality glass manufactured in Luxembourg, they result in substantial energy and emissions savings. As well it requires about the same amount of energy to manufacture one tonne of paper from primary resources as it does one tonne of steel, so energy savings from paper recycling are also substantial although the process occurs in the Greater Region rather than Luxembourg.
- Those savings are so large compared to using primary raw materials that there is no argument among experts over advantages of using secondary raw materials.

However there are arguments about the ultimate rate of recycling which might be achieved for each material, and how long primary raw materials will be required in view of growing world demand.

The question of substitution is central to a solution, and Luxembourg has the intellectual resources to start answering the challenge, especially in the biobased feedstock and nanotechnologies areas. See R&D section for more information.

5.2. The Potential

Luxembourg is undertaking and plans to undertake activities, which improve or reduce environmental impacts. For more details on those refer to the Sectorial snapshots section.

As well, Annex B describes many examples of circularity-certified products and systems available in Luxembourg and the Greater Region. Those are virtually unknown to most companies and industries across Luxembourg so there is ample room for increasing awareness as well as scale-up.

Substitute HFCs

In 2014 the EU put in force new legislation for regulating fluorinated gases which will require industry and users to dramatically cut usage of those chemicals. F-gases are hundreds of times more aggressive than CO_2 as greenhouse gases and threaten the ozone layer. HFCs account for only a small fraction of climate change gas emissions in Luxembourg, but their impacts are greater due to their aggressiveness. As well, emissions statistics do not account for systems, which contains HFCs and are exported at the end of their use.

As part of impacts-reduction, Luxembourg industries might take steps to save costs, conform with the new EU directives as well as significantly contribute to workers health and reducing emissions of climate change gases.

Why are F-gases relevant for circularity?

The principles of the Biosphere cycle require that substances designed for release into the environment, or which have substantial unintended releases, are compatible with biological processes.

F-gases are among the worst examples of bio-compatibility because they disrupt the atmosphere and accelerate negative impacts of other substances by activating them.

In the marketplace today, substitutes for F-gases operate in closed loop systems. In those ways, circularity is one of the most effective and practical ways to cut the negative impacts of greenhouse gases. Luxembourg industries will be able to set an example by joining in.

The European Commission describes the new F-gas legislation this way;

> *The original F-gas Regulation, adopted in 2006, is being replaced by a new Regulation adopted in 2014 which applies from 1 January 2015. This strengthens the existing measures and introduces a number of far-reaching changes by:*
>
> ***Limiting the total amount** of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030. This will be the main driver of the move towards more climate-friendly technologies;*
>
> ***Banning the use** of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols;*
>
> ***Preventing emissions** of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.*
>
> *These measures will build on and benefit from the successful phase-out of ozone-depleting substances which was achieved in the EU 10 years ahead of the internationally agreed schedule.*
>
> (Source http://ec.europa.eu/clima/policies/f-gas/legislation/index_en.htm)

Substituting HFCs profitably

In July 2014 the Environmental Investigation Agency (EIA) published *Putting the Freeze on HFCs, a Global Compendium of climate friendly refrigeration and air conditioning technologies*, summarising how industry saves costs by replacing HFC and other chemicals with CO_2 based chemicals;

Fast action to reduce HFCs will virtually eliminate one main class of greenhouse gases (GHGs) and prevent between 90 and 146 billion tones of carbon dioxide equivalent (GtCO_2 e) emissions by 2050 from a business as usual (BAU) scenario.

For Luxembourg's hospitality, refrigerated transport and other industries the publication provides a roadmap for cost-saving conversion. For Luxembourg's government agencies and financial firms, the publication provides a guide for procuring and investing in the right cost-saving technologies. The approach supports circularity because refrigerants are materials, and by using the right materials it is possible to save energy and pollution;

In the retailer sector refrigeration accounts for the lion's share of a supermarket's total electricity consumption, and is estimated to represent about 3 to 4 percent of the total sales price of a refrigerated food or drink item. In the current economic climate, it should come as no surprise that companies are more eager than ever to identify opportunities for energy savings… Swiss retailer Coop Schweiz, which has one quarter of its estate running on transcritical CO_2 systems, plans to have its entire estate converted by 2023. Coop Schweiz is reporting energy savings of approximately 30 percent when compared to systems using fluorinated gas refrigerants…Japanese retail giant AeOn, which has committed to introduce CO_2 in all its new stores, reports energy savings between 10-30 percent in the stores it has converted to CO_2 since 2009.

Approximately 59 companies in Luxembourg including some of the largest are certified with the MDDI programme on controls for fluorinated gases (Source Liste des entreprises certifiées conformément à la loi du 28 juillet 2011, http://www.environnement.public.lu/air_bruit/dossiers/f-gaz/controle_d_etancheite/Liste-des-entreprises-controle-etancheite.pdf)

For Luxembourg businesses that made the switch there is a substantial CSR claim to celebrate. Savings also apply to domestic refrigeration. It might be worthwhile to investigate how many stores in Luxembourg offer HFC-free refrigerators. Likewise with refrigerated transport.

Remarkably, those saving are being achieved by using a climate change gas, CO_2, in closed loops as a Technosphere material. The system is a compelling example of how CO_2 is transformed into a beneficial technical cycle chemical.

Biobased lubricants

Hundreds of studies describe how aerosols and particulates from petroleum-based lubricants are workplace hazards. In some cases ventilation reduces the risk, but often does not catch microparticles that cross the blood-brain barrier, especially where workers are proximate to where lubricants vaporize.

Biobased lubricants often do not contain the same types of hazardous chemicals and are well-established in the marketplace today. For example Vanderlande Industries replaced its petroleum-based lubricants with biobased lubricants for its conveyor systems as part of its cradle-to-cradle redesign (Source Vanderlande Industries). As well, if properly designed, biobased lubricants are nutrients for the Biosphere instead of being contaminants.

Every manufacturer in Luxembourg uses lubricants and although these are often recommended by the equipment supplier there are often options for changing lubricants.

Measuring progress

Positive impacts are often not recognised due to the limitations of one of the leading methods used to measure impacts; Life Cycle Assessment or Analysis, usually referred to as LCA. See Life Cycle Assessment under Research and Development section for challenges of using LCA to measure circularity.

Potential next steps

- *Secondary Raw materials. Optimizing and scaling-up* existing practices for secondary raw materials in primary and other industries is an effective way to improve environmental impacts.
- *Substitution* is one of the leading ways of improving environmental impacts in Luxembourg and will become mandatory under new EU regulations. Luxembourg industries will set an example by establishing a national programme for HFC substitutes and biobased lubricants, in association with the Chambre des Metiers and one of the CRPs or University of Luxembourg.
- Students might do an inventory of available products and properties.
- By partnering with equipment and biobased lubricant manufacturers, Luxembourg has the potential to generate knock-on effects greater than its own scale because those providers also supply other companies globally.
- Support R&D into biobased substitutes for fossil fuels. See R&D Chapter 8.
- Start a task force for adapting LCA for circularity. See R&D Chapter 8.

6. THE LEGISLATIVE FRAMEWORK

The following section is brief because most of the information is contained in Annex F on positive criteria for legislation as well as Annex G containing extracts from other studies on barriers to implementing circularity.

As well, see Life Cycle Assessment (LCA) under Quick Wins, as LCA underpins much of the legislation being developed affecting circularity.

Takeaways

Internalisation of externalities is the most significant impact of the legislative framework for companies and agencies in Luxembourg and internationally.

Luxembourg has the potential to apply a set of universal positive circularity principles across a range of legislation, regulation and procurement criteria. Those principles were developed on request of the Ministry of the Economy for the present study and are described in Annex F.

6.1. The Present Situation

Circularity is on its way to being adopted in the European and national legislative frameworks through a range of instruments. For example;

- The European Commission circular economy outlook is summarized in its Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions; Towards a circular economy: A zero waste programme for Europe.
- EU framework legislation, strengths and weaknesses, are depicted in the August 2014 EC *Scoping study to identify potential circular economy actions, priority sectors, material flows.* It has ~122 mentions of legislation as well as references to incentives and regulations.
- A 2014 study by the U.K. The All-Party Parliamentary Sustainable Resource Group published *Remanufacturing: Towards a Resource Efficient Economy*, makes recommendations for legislation, regulation and incentives to support re-manufacturing.

Together those studies constitute a wide-ranging set of information on the legislative framework as well as recommendations on how to improve it. Due to the extent of those segments it is suggested to refer to those studies rather than repeat their findings here.

The question examined in the present study is; what is the relevance of those legislative, regulatory and incentives for Luxembourg?

Internalizing Externalities

One of the clearest descriptions of the relevance is described in a 2014 KPMG report entitles *A New Vision of Value*, which described the sum total impacts on companies and governments of legislation and regulations in the social and environmental universe. The report makes compelling reading;

> *Historically, externalities have had little or no impact on the cash flows or risk profiles of most companies. Companies have not been fully rewarded for their positive externalities and have also not paid for much of the damage they cause through negative externalities…*
>
> *…Companies need to better understand their so called 'externalities'. That is because what was 'external' is rapidly being internalized, whether through regulation such as taxes or pricing, changing market dynamics including resource shortages, or more frequent and impactful stakeholder pressure.*
>
> *…What executives need is a method to understand and quantify their externalities and the likelihood they will affect their company's earning capability and risk profile in the future*

DRIVERS OF INTERNALIZATION	EXPLANATION	EXAMPLE
Government regulations and product standards	National, regional or local regulations and industry-specific performance standards designed to change corporate behavior	Laws that limit branding and promotion of tobacco products Product standards such as energy efficiency standards for appliances and emissions standards for cars
Pricing	Mechanisms that put a direct cost on negative externalities	Carbon pricing mechanisms
Subsidies	Removal of subsidies that support the creation of negative externalities or the introduction of subsidies which incentivize the creation of positive externalities	Removal of fossil fuel subsidies
Taxes	Fiscal incentives that encourage positive externalities, penalties that discourage negative externalities	Tax incentives for renewable energy or electric vehicles
Disclosure regulations	Requirements for companies to be transparent about their value creation	Reporting requirements on conflict minerals in the US
Certification standards	Industry collaboration and voluntary action to address externalities and improve societal value creation	The Roundtable on Responsible Palm Oil

Figure 6.1: Drivers of internalization. Source KPMG (p. 21)

Where legislation fits into the picture for internalizing externalities.

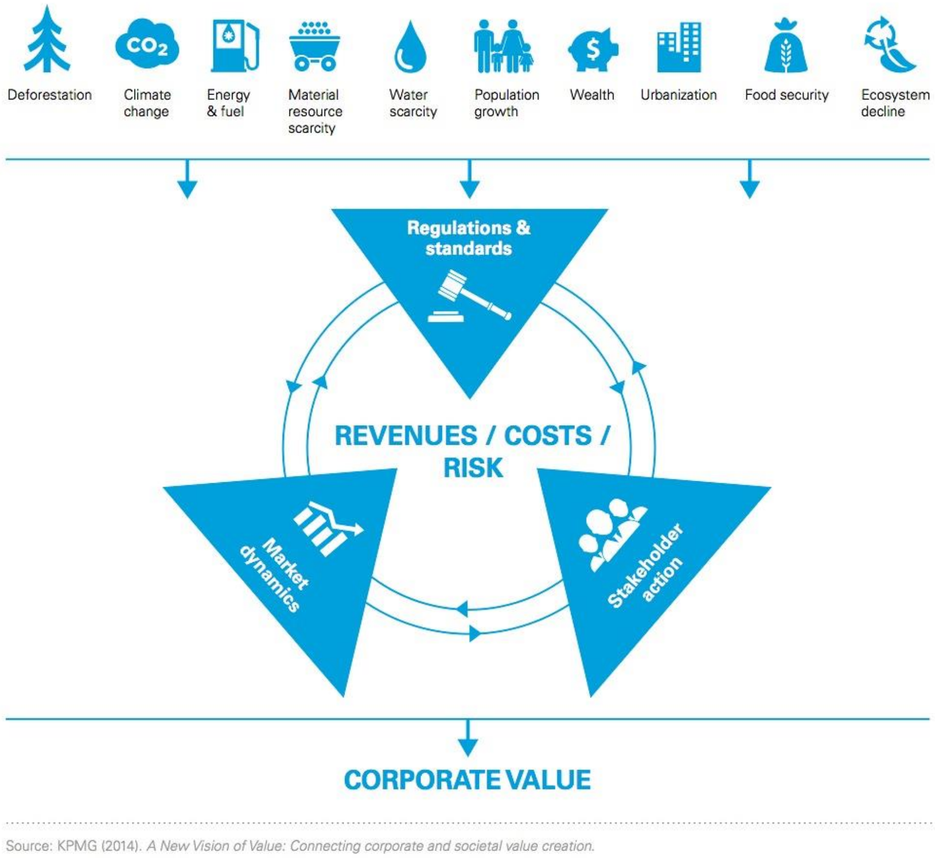


Figure 6.2: The legislative framework is one of three key drivers for internalizing externalities. Source KPMG

6.2. The Potential

The emphasis in the KPMG report that executives need tools to deal with the internalization of externalities, is an effective justification for the focus of the present study. Using materials as a basis, examples of circularity tools described in other sections of the present study include, for example;

- Systems for valorizing secondary raw materials in real time.
- Circularity assessments to evaluate the positive potential of ingredients.
- Upcycling LCA to measure the positive impacts of circularity.

How to consolidate those tools in a legislative framework?

- In July 2014 the Ministry asked EPEA for circularity parameters to include in legislation for government grant funds for R&D, in order to conform with new EU legislation. The aim of the guidelines as requested by the Ministry of the Economy was to make sure the legislation did not accidentally exclude the potential for circularity. Although the guidelines were not in the terms of reference of the study, EPEA and the Ministry took it as an opening to show early results in the context of an approaching national legislative deadline.
- The results are described in Annex F - Principles for new legislation to encourage environmental protection and rationale use of resources. The principles integrate many of the observations and proposals of previously described studies, but are also based many years of marketplace experience. As a result it was later suggested by some members of the study Steering Committee that the guidelines might be used for other types of legislation and regulation in Luxembourg, as well as for procurement and the private investment sector.

The significance of those positive principles for circularity in legislation is high. These will support Luxembourg in assuring that legislation at national and EU levels as well as international conventions, investment guidelines and procurement criteria support circularity in the right ways, and allow companies to internalize externalities competitively. The principles might be utilized for example as a guide by Luxembourg during its EU Presidency.

7. EDUCATION, TRAINING & NATIONAL BRANDING

Overview

Because knowledge of the circular economy is low but readiness to learn is high, the government has a brief opportunity to seize the initiative to be certain everybody gets the right message.

Potential pathways for circularity education, training and messaging for Luxembourg include;

- National quality label to distinguish & promote Luxembourg products internally and externally, also as a public education and awareness tool to generate critical mass for as well as a sense of national participation in the circularity concept.
- National training & education modules adaptable to every level starting with the metiers, the continuing to a range of academic courses, with a focus on adapting to existing mechanisms. Examples exist to draw from.
- Circular supplier communities based on existing communities in construction, manufacturing and office supplies. These redefine the relationship between customer and supplier to improve value and savings and are mechanisms for on-the-job circularity training.

Why

There is a 20% unemployment rate among youth in Luxembourg.

Luxembourg is losing lower-skilled jobs and circularity might provide solutions.

Requirement for circularity skills is identified by most every study on circularity.

A communications mechanism is required to improve public awareness of the circular economy.

Haut Comité pour L'Industrie recommends improving circularity-related competencies.

What

Messaging. Establish a national quality label or brand based on circularity to strengthen existing Luxembourg labelling, distinguish Luxembourg and raise awareness of Luxembourg business as recommended by the Haut Comité report.

Training. Establish a national portfolio of circularity training models to be adapted for diverse disciplines. Integrate training with these tools;

- Circularity Training Space (CTS) for hands-on training of metiers & managers in co-operation with training programmes developed from LuxBuild2020
- Luxembourg industrial competency programme for secondary raw materials.
- High-tech initiatives on Biomaterials Roadmap, composites, nanotech.
- Existing materials initiatives. Avoid reinventing the wheel.
- Working group to adapt LCA for measuring positive impacts of circularity.

Supplier communities. Adapt best practices with supplier communities as a central enabling mechanism for scaling up circularity.

How

Circularity Education, Training & R&D Task Force.

Enrol sector-specific training organisations and provide assistance with curriculum development. For example; Integrate into Luxbuild2020 and other training for the building industry.

Messaging initiative focused on internet media based in Luxembourg

Luxinnovation facilitates circular metals & glass supplier communities in the Greater Region.

Tudor organises an LCA community to optimise LCA for measuring circularity positive impacts

S.W.O.T.

S Luxembourg and The Greater Region co-operate on education.

Education and training on circularity already started.

W General lack of knowledge about how the CE is defined and applied.

O Solving youth unemployment with circularity training.

Flexibility at University of Luxembourg to be exploited quickly due to the newness of the institution.

Focus on materials to upgrade existing economics, sustainability & green education

T Diluting circularity until it becomes waste management or sustainability 2.0

Takeaways

National Co-Branding. Luxembourg faces a historic opportunity to utilise circularity to re-enforce and accelerate its national quality brand.

Circularity education is the priority. In order to maximise advantages and minimize risks of circularity for Luxembourg, an early focus on education and training is a priority. The main strategies might be;

- *Adaptable modules.* A priority is to develop basic training modules for describing circularity, including hands-on training for circularity. While many modules exist already outside Luxembourg *it is strongly recommended to do a quality assurance review on those,* because many contain misconceptions about circularity materials science, which might lead to the wrong usage of materials. See “Science meets Circularity”, Chapter 3.3.

- *Integrate with existing educational mechanisms.* The optimal approach is to integrate circularity into existing education, training and marketing programmes rather than start new ones. Support existing initiatives instead of competing against them. Positively defined materials are universal connectors because everybody uses materials, and most educational and training courses lack modules on positively defined materials.

- *Integration with R&D.* Education goes together with Research and Development. To save costs and improve synergies, integrate R&D initiatives with circularity education & training. See R&D section for information on potential priorities.

Clarify Circular Economy for Stakeholders. Interviews conducted for the present study revealed a clear trend; Awareness of the term ‘circular economy’ is high, motivation to learn more is high, and know-how about supporting technologies and services is high, but the level of knowledge about circularity is low. In many cases companies are already on the way to circularity but don’t call it that.

- *Accuracy*. The opportunity arising from high motivation and low knowledge is to have an accurate story from the beginning. The risk is getting it expensively wrong, as sometimes occurred with sustainability e.g. biobased fuels competing with food, and energy efficiency creating poor indoor air quality. Already there warning signs about these risks with circularity, but Luxembourg still has some time to get it right.

- There is also concern that earlier political struggles with sustainability e.g. plastic bag fees (source Cactus) might be repeated with circularity. Those concerns might be addressed at an early stage through education.

7.1. The Present Situation In Luxembourg, The Greater Region & Benelux

National co-branding

In 2013 the Prime Minister announced the intention of the government to accelerate its national co-brand;

Promotion du Luxembourg

> *Image de marque*
>
> *La promotion du Luxembourg en tant que terre d'accueil d'investissements étrangers, en tant que pays exportateur et en tant que destination touristique, culturelle et commerciale sera fondée sur la mise en place d'un concept de « Nation branding ». Des valeurs positives véhiculées par l'image du Luxembourg seront établies et utilisées par les différents acteurs et dans les campagnes médiatiques officielles pour lesquelles le Gouvernement mettra à disposition les moyens nécessaires. Une approche systématique visera à mesurer, établir et gérer la réputation du Luxembourg.*
>
> *La réalité du vécu au Luxembourg sera en ligne avec les valeurs issues de ces travaux. Le Gouvernement créera un réseau entre tous les acteurs publics et privés qui contribuent à promouvoir l'image du Luxembourg à l'étranger.*

(Source; Statement by the Prime Minister on the Governmental Programme, December 10, 2013.)

The approach was later supported in a presentation by the President of the Chamber of Commerce. (Source Pour une nouvelle croissance. Discours de Michel Wurth, Président de la Chambre de Commerce le 22 avril 2014.)

As well the concept of national co-branding for sustainable construction was described by the Ministry for the Economy;

> *Ecotechnologies (...) Les PME seront soutenues davantage en leur facilitant l'accès à l'innovation et la recherche, en effectuant un «*

branding » du secteur, en réalisant des projets phares et en favorisant l'entrée des acteurs nationaux sur le marché de la Grande-Région. »

(Source Systèmes de certification pour quartiers urbains durables, Tom Eischen Directeur Général de l'Energie Ministère de l'Economie Ettelbrück, le 30 juin 2014)

As well, the Chambre de Commerce and the Chambre des Metiers already have a well-established "Made in Luxembourg" brand with hundreds of businesses participating.

Figure 7.1: Made in Luxembourg label. Source www.luxembourgforbusiness.lu

Figure 7.2: Crafted for Circularity co-brand. Source www.luxembourgforbusiness.lu

Figure 7.3: Examples of co-branding for circularity. Source compiled.

Luxembourg has a range of national-type brands. In the context of many statements from diverse sectors on the value of national branding, a *National Quality Co-brand for Circularity* might be a unifying theme across construction, manufacturing and retailing, especially to complement and support existing labels by gathering them around a theme. However, it will be important that the label is perceived as support and not competition for existing labels. A model might be 'Intel Insight' used by dozens of computer manufacturers, who keep their own identities but gather them around the Intel co-brand to collectively improve marketing of quality. See also chapter Retailing under Sectorial Snapshots for examples of local labels developed by The Pall Center, Cactus and Oikopolis.

Academic & business education & training initiatives

Circularity training and education have started in Luxembourg. There is a strong potential and necessity to integrate them with existing education and training courses in Luxembourg and the Greater Region.

- CRP Henri Tudor and Ecoparc Windhof are participants in the nine-region Interreg C2CBizz project, which in November 2014 published a Guide and Tools for circularity in business development sites. http://www.c2c-centre.com/news/how-realize-your-c2c-ambitions-c2ccentre-gives-you-helping-hand-cradle-cradle-tools
- As part of C2CBizz, Ecoparc Windhof and CRP Henri Tudor did a study on customer/supplier communities for transforming waste into resources. The study is a valuable starter for circularity and might be applied across diverse sites in Luxembourg.
- Neobuild, LuxBuild2020 and the IFSB are developing training programmes for the construction industry, which might have circularity elements. MYEnergy is national coordinator with Chambre des metiers. Federation of handicrafters, and IFSB/CDEC as partners.
- ArcelorMittal has a sustainability communications programme describing the use of recycled steel also for recyclable & reusable structures.
- The Chambre of Commerce, companies and the Luxembourg government developed a Public Private Partnership Learning Factory with potential for integration with a circularity training programme http://www.learningfactory.lu/en/who-we-are.php
- Wallonia is part of the Regions group of the Ellen MacArthur Foundation and is focusing on education about circularity in textiles.
- The EcoInnovation cluster gives presentations on the circular economy.
- Tarkett has an extensive internal communications programme on designing products for circularity, including an E-learning programme.
- Futurelab, Fablab and other learning labs in Luxembourg have the potential to be quickly integrated for circularity.

In the Benelux, a range of circularity training and education courses exist. For example the following is only a sampling rather than an exhaustive list;

The City of Venlo has market consultations with suppliers who want to build with the city according to Cradle to Cradle and circularity. The approach deserves mention because Venlo is saving substantial amounts every year on its new city hall as a result of implementing Cradle to Cradle and circularity with its suppliers and materials. See Venlo case example under Construction in Sectorial Snapshots.

- Ellen MacArthur Foundation in collaboration with e.g. Bradford University has education courses for students as well as seminars for companies and governments and issues one of the first CE-MBA titles.
- Masters courses for Cradle to Cradle are at Twente University and Rotterdam School of Management in The Netherlands.
- TUDelft offers a C2Clab for the built environment.
- Various Netherlands-based companies including Desso & Mosa provide employee training on C2C and circularity.
- Lateral Thinking Factory in Brussels offers seminars on circularity.
- C2CExpolab in Venlo provides seminars on C2C and circularity and has a showroom of products designed for circularity, of high relevance for Luxembourg.

Additional to courses on circularity there are a number of training and education courses, which might provide application tools for circularity, and these include for example;

- Financial leasing
- Modular construction techniques
- Biobased materials and especially biobased additives
- Designing for biodegradability
- Reverse logistics

Finally there are traditional courses, which might be rehabilitated to circularity;

- Waste management & wastewater management
- Energy efficiency & Energy recovery
- Supply chain management

Those differing levels of courses are depicted in Fig. 7.4 to show a potential ‘Circularity Pyramid’ for prioritising education & training in circularity.

Circular supplier communities

Economic successes at Desso, Venlo, Ronneby, Park 2020 and many other organisations in the Benelux have one thing in common; they started circular supplier communities, which brought suppliers and customers together in new ways to improve value. Those successes are being repeated outside the Benelux, for example with the Carlsberg Circular Community which has so far brought together packaging suppliers with combined revenues of €30 billion.

However it is not easy. There are specific management techniques to involving suppliers in a community. As former CEO and circularity pioneer Stef Kranendijk says;

> *It's profitable but it's a lot of work!*
>
> Source EPEA participation at Desso presentations

Circular supplier communities start by educating suppliers about the goals of circularity and what's in it for them and their customers. Communities are already functioning in and around Luxembourg, for example at Tarkett, Ecoparc Windhof, Neobuild, and to a lesser degree at ArcelorMittal, Eurofoil, Norsk, and Guardian Industries. By initiating circular supplier courses across a range of activities Luxembourg has the potential to be a circularity frontrunner.

7.2. The Potential

There are three parallel connected pathways for education, training and messaging on circularity for Luxembourg;

- *National quality label* to further distinguish & promote Luxembourg products nationally and internationally, also as a public education and awareness tool to generate critical mass for as well as a sense of national pride in the circularity concept.

The national co-branding label is described in Chapter 14.5.2 so not further described here, but its importance is high for public education and marketing Luxembourg's image.

- The role of the media in circularity messaging
- Media was not selected by the Study Steering Committee as a focus, but these considerations are worth mentioning here and exploring further; RTL as well as many internet-based media based in Luxembourg together represent a powerful national and international multiplier for education, training and messaging, especially because internet sites are used for

circular leasing and sharing, so are a business case for those websites. Media extensively use high quality and rare strategic materials in their equipment. Their dependence on those materials makes them primary candidates for education on resource productivity and quality.

- National portfolio of practical training & education modules adaptable to every level with a starting focus on the metiers.
  - Adapt the modules to a range of academic and training courses. The focus is on adapting to existing mechanisms. The potential is to develop a portfolio of courses in Luxembourg and the Greater Region with potential to link to circularity, then support those with circularity training modules adapted to their speciality focus. See Annex H for a preliminary list of academic activities, which might be integrated with circularity.
  - While many modules exist already *it is strongly recommended to do a complete quality assurance review on those,* because many contain basic misconceptions about materials science, which might lead to the wrong usage of materials. See "Science meets Circularity", Chapter 3.3.
- *Circular supplier communities* across the spectrum from construction to manufacturing and office supplies. The communities build on existing supply chains but redefine the relationship between customer and supplier to improve value and savings. The communities are core tools for on-the-job circularity training.

Coordination. Due to the range of players in education and training, it will be important to establish a coordinating mechanism, especially for disseminating educational modules and for quality assurance. Luxinnovation working with the Ministries of Education and Labour is one possibility.

Integration with existing Luxembourg education and training

Education and training in Luxembourg need no lengthy introduction here as the infrastructure is well known the Ministry of the economy and other stakeholders. For example the education community is described in the Haut Comité pour l'Industrie report. There are more than 20 universities in a 200km radius of Luxembourg. An inventory of their work on materials, sustainability might be valuable. The GR university consortium is a valuable tool.

See Annex H for the start of an inventory of courses, which are candidates for being connected to circularity in the materials R&D field.

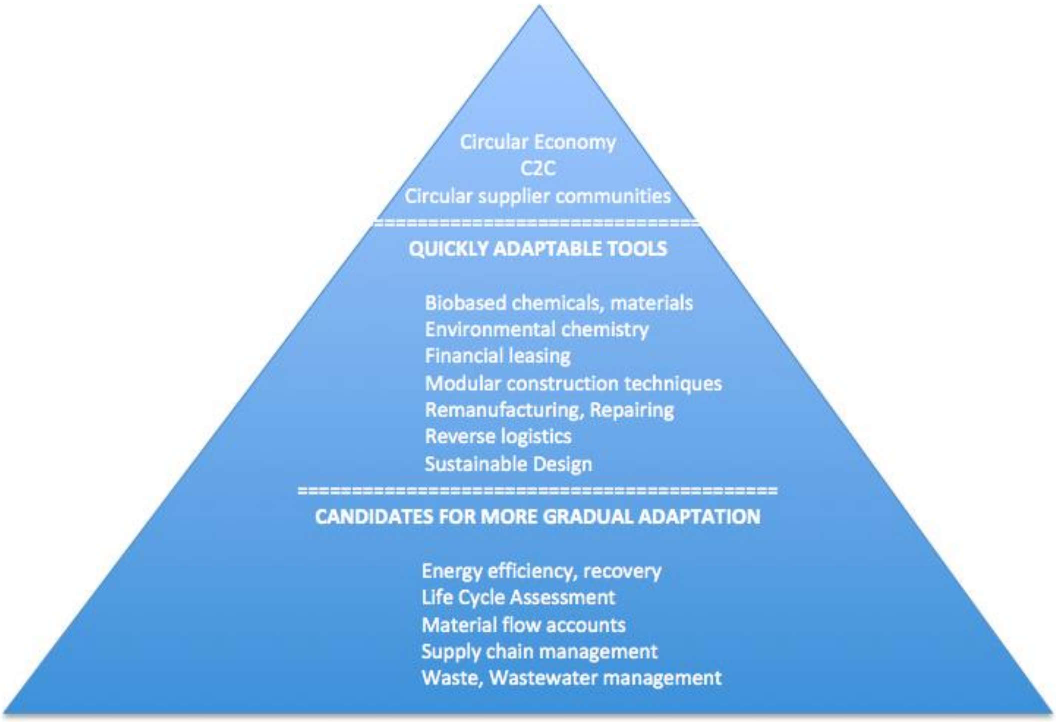


Figure 7.4: Circularity pyramid for prioritising training & education. Source EPEA

Where to start

- National quality label based on circularity to improve competitiveness of local products and raise public and business awareness. See Chapter 14.5.2
- Circular Customer/Supplier Communities in manufacturing and office supplies. For example a National paper upcycling campaign with the financial sector and ministries, and National Secondary Materials campaign with the metal and specialty glass industries. See Chapter 14.5.7 more information.
- Circularity Training Space (CTS) to provide hands-on training for Metiers as well as professionals in designs for assembly & disassembly and other circularity skills. See Chapter 14.5.3 for more information.
- LCA circularity task force to develop understanding of how LCA might be adapted for measuring positive impacts of circularity. See Chapter 14.5.5 for more.

8. RESEARCH & DEVELOPMENT

Materials R&D is the main focus of the following chapter because;

- It is the main guidance focus from the Study Steering committee
- Luxembourg-based companies have high competency in materials R&D.
- The majority of the Luxembourg R&D programme focuses on materials. See Figure 8.1. (Source Ministry of the Economy, National plan for smart, sustainable and inclusive growth Luxembourg 2020 p. 32)

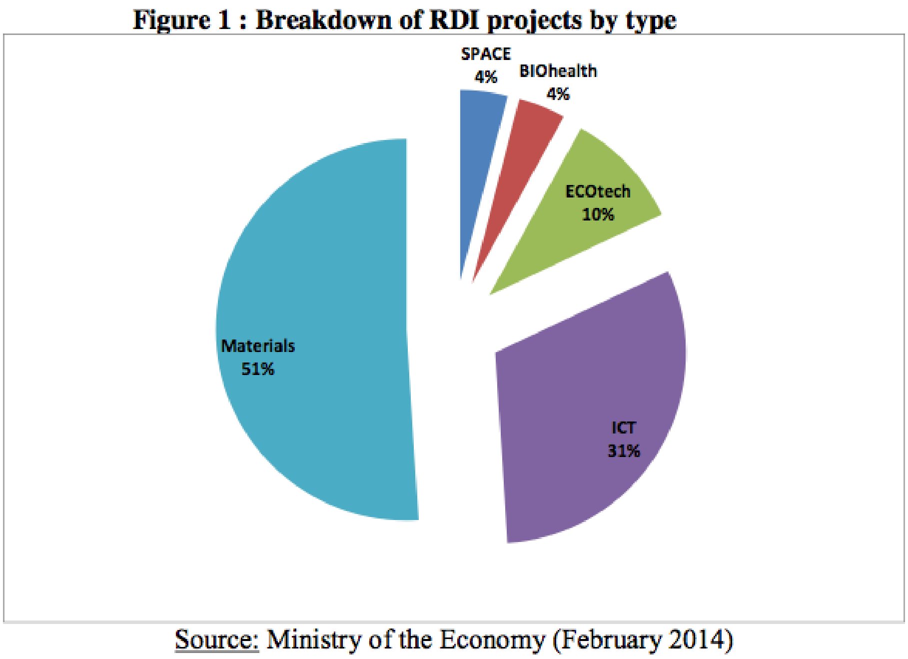


Figure 8.1: Breakdown of RDI projects. Source Ministry of the Economy

Science meets circularity through research and development. Companies focused on R&D for circularity are already successful in the marketplace.

In that context big potential circularity wins for R&D in Luxembourg include;

- At a transformative technologies level, integrate 3D additive manufacturing, robotics and automation with circularity to drive near-shoring of jobs in Luxembourg.
- At a traditional and transitional level, work on positively-defined materials, technologies and systems that are healthy and functional.

The opportunity is to take inspiration from existing materials, products and systems designed for circularity. A range of products and supplier communities is already functioning in and near Luxembourg for researchers to benefit from.

Why

Hundreds of substances used in products are already positively defined according to a well-tested methodology and are useable now, but thousands more are not and have to be optimised or replaced.

The Circular Economy depends on R&D to develop positively defined materials and those materials depend on additives, ingredients and coatings to be functional and beneficial.

Profitable recycling depends on positively defined materials and ingredients.

Nanomaterials, composites, biomaterials are revolutionizing materials science, and rapidly entering the marketplace. Those pose advantages & risks.

Luxembourg and the Greater Region have excellent materials science capacities. The materials cluster is surveying composites potential. Biomaterials have one of the largest growth potentials among materials and Luxembourg institutions just completed a draft biomaterials roadmap.

What

A focus for materials and processes is still to be determined.

However, present directions in Luxembourg suggest additive manufacturing, biomaterials, robotics, nanomaterials and composites.

How

Utilise the Greater Region university co-operation framework for circularity and align the Biomaterials Roadmap with a circular materials R&D roadmap.

S.W.O.T.

S Corporate R&D based in Luxembourg. Greater Region connectivity between universities.

W Scaling up research into markets

O Near-shoring by integrating biomaterials, reverse robotics, 3D manufacturing & disassembly

Focused investment into essential technology to establish cutting edge lead, which is hard to replicate (e.g. additive manufacturing. Concrete 3D printer).

T Businesses under-estimating the fundamental role of science in circularity

8.1. The Present Situation

Snapshot of materials R&D organisations in Luxembourg

Luxembourg has a rich diversity of organisations with high level materials competencies which are described in an April 2014 pamphlet published by the Luxembourg Materials Cluster, and there is no need to repeat the same information in the present study. Additional to the organisations described in Fig. 8.2 on materials research (Source Luxembourg Materials Cluster. *Turning Innovation into Business. Luxembourg materials competencies. April 2014)*, companies like Tarkett and ArcelorMittal have extensive expertise in a range of materials, so the expertise is still more extensive than shown here.

In total, Luxembourg is well positioned with expertise in the past, present and future materials important to Europe's economy and to the circular economy. The questions are, which are most relevant for circularity and where to focus for Luxembourg?

Table 8.1 describes the range of R&D going on in and around Luxembourg with potential relevance for circularity. The table is a starting point for the Innovation clusters to start evaluating and coordinating circularity work.

Innovation clusters role

The innovation clusters (Fig. 8.3) are central mechanisms in Luxembourg for coordinating R&D, but they are relatively new and some are still looking for a focus. The present study concludes that circularity might be a unifying focus for the Innovation clusters, and that the Ecoinnovation Cluster is the optimal place to put the working group for the National Circularity Initiative. For materials related research the EcoInnovation cluster (Fig. 8.4 + 8.5) and the Materials cluster each have valuable capacities to draw from and it will be important to align those. In general, it will be productive to align circularity aspects of diverse materials-related initiatives from across the innovation clusters.

PRIVATE SECTOR

Amer-Sil 08
Ateliers Nic Georges 10
Ceratizit 12
Delphi Automotive Systems Luxembourg. 14
Dupont de Nemours (Luxembourg) Sàrl 16
Dupont Teijin Films Luxembourg S.A. 24
Euro-Composites 26
Eurofoil Luxembourg S.A.. 28
eXtream engineering 30
Glanzstoff industries 32
Goodyear S.A.. 34
Hitec Luxembourg S.A. 36
IEE S.A. 38
Ingenium Tooling S.A.. 40
Saturne Technology 42

PUBLIC RESEARCH

CRP Gabril lippmann Science and Analysis of Materials department (SAM) 44
CRP Henri Tudor 46
University of Luxembourg: Research Unit in Engineering Sciences. . 48
University of Luxembourg: Research Unit Physics and Materials. . . . 58

Figure 8.2: Examples of materials competency organisations in Luxembourg.
Source Luxembourg Materials Cluster

Figure 8.3: Overview of Luxembourg Cluster Initiative. Source EcoInnovation Cluster

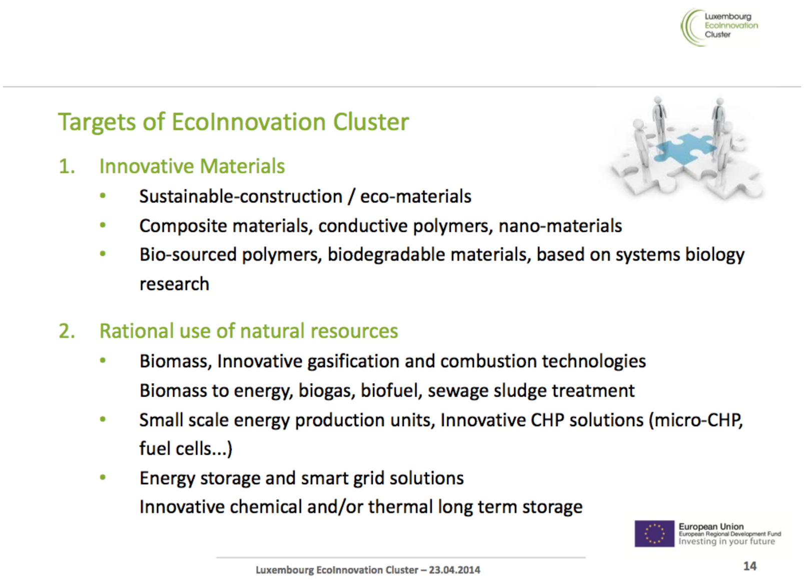


Figure 8.4: Targets of EcoInnovation Cluster. Source EcoInnovation Cluster

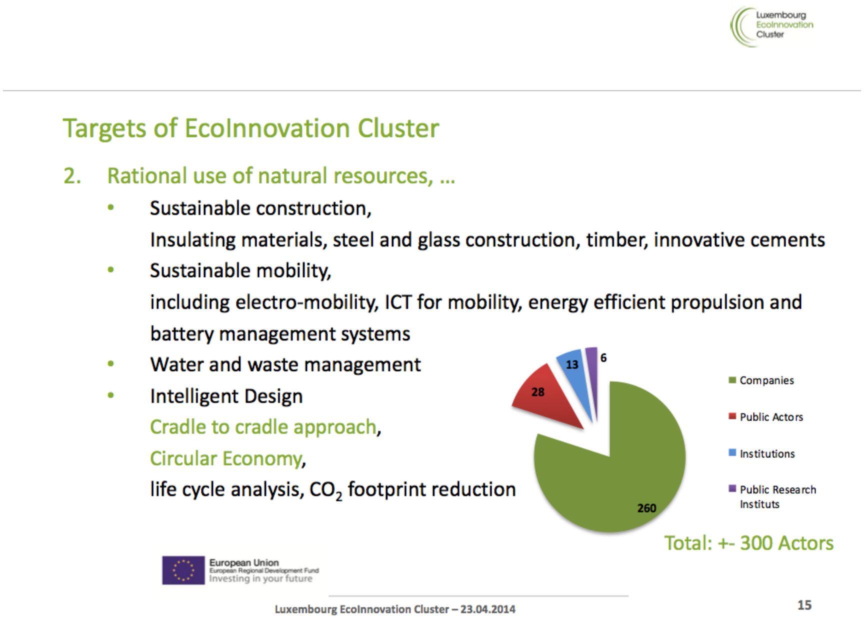


Figure 8.5: Overview of EcoInnovation cluster materials-related initiatives (ctd.). Source EcoInnovation Cluster

8.2. Overview Of R&D Categories For Circularity In The Present Study

Research and development are achieved through the interaction between science and commerce. In the circular economy, science and commerce interact at fundamental levels because under the biological and technical parameters of the CE, and in practice, functional healthy materials are advantageous for a profitable circular economy.

For the purposes of the present study and accounting for the materials focus, R&D as well as science for circularity falls into the following categories relevant for Luxembourg. These categories are by no means comprehensive because a far wider range of environmental chemistry, ecosystem analysis, and behavioural science affects the CE, but because the present study is focusing on materials and economy here are the most relevant categories;

A. Multifunctional, positively defined ingredients, materials & coatings

B. Systems for manufacturing, using, and recovering circular materials, components & products.
C. Measuring circularity impacts.

The following table 8.1 describes R&D examples in Luxembourg and the Greater Region relevant for those circularity categories;

Table 8.1: Examples of R&D activities in Luxembourg with circularity relevance (*A, B, C denotes circularity categories described previously)

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
	Luxembourg	
Tarkett research on circular materials **Relevance to Past, present, future;** **Past**; how to deal with old PVC **Present;** materials already upgraded for circularity **Future**; new options for materials	Research on & measurement of healthy materials defined as biological or technical resources. Relevant to; A,B,C	http://www.tarkett.com/en/content/good-materials; http://www.tarkett.com/en/content/reuse
Cimalux **Relevance to Past, present, future;** *Past;* re-use of old concrete *Future;* carbon capture and re-use	Carbon capture and re-use, Credits for carbonation effect; re-use of recycled concrete. Relevant to; A,C.	http://www.innovation.public.lu/en/collaborations/trouver-partenaires/entreprises/c/cimalux/rdi/index.html
Eurofoil facility expansion for optimizing recycled aluminium use **Relevance to Past, present, future;** **Present**; optimising re-use of scrap aluminium	Relevant to; A,B.	http://www.eurofoil.com/newsletter/201312/EurofoilAnnouncesStrategicInvestment_EN.pdf

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
Tudor - Ecopark Windhof C2C waste recycling incl. paper **Relevance to Past, present, future;** **Present;** optimizing recycling **Future;** Optimizing the printing cycle including inks, fillers, smoothers, whiteners.	Towards Cradle to Cradle waste management – A case Study of Ecopark Windhof. Relevant to; A,B,C	Internship report at CRP Henri Tudor
Research on LCA – CRP Tudor, ArcelorMittal, Tarkett also continuously developing and implementing LCAs **Relevance to Past, present, future;** **Present & Future;** Quantifying positive impacts	Relevant to; C.	Tudor http://www.tudor.lu/en/product/environmental-evaluation-and-ecodesign; http://www.tudor.lu/en/product/development-ecotechnologies-and-support-eco-innovation ArcelorMittal http://corporate.arcelormittal.com/what-we-do/research-and-development/life-cycle-assessment Tarkett http://www.tarkett.com/en/content/innovation
Neobuild research on building systems and materials **Relevance to Past, present, future;** **Present;** Using best available technologies **Future;** Total quality environments, improved residual value.	Healthy buildings as well buildings as material banks are important factors for circular materials flows. Relevant to; A,B.	http://www.neobuild.lu/

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
Fablab 3-D design facility @ Technocenter **Relevance to Past, present, future;** **Present;** Prototyping **Future;** Designs for reversibility, Optimizing feedstock for scaling up 3D series manufacturing , repair and re-manufacturing services for small series and on demand spare part production.	Relevant to; A,B.	http://www.technoport.lu/online/www/content/fablab/188/ENG/index.html
Goodyear **Relevance to Past, present, future;** **Past;** *Old Tires* **Present;** *Used Tires* **Future;** *Biobased tires & additives*	Biobased materials, Pyrolysis Relevant to; A,B,C	
Investigation into human-robot interactions (HRI) for disassembly (Prof. Plapper) **Relevance to Past, present, future;** **Future;** Rapid disassembly of products & systems	Disassembly plays important role in Circularity; optimizing that process makes the difference between profit and loss in material recovery. Relevant to; B	www.business-meets-research.lu/content/download/17356/168395/version/1/file/1. BPlapper-Uni_lu.pdf; http://www.plapper.com/robotik.php
Biomaterials roadmap **Relevance to Past, present, future;** **Future;** Biomaterials for Biosphere & Technosphere	LIST will have joint Materials department, incl. work on biomaterials. Relevant to; A,B,C	http://www.list.lu
SDK – pilot projects **Relevance to Past, present, future;** **Past & present** optimising separation **Future;** Valorising products instead of waste	Various pilot project with households and business to raise awareness and optimize material flows for re-consumption. Relevant to; B,C	http://sdk.lu/de/Home.html

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
Retail - local label research done by Cactus, Pall Center, Oikopolis - independent, market based research **Relevance to Past, present, future;** **Present & Future**; Local materials quality & marketability	Various labels focusing on local quality over price have been brought to market supporting local value chains; experience can be used to build national quality label. Relevant to; A,B,	See retailer websites as well as Chamber of Commerce and Chambre des Metiers "made in Luxembourg" label. http://www.made-in-luxembourg.lu/
New Luxembourg legislation for grants to private companies for R&D **Relevance to Past, present, future;** **Future;** Avoid discouraging potential for positively defined funding parameters for circularity.	Ensuring that legislation for grants to private companies in Luxembourg does not include parameters giving CE projects a disadvantage. Relevant to; A,B,C	http://www.innovation.public.lu/en/financer-projets/rd-entreprise/index.html
Investigation into circularity statistics by GR Eco-innovation group **Relevance to Past, present, future;** **Future;** knowing what you have in order to measure circularity	Material flow statistics usually centre around waste flows; for circularity new data points need to be gathered to have meaningful reflection on circularity potentials and value creation	EcoInnovation cluster is organising part of the group. Marcel Klesen.
Investigation into insulation materials by energy group of Ministry of Economy **Relevance to Past, present, future;** **Future;** Healthy efficient insulators	Phase change, improving R-values.	
Composites survey by materials innovation cluster **Relevance to Past, present, future;** **Future;** potential composites for development focus	Feasibility study for the establishment of a Composite Competence Centre in Luxembourg	http://www.materialscluster.lu/News/A-study-to-assess-the-needs-of-the-composites-value-chain-in-Luxembourg
Clean tech sector in Luxembourg (Requires separate analysis for circularity)		http://www.luxembourgforbusiness.lu/en/news-benchmarks/luxembourgs-new-website-dedicated-clean-technologies

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
	Greater Region	
Wallonia – reverse metallurgy **Relevance to Past, present, future;** **Future;** Designing metal product to maximise residual value.	Designing metal product to maximise residual value.	http://www.gre-liege.be/reverse-metallurgy-2/
Wallonia - circularity textiles activities **Relevance to Past, present, future;** **Present & Future**; textiles recovery	In development	http://www.agoria.be/fr/Economie-circulaire-comment-participer-au-programme-wallon-NEXT
Wallonia - Centre d'Impulsion Bois et Construction durable	Researching sustainable construction with wood	http://www.wfg.be/francais/wfg/
Concrete recycling, Greater Region Universities **Relevance to Past, present, future;** Past & present	Large, local material flow in Luxembourg; re-use options are value-added	www.uni-gr.eu/recyclingconcrete
Neobuild as part of CDEC is conducting research with its new building. **Relevance to Past, present, future;** **Present;** Optimising insulators, renewable energy use, urban biodiversity **Future;** Healthier buildings	Sourcing regional products	http://neobuild.lu/NIC_Tour
DuPont Nemours **Relevance to Past, present, future;**	A range of R&D for example on geotextiles for stabilizing excavation soils, phase change materials for improving insulation in walls & floors.	http://www.innovation.public.lu/application/catalogue/entreprises/dupont-de-nemours/pdf_en_dupont-de-nemours.pdf

R&D Project Name Relevance to past, present & future materials	Description Relevance to Circularity R&D Categories	Contact/ Website
Academic courses	A range of research related to circularity is happening as part of Masters and other academic courses at Greater Region universities. For a list of related courses see Annex H.	
Financial, Big Data, and construction systems R&D are covered under Sectorial Snapshots in the finance & construction sections.		

8.3. Positively-Defined Additives, Ingredients, Materials & Coatings

Coatings and trace elements make a solar panel functional. A 100 percent cotton shirt is only 80 % cotton and the rest is coatings, smoothers, and colorants. Plastic packaging contains thousands of additives to make it functional. Those are a few examples of why the circular economy depends as much on additives as on materials and systems that manufacture and use them.

There are many examples of positively defined and actively beneficial materials in the marketplace including; floor and wall coverings that actively clean the air, walls and roofs of buildings that actively store and release energy, and others.

In Luxembourg, organisations like Ecoparc Windhof and Neobuild are dedicated to developing and using multifunctional materials in buildings as well as transferring actively positive technologies from other industries into the building sector (Source Bruno Renders & Jeannot Schroeder Interviews).

However, in order to be positively defined and actively positive, products and systems involve a relatively high level of science. Hundreds of thousands of ingredients go into products, and those ingredients as well as manufacturing systems, which produce them, are based on science. In that context here are some relevant numbers;

- The total number of bulk materials, which constitute most products today, is less than one hundred, considering glass, metals, polymers, and other materials.
- The total number of substances e.g. additives, coatings and other ingredients which are essential for manufacturing and give products & systems functionality is in the hundreds of thousands. Among those about five thousand are used on a regular basis for polymers, glass, metal, paint, wood and paper products, food, textiles, etc.

However, because most economists are not materials scientists, the role of additives in the circular economy is seriously under-estimated. As a result most attention on circularity today is going to bulk materials, whereas the functionality, circularity impacts and economics of recycling rely on additives.

WHERE TO FOCUS CIRCULARITY INVESTMENTS?

TOTAL TYPES OF BULK MATERIALS USED IN 95% OF INDUSTRIAL SOCIETY

< 100

TOTAL ADDITIVES, COATINGS & CATALYSTS, WHICH MAKE MATERIALS FUNCTIONAL

>100,0000 of which ~5000 are used commonly.

Why the under-emphasis on additives & ingredients?

Additives, ingredients and coatings are the building blocks of product functionality. Because of this they have a big influence on circular economy value streams. The residual value of materials and products, the design of recycling technologies and energy required to recycle are each affected.

However, the science surrounding additives plays only a minor role in circularity reports. For example, the EC scoping study contains no mentions of coatings, one mention of the term ‘additives’ and only two of ‘ingredients’. The under-emphasis on additives is clear in the following section of the EC review;

> *Improving material selection, product design (standardization/ modularization of components, purer material flows, and design for*

easier disassembly) and changing production methods are levers for a circular economy. (p. 22 Annex 1)

The emphasis is on mechanical & systems designs rather than additives designs. The exception is reference to 'purer materials flows'. However the term 'purer' refers to de-materialization of complex materials back to their molecular state. While such pure states occasionally occur with metals, glass and polymers, the purity is short-lived because additives are used to give those materials their functionality, as part of the dematerialization process.

As a result, materials in products are almost never pure. As more composites enter the marketplace, "pure" materials are becoming a thing of the past.

The cause of the lack of focus on additives in those publications is easy to identify; materials scientists were usually not involved in drafting circular economy reports, and if they were they were often not trained in circularity methods (Source; EPEA participated in the studies but at a late phase).

Implications of additives for business

> The difference between science-based and non-science-based circularity is the difference between recycling and downcycling as well as profit and loss.

Substances defined for circular cycles, for example in the flooring, textiles & logistics industries, are proving successful. For example various case examples on products by companies like Desso (Airmaster®), Shaw (EcoWorx®), (Rohner/Gessner (Climatex®), Vanderlande Industries (Blueveyor® conveyor systems), and Hermann Miller (Mirra® chair) describe how it is possible to redesign materials for circularity. Those products are in the marketplace for between 3 and 12 years so are proving their worth.

However, systems, which do not account for additives, for example most traditional recycling systems, are running into expensive quality assurance problems because the additives become contaminants. A brief scholarly search for 'contaminants' in recycling of paper, metal, polymers and other materials (9,000 Google hits) testifies to the depth and cost of the problem.

As well, the interactions between additives and the health impacts of some additives are simply not yet known, and this is especially true of nanomaterials and composites. The degree of unknowns is accelerating rather than decreasing as thousands of new substances enter markets.

New materials

The High Committee for Industry acknowledges the role rapid prototyping, nanotechnologies, and new materials are playing and will play in the economy. Composites and nanostructured materials are rapidly taking over the functionality aspects of products. This is not to say the role of basic materials is declining; actually in real numbers it is increasing.

However, composites and nanomaterials are being added to basic materials as surfaces, coatings, and additives to improve functionality. The new Airbus and Boeing aircraft as well as new passenger vehicles are prime examples, where materials weight is reduced but materials complexity is increased.

The complexity those nanomaterials and composites bring to circularity is the opposite of what is recommended in the 2014 WEF publications Towards the Circular Economy. The WEF publication recommends focusing on “pure” materials, at a time when industry is heading in the opposite direction.

However, at the same time extensive R&D is going on into nanomaterials that self assemble and disassemble, as well as biological methods of separating, decomposing and recycling composites, and these methods hold basic significance for the future of materials re-use.

8.4. Biobased Ingredients, Materials, & Coatings

Why biobased?

In the circular economy biobased materials have the potential to establish a positive feedback cycle of raw material production, conversion, manufacturing, use, and re-use. The approach applies to the Technosphere and Biosphere because biobased chemicals are also used for technical cycle products.

The following graph Figure 8.6 describes the market potential for biobased chemicals and materials.

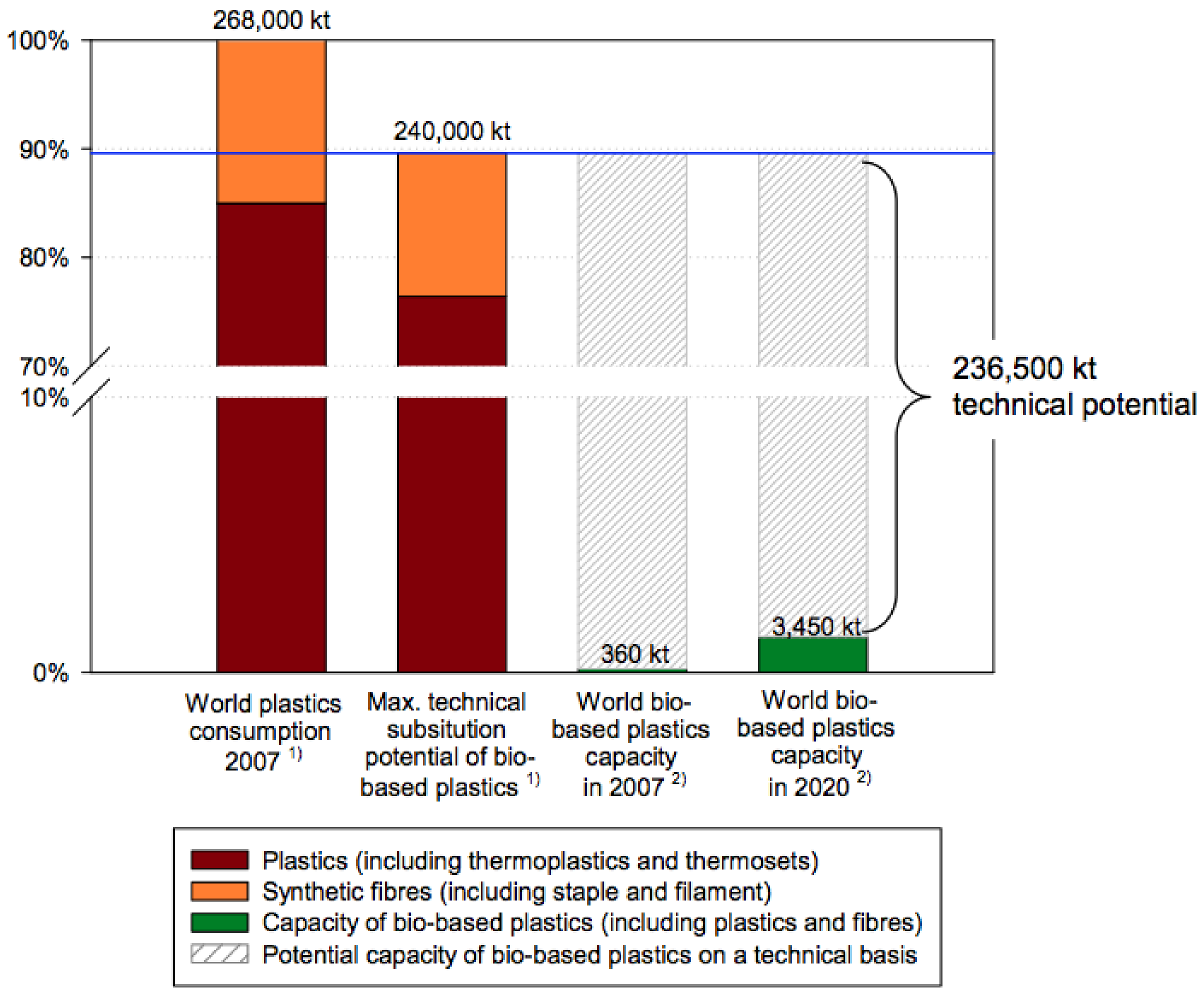


Figure 8.6: Potential for replacing non-renewable polymers, and projected growth rates for bio-based plastics. Source Shen et al.

Defining Biobased

To maximise the marketplace potential a first step is to clearly describe what are biobased chemicals and materials. Scientists interviewed for the present study agree there is lack of clarity among politicians and business leaders about the term biobased materials, which has also complicated funding for the field. Examples of items to clarify;

- Biobased and biodegradable are not the same, but are often confused with each other.
- Biobased chemicals are as important economically if not more so than biobased materials. The materials are made from the chemicals.
- Non-renewable also can be biodegradable. Materials manufactured from non-renewable, non-biobased sources can be designed to be biodegradable.
- Non-biodegradability is often good. Biobased materials are often designed to not be biodegradable. In the case of technical cycle products non-degradability is a preferred trait to improve recycling potential. The approach is to bring biobased material to higher performances to be able to compete with conventional oil-based polymers (and not only be used in the production of disposable products)
- Additives. Regardless if materials are biodegradable, if the additives or coatings used to give them functionality are not biodegradable then the overall product is rendered non-degradable or unsafe for biodegradation in ecosystems.
- CO_2 is a functional and profitable biobased chemical, not just a climate change gas to be reduced. Where does it fit into the biobased materials roadmap?
- Natural vegetation is a biobased material, which on its own performs valuable circularity functions and is already used in large-scale applications like air filtration. How does it fit into a biobased materials roadmap?

An important step in the biobased composites roadmap recently drafted in Luxembourg as part of the *Composite Unit of the future Materials Department of the LIST,* is to clarify those questions. For example, a further step in the drafting of the roadmap is defining biobased materials and additives for circularity according to their intended use in the Technosphere or Biosphere.

Present situation with biobased R&D in Luxembourg & the Greater Region

Biomaterials roadmap. In October 2014 the R&D community in Luxembourg generated the first draft of a biomaterials roadmap as part of the Composite Unit of the future Materials Department of the LIST, and considering that "Biocomposites" as a research topic has been selected together with 6 other topics (including nanotechnologies) by the Conseil d'Administration of LIST to be a "vitrine" and a topic of excellence of the future LIST (Source Dr. Valérie Toniazzo, Materials' Research Unit Manager, CRP Henri Tudor).

Luxembourg's academic researchers have been more and more involved in biobased materials research over the past years, as described by Dr. Valérie Toniazzo;

> *We actively collaborate with the following Universities and Institutions for projects on*

(i) *PLA,*

(ii) *(ii) Biobased plastics/composites/fire retardents,*

(iii) *Natural Fibers composites or*

(iv) *partially biobased thermosetting resins :*

> *- Mons University, Belgium - Pr. Philippe Dubois (High impact PLA for durable applications; valorization of recycled PLA and PLA blends)*
>
> *- Lorraine University, Pr. Stéphane André (Mechanical properties of recycled PLA and PLA blends), Pr. Michel Ferriol (fire retardancy of biobased systems)*
>
> *- Lille University (UMET): Pr. Bourbigot (Biobased Fire Retardants)*
>
> *- Strasbourg University : Pr. Nadia Bahlouli (Natural Fibres Composites for the automotive industry)*
>
> *- Cergy Pontoise University: Pr. Frédéric Vidal (Inter Penetrated Networks to improve partially biobased thermosetting resins)*
>
> *Our network is much larger but only collaborations currently active <u>on funded projects</u> have been mentioned above*
>
> *The way we collaborate: we are either partners in competitive funding projects, or we co-supervise PhD students affiliated at the above*

mentioned foreign Universities (the ability to affiliate our PhD students at Luxembourg University is only very recent). (Source email Dr. Valerie Toniazzo Sept 2, 2014).

The situation regarding biobased materials in Luxembourg and the EU was summarized in an interview for the present study (Source interview Dr. Valerie Toniazzo);

'The incursion of Biomaterials in the market remains low in Luxembourg, but this is also true for the rest of the EU.

This is not only due to (still) higher prices or lower performances (in various areas alternate biomaterials prove more and more to fulfill most of the technical and market specifications), but mostly to political/legislation and economical framework reasons:

Over the last ten years numerous studies have demonstrated the potential of bio-based chemicals and materials in creating new green jobs (Bio 2010, Carrez 2010), increasing resource efficiency and making a great contribution to climate protection based on Innovation. It has been demonstrated that the added value and the job creation coming from the use of biomass to produce biochemicals and biomaterials instead of using if for bioenergy was tremendously higher (5 to 10 times!!). Despite these recognized potential benefits, the investment in industrial biotechnology and biorefineries in Europe remains low. The political and economical framework in all Europe (and therefore the impact on Luxembourg) does not support [or not enough… even if it starts now with the BBI JU between EU and the Bio-Based Industry in July 2014] the industrialization of the biomass to produce materials. This is in contrast to bioenergy and especially biofuels, which has expanded rapidly in the EU over the last ten years.

In the context of oil price increase and oil resource depletion, biomass is and will remain the only renewable source of Carbon! Therefore, despite these economical and political locks, the use of biobased materials raised over the past years in many market segments and is expected to continue to grow in the future, as well as the production capacities of some biopolymers (PLA, Bio, Bio-PET, PEF).

Supporting the new BBC; biobased biocompatible chemicals

The potential for biobased materials and chemicals for Luxembourg

The potential of biobased materials to substitute for non-renewable materials is clearly described in Figure 8.6.

As well, in October 2014 Germany's Federal Ministry of Education and Research published a landmark addition to its existing National research strategy on biomaterials; *Destination Bioeconomy. Research for a Biobased and Sustainable Economic Growth.* The publication makes clear Germany's intentions for continued large investment into the biobased economy.

For example; there is considerable research into replacing high cost carbon fibre manufacturing with biobased sources, because the energy demand of carbon fibres is huge compared to biofibres, and recent discoveries promise to cut graphene costs by up to 90%. (Source; Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy)

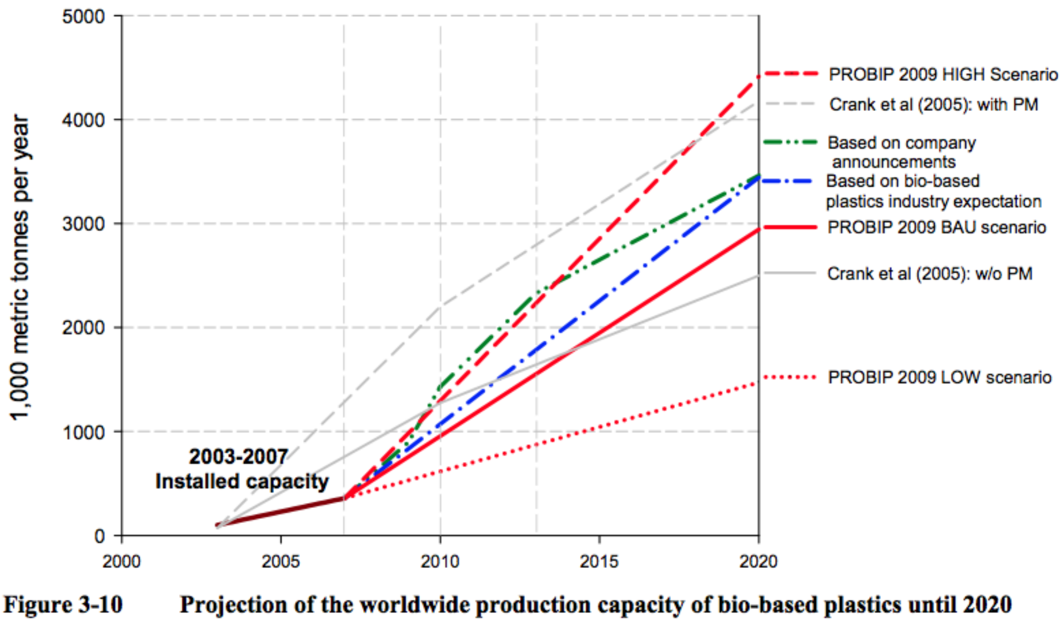
Why do it in Luxembourg?

A Ministry of the Economy representative asked the following question; If Luxembourg has such a small territory for biomass, and its R&D institutions are not so well developed in the biobased economy, why focus on biobased materials?

The question is valid and the answers are clear;

- Among the big wins in biobased materials are intellectual property for new technologies to exploit those materials, as well as in the thousands of additives used to give biobased materials their functionality. Companies like e.g. DuPont Nemours are potentially big players in those fields, but also the various R&D institutes in Luxembourg working through their well established network of research institutes in the Greater Region.
- *Sourcing.* Luxembourg might have a small territory but 85% of it is farmland and forest. Those assets represent a large laboratory for piloting biobased materials. One area for investigation is whether Luxembourg's forestry assets are under-utilised. As well, new technologies like closed-loop algae production occur vertically rather than horizontally, reducing land requirements and allowing integrated land use. Potentials include unused brownfields, and Luxembourg's brewing and wastewater industries, which generate nutrient-rich effluent. Institutes in some countries are beginning to utilize those sources and locations for biomass. As well, large CO_2 producers like the primary metal and glass industries are candidates for algae pilot projects. CO_2 is being captured and reused by companies like Mitsubishi Heavy Industries.
- *Materials security, re-use.* Luxembourg's secondary manufacturing industries like automotive components rely on polymers. Those polymers will increasingly become biobased. As well, if biodegradation of composites is established for the automotive industry, Luxembourg has the reverse logistics, scientific, automotive and other capacities to exploit the trend. The approach is in line with the focus on automotive high technologies recommended by the Haut Comité pour l'industry.

- *Jobs potential.* The employment potential for circularity of composites, nanomaterials and biobased materials is as great or small as the imagination and investment readiness of Luxembourg-based institutions allows. If as forecasted in Fig. 8.7 biobased materials continue replacing millions of tonnes of fossil fuel-based polymers at the current rate of growth, the jobs connected to the R&D, piloting and scale-up are in the thousands.



8.7: Projected worldwide production capacity of bio-based plastics. (Source V. Toniazzo , CRP Henri Tudor)

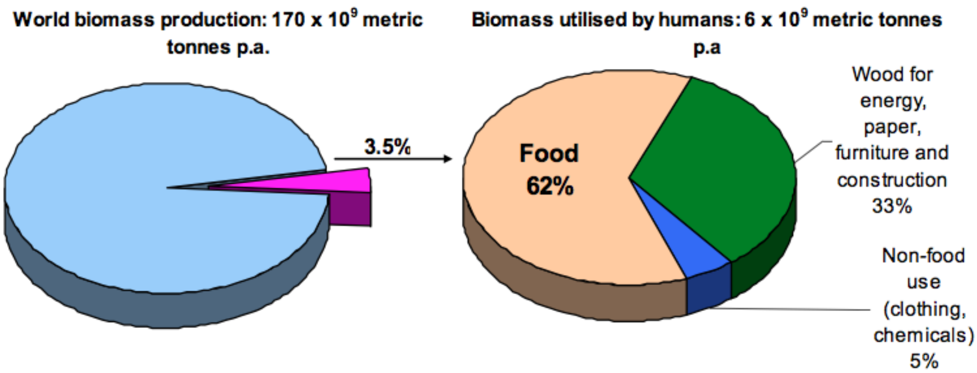


Figure 1-1 World biomass production (left) and biomass utilised by human (right)

Figure 8.8: The potential for using biomass compared to what nature generates is exponential. Source. Shen et al

Figure 8.9: The wider framework potential for the biobased economy visualized. Source Nova Institute, http://www.nova-institut.de/bio/?lng=en

Biobased additives, coatings

As described earlier, additives and coatings improve the functionality of materials. There are more than 100,000 related substances in use today, but among those about 5,000 are most commonly used. Still, 5000 is exponentially greater than the variety of base materials used in manufacturing.

Considerable R&D is going into biobased additives and coatings to replace substances derived from non-renewable resources like metals and petroleum.

For additives, biomass is an extraordinary chemical platform reservoir that R&D is now starting to extract from, purify and exploit to produce;

- alternate fire retardants (alternative to halogen-based), solvents (to limit VOC in utilization) & lubricants.
- biobased: aromatics, diols, diacids, bioethanol from 2nd generation feedstocks for biofuels and biochemicals.
- for coatings (but also packaging and printing), mainly hydrophobic molecules (mainly proteins and peptides derived from second generation sugars from agricultural residues) are targeted to replace the harmful fluorinated compounds and silanes derived from fossil fuels. (Source V. Toniazzo , CRP Henri Tudor)

CO_2 as a biobased chemical

CO_2 is a large available source of carbon to produce materials and chemicals. Research for the capture of CO_2 and its conversion into chemicals and building blocks is starting with the development of related new processes. CO_2 is a safe and effective solvent to replace toxic chemicals for preparing metal surfaces across diverse industrial activities.

As an example of the rapid acceleration in CO_2 Reutilisation technologies; at least three CO_2 Re-utilisation conferences were held over a 3-month period in 2014 in western Germany;

- 3rd International Workshop "CO_2: How to use it as a resource" [http://www.energieagentur.nrw.de/kraftwerkstechnik/3rd-international-workshop-co2-how-to-use-it-as-a-resource-25301.asp?find=]
- Conference on Carbon Dioxide as Feedstock for Chemicals and Polymers http://10times.com/chemicals-polymers-summit
- https://www.chemiehoch3.de/de/home/events/2014/3rd-carbon-dioxide-utilisation-summit.html

Is CO_2 re-utilisation too advanced for Luxembourg? No. It is in the markets already today. See section on Improving Environmental Impacts for substituting HFCs with CO_2.

Biobased materials potential next steps

- Luxembourg government to closely examine the draft composites roadmap after the composites survey of Materials Cluster members is completed, to integrate the context of circularity, and identify focus areas for deep investigations into feasibility. Include clarifying definitions of biobased, biodegradable and biocompatible so there is a clearer understanding for making investment decisions.
- Production of biobased chemicals and materials is just one part of the cycle. The sourcing, use, re-use, cascading and nutrient recovery from those materials together constitute the whole cycle, and in that cycle are diverse opportunities for value capture. Luxembourg has the potential to be a pilot location because it has most every part of the cycle in its borders or in the Greater Region. Given that biomaterials experts are located in Luxembourg and the Greater Region, also at companies like DuPont, it is a large opportunity.
- *Pilot potential*. An example of how biomaterials might be integrated with healthcare and product innovation is the Pharmafilter technology described under healthcare in the Sectorial Snapshots section.
- Biobased 3D printing feedstock for critical pilot applications using advanced, big data technology for storing and manipulating product design codes would play to Luxembourg’s strength of integrating different R&D skills into client-ready services. While research is typically advanced in Europe, its valorisation for technical and business applications is limited as it requires know-how transfer and integration into services across sectorial boundaries. A task, where Luxembourg enjoys a great track record-.

8.5. Systems For Manufacturing, Using, And Recovering Circular Materials

The present situation in and around Luxembourg

Products as systems

A surprising variety of products designed or certified for Biosphere and Technosphere circularity cycles are available in or near Luxembourg. Those products are valuable platforms for replicating and scaling up, as well as for Luxembourg to be a test market. Figure 12.1 provides a snapshot of those products, their functionality, and where to get them in Luxembourg.

Products designed for circularity involve complex customer supplier systems. For example if a product is certified for the Biosphere or Technosphere circularity cycles, certification includes back-casting into the supply chain to identify substances used along the path, as well as forecasting the pathway the product will follow. Certification or optimisation involves contacting and cataloguing sometimes hundreds of suppliers who contribute to a product.

Those supply and use streams are far from perfect. Science is a central tool for innovating and optimising to make them suitable as well as economic for circularity.

Customer supplier communities

A range of customer/supplier communities is already working in or around Luxembourg. Those communities are able to support the setup of infrastructures such as reverse logistics for circularity. Refer to Annex B for examples of supplier communities.

8.6. Measuring Circularity Impacts

Table 8.2 describes a few tools being used to measure impacts of circularity. It is emphasized that these each represent components of an evaluation capacity, because there is no definitive tool.

As well, the list is not comprehensive but rather a starting point for Luxembourg to consider adding to. The interest goes beyond academics. 'Only what gets measured, will be managed', is a truism, which is explicitly true in times of transformational shifts.

Due to decades of environmental chemistry and sustainability, hundreds of tools are available for measuring CO_2 and other environmental footprints as well as toxicity and hazards. However only a few are applicable for evaluating the positive impacts of circularity. It is a significant challenge to define and measure positive impacts, and the following tools are only a beginning.

Table 8.2: Tools for measuring circularity

TOOL (Alphabetical order)	FEATURES	YEARS IN USE	#s OF PRODUCTS OR MATERIALS APPLIED TO	#s OF ORGANIZATIONS USING
		MATERIALS & SYSTEMS EVALUATION METHODS		
ABC-X ASSESSMENT	Chemistry-based assessment of materials according to their intended use. Identifies hazards and positive potential. www.epea.com	**15+**	2000+	16 assessors 1000+companies
C2C ORGANIZATION CHARTER	Guidelines for becoming a circular organisation across a range of activities.	**5+**		10+

TOOL (Alphabetical order)	FEATURES	YEARS IN USE	#s OF PRODUCTS OR MATERIALS APPLIED TO	#s OF ORGANIZATIONS USING
CIRCULARITY INDICATOR (ELLEN MACARTHUR FOUNDATION)	A web-based measurement system that will provide businesses with the tools required to track their progress in delivering a circular economy based business model. http://www.ellenmacarthurfoundation.org/business/metrics	**1**	N/A?	in development
CIRCULARITY ASSESSMENT FOR ORGANISATIONS (CIRCLE ECONOMY/PGGM)	Aims to create an indicator set that links the activities of a company to absolute planetary boundaries and economic trends, and provides some more technical insights into the reasons for the organization's level of performance. http://www.circle-economy.com/opinion/circularity-assessment-for-organizations/	**1**	Information available from Circle Economy.	In development
LCA Life Cycle Assessment	Measures environmental impacts. Does not consider the bio and technical cycle and often does not consider continuous cycles.	**25+**	Thousands	Thousands
MATERIALS REUTILISATION SCORE	Evaluates the re-use potential of materials in products for biological and technical cycles.	**10+**	1000+	16 assessors 1000+ companies
REACH Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals	REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry.	**5+**	Thousands.	

TOOL (Alphabetical order)	FEATURES	YEARS IN USE	#s OF PRODUCTS OR MATERIALS APPLIED TO	#s OF ORGANIZATIONS USING
RITS Resource Identity Tag System	Labeling raw materials to make them simpler and more efficient to recycle and reuse in the production process. The level of identification of additives in materials remains unclear.	**1**	Unknown	Unknown
		VALORISATION MECHANISMS		
COMMODITIES TRADING MARKETS	Traditional commodities markets track daily and future value of commodities. In some cases they track value of secondary raw materials but those cases are limited to a few materials.	centuries	Thousands	Thousands
MATERIALS PASSPORTS	Evaluate a range of indicators which give materials value for their present and next use.	3	Thousands in ships. Still in development for other products.	5+
SECONDARY RAW MATERIALS VALORISATION SYSTEMS	Real-time valorisation of Municipal Solid Waste and other streams to confron with anticiated EU rules on increasing recycling rates.	**1**	Being introduced to 50+ municipalities.	In development
WASTE TRADE	Waste trade markets have existed for hundreds of years and more recently are mandated by waste legislation. These markets are often barriers to circularity because they tend to focus on bulk mixed waste, although some markets are improving.	centuries	Thousands	Thousands

There are also many functionality tracking tools and technologies relevant for circularity. Examples include;

- Underwriters Laboratory label used for most electronic and mechanical devices. http://ul.com/
- Building Information Modeling (BIM) software used for buildings which includes some materials. http://www.autodesk.com/solutions/building-information-modeling/overview
- Inventory & tracking software like HP CDX, IBM container tracking, used for example in Luxembourg cargo terminals. http://www.zurich.ibm.com/news/05/trec.html https://public.cdxsystem.com/de/web/cdx

Using life cycle assessment to measure circularity

Business and academic institutions in Luxembourg have extensive and diverse experience with Life Cycle Assessment or Analysis (LCA). The CRPs have centres of excellence for LCA and companies like ArcelorMittal and Tarkett among many others have LCA experts on staff.

LCA is not a uniformly developed or applied tool. There are diverse software programmes with diverse value sets and there is wide variation in the boundaries as well as scoping of LCA parameters.

Organisations such as the International Standards Organisation (ISO) have standard LCA definitions as described in ISO 14000 those are far from being applied universally and the boundary assumptions of those methods are open to wide interpretation.

Additional to the substantial challenge of comparing diverse scoping methods and value assumptions, the challenge with LCA in relation to the circular economy is this;

- For a few types of materials cycles like glass for example, LCA recognises the environmental savings associated with multiple re-use of products. However for most products ranging from steel to wood, LCA is primarily a “cradle to gate” measurement, which stops at the first end of use of the product.
- LCA usually does not follow materials through multiple cycles, nor does it account for the environmental functionality of products.
- An outstanding example where the present LCA approach penalizes materials innovation is with products that clean the air. A range of carpet and wall covering products in the marketplace today capture and destroy or metabolise pollutants, thus improving indoor and outdoor air quality.

- However most LCA programmes used to evaluate the environmental impacts of those products have no provision to account for this type of positive impact. Instead they focus on embodied energy and materials efficiency of the products.
- As well, LCA usually does not account for defined content. For example, a product which is designed to be recyclable at a high level of quality but contains only 10 percent recycled content scores lower in many LCAs than a product which has 40 percent recycled but undefined content and is not designed for high quality recycling.
- Those deficiencies in LCA were explored in a 2011 study by the Netherlands Government agency Agentschap in a publication entitled *Usability of Life Cycle Assessment for Cradle to Cradle Purposes*. Because C2C cycles are broadly acknowledged as a basis for circularity, the study has high relevance to the goal of reducing environmental impacts. The study was done by a panel of circularity as well as LCA experts, and for transparency purposes it is noted here that one of those panel members is a co-author of this study.

The study concludes that while LCA can add to a C2C inventory and can help to determine whether burdens are shifted when changes are made to a product or process;

LCA is not designed to indicate how much progress has been made with a C2C product.

The Agentschap study identified the following underlying contradictions with using LCA to evaluate C2C;

*Measuring **qualitative** solutions with a **quantitative** measurement tool.*

*Measuring a **future** solution using **current** data.*

*Measuring a **beneficial** environmental footprint with an instrument that is designed for measuring an environmentally **damaging** footprint.*

Steps to improvement for LCA

As part of the National Circularity Initiative described in this study, establish a multi-stakeholder taskforce to build on the Dutch LCA report conclusions as well as those reached about LCA by Luxembourg-based manufacturers and academics, to adapt LCA for circularity.

8.7. Circularity Economic Indicators

Is it possible to develop reliable definitions, indicators and statistics for a circularity baseline, and quantify the potential for the future? Management science suggests, that only what can be measured, can and will be managed. Therefore being able to understand material flows, the associated value adds and the key influencing points is a very critical element in identifying, initiating and implementing circular economic activities.

Developing circularity economic indicators is outside the terms of reference of this study, but in order to fulfil the terms of reference it is necessary to describe the situation today as well as potential for the future;

Across Europe there is a notable lack of the right kind of economic indicators for reflecting and supporting circularity. The absence of those indicators represents a threat to effective decision-making.

The following section provides examples encountered in the present study of relevance for Luxembourg. Interviews with Statec officials suggest the data is not gathered or published systematically, yet.

The challenge with economic indicators for circularity is exemplified by the EU's new resource efficiency scoreboard;

Luxembourg is ranked number one on Resource Efficiency in the new EU resource efficiency ranking tool. However, the EU includes a significant caveat on the rankings;

> *The resource efficiency scoreboard shows that the most resource-productive member states are the United Kingdom and Luxembourg, which generate €3.22 and €3.21 respectively per kilogram of raw material. In third place is the Netherlands (€2.89/kg), while at the bottom of the ranking are Bulgaria, Romania and Latvia (respectively €0.20, €0.21 and €0.32/kg).*
>
> *This however reflects the structure of the economies of these countries. In the UK and Luxembourg, most GDP is generated by services, which consume relatively little raw material. The resource productivity indicator does not include resources embedded in imported products, and therefore does not fully reflect countries' resource consumption. However, Eurostat is working on a "material footprint" indicator for Europe that will show the global environmental pressure generated by resource use in the EU and its member states.*

(Source Eurostat publishes first resource efficiency scoreboard 17/12/2013)

The caveat shows that the results of the EU resource efficiency rankings do not reflect underlying costs of materials. Hopefully the Material Footprint referenced in the publication will be an improvement, but it too faces challenges.

8.7.1. Examples of under-represented or missing indicators

Multiplier effects of circular materials developed in Luxembourg

Luxembourg-based R&D is driving circularity for €2 billion in annual sales of flooring products by Tarkett, including ingredients for PVC, wood, linoleum, and rubber. Those methods have the potential to be extended to materials in other Luxembourg sectors, and Tarkett exhibited a willingness to be transparent with its work. However, the existence of those improved materials and the knock-on effects of materials R&D at Tarkett's Luxembourg-based facilities to the company's materials streams as a whole are not reflected in statistics gathered in Luxembourg. (Source Tarkett)

Materials renting, leasing

- About one-third of Luxembourg-based ArcelorMittal's steel piles business is based on renting and reverse logistics. The model is running for many years profitably and represents a model for optimisation and replication (source ArcelorMittal). However the revenues are not shown separately in ArcelorMittal financial statements and the amount of steel leased is not shown in Statec statistics on steel.

Aggregated data on paper flows

- Paper is a circularity messenger. Because everybody uses paper it is an educational and communications mechanism for Luxembourg to 'walk the talk'. Statistics for evaluating its progress would be a valuable economic tool.
- Paper recycling has scaling-up and savings potential. About the same amount of energy ~600 kWh is saved producing one tonne of recycled paper as producing one tonne of recycled steel. However, recycled white office paper represents only 10-15% of the overall ~15,000 tonnes white office paper market in Luxembourg (Source email from MW).
- In response to paper being suggested in the study as a potential quick win, members of the Steering Committee for the present study asked what is the relevance for Luxembourg if there is no paper recycling in Luxembourg?

    - According to a study by CRP Henri Tudor economic savings are possible in Luxembourg despite no paper recycling per se in the country (source Ecoparc Windhof & CRP Henri Tudor). By improving separation and establishing customers as suppliers to recyclers and vice-versa cost savings are possible along the value stream. Circularity procurement is also relatively easy to achieve with paper due to the short supply chain.
- However, there seem to be no aggregated statistics available at Statec on;
    - How much of what grade of recycled paper is used in Luxembourg,
    - How much old paper leaving the country returns as recycled paper.
    - The amount of recycled content.

Economic benefits of improving separation

- The economic advantages of separating waste was made clear in the financial crisis when recycling centres which separated their waste did better than those which did less separation. (Source Schmit interview). There seems to be room for 'crisis-resilience' in Luxembourg with improved separation. However, Statec does not seem to collect information on separation grading of various types of materials.
- Bio-residues. Luxembourg collects the highest amount of bio-residues per household in the EU at 147.4 kg per person annually, so although the real numbers might be small compared to other countries, the relative concentrations are high and there seem to be significant potential for re-use of those resources. (Source Waste Management 33 (2013) 2434–2448). However, aggregated statistics on bio-residue origins and fate across Luxembourg do not seem to be available.

Next-use fate of materials

- The fate of waste generated in Luxembourg then exported. For example, most plastics, paper, packaging, WEEE are exported for processing. Are they incinerated, landfilled or if they are recycled to what level e.g. disassembled, shredded, granulated etc.? MDDI has results from export forms, but these apparently do not show the 'next use' after the exported materials reach their first destination (Source MDDI). SDK is collecting some information on next uses but says more could be done (Source SDK interview). The question also applies for construction waste; further breakdown of contents & fate.
- Overall, the value of waste fractions as secondary raw materials rather than the cost of processing.
- Next-use fate of secondary raw materials, which enter Luxembourg. e.g. scrap steel, aluminium, glass. After primary manufacturing, which goods are manufactured containing secondary raw materials?

Tracking

- Retailers have inventory systems potentially suited for upgrading to circularity for packaging. However, each company has its own system. (source Cactus interview). An analysis is required to determine how varied the systems are and which categories they contain, but it is likely that circularity criteria for packaging are applicable for each system.

8.7.2. Product statistics

To establish a baseline on materials for the circular economy, and to establish knowledge of materials flows, here are statistics questions, which do not seem to be answered in the way existing statistics are represented by Statec;

For primary products manufactured or sold in Luxembourg;

- Breakdown of material grades according to standards established in each industry e.g. steel, aluminium, paper, wood, glass.

For consumer products manufactured or sold in Luxembourg;

- The percentage of recycled content in the total product. e.g. product label might say 'contains recycled content' but not describe what or how much.
- Product content. e.g. Does the product have a certificate which identifies its contents? EPD, MSDS or other certificates usually only identify hazardous contents.
- How many and what types of goods entering or leaving Luxembourg are being returned to manufacturers for repair, remanufacturing or recycling e.g. reverse logistics. Statec has NACE codes for returning goods but the breakdown requires further delineation. It is of high relevance for determining value capture potential for Luxembourg.

For white goods and other large consumer goods;

- How many refrigerators, ovens, air conditioning units, and other appliances are presently existing in Luxembourg and what is their age?

For automotive components manufactured in Luxembourg;

- Which percentage of remanufactured parts are used by automotive fleets in Luxembourg for repairs?

For agriculture;

- How much fertiliser is recycled and how? e.g. manure, NPK.

For infrastructure and buildings;

- Total cost of construction for buildings & infrastructure in Luxembourg on an annual basis, to allow extrapolation of the total cost of materials.
- Amount and type of strategic materials on the EU strategic materials list in capital stock. e.g. how much steel, aluminium and copper is in the assets of the electricity transmission, roads and rail infrastructure ?

Statistics confidentiality

Under present rules, statistics involving less than a minimum number of companies are kept confidential because competitors might guess which company is producing what. However in some cases like aluminium products, a quick search of websites comes up with an approximate figure. In cases where the data is already available, exceptions to the rule might be made.

9. STRENGTHS & WEAKNESSES, OPPORTUNITIES & THREATS

Introduction and overview

In performing the S.W.O.T. analysis the present study accounted for S.W.O.T.s done by the Haut Comité as well as by surveys of Luxembourg's economy and environment in global competitiveness reports (e.g. Report on Global Environmental Competitiveness of Luxembourg). As well, S.W.O.T.s by the 2014 EC scoping study on the circular economy, and the U.K. All-Party Parliamentary study on remanufacturing, were considered.

For additional background information on S.W.O.T. Context and Methodology see Annex G. A traditional S.W.O.T. analysis structure is not the most practical for Luxembourg because with circularity often weaknesses are also strengths and threats are opportunities. The S.W.O.T. in the present chapter was organized by topic to describe challenges and solutions along thematic lines.

However, here are highlights according to a traditional S.W.O.T. structure;

S.W.O.T. highlights for present & potential circularity in Luxembourg

Strengths:

- Excellent geographic location and multi-cultural capabilities with an already extremely high share of transit volume and business relationships.
- Excellent R&D and piloting capabilities across wide spectrum of CE-relevant topics (from material intensive applications (i.e. construction, agriculture, heavy industry) to high-end service provisioning.
- Diversified economy encapsulated in a focused geographic location with strong personal and professional ties to effect cross-sectorial change with a government with clear commitment to guide economic development according to strategic objectives

Weaknesses:

- Little awareness about CE-opportunity in business community
- For some fractions sub-scale volumes (e.g. for own re-valorization activities) and limited value chain coverage (i.e. only R&D or logistics handling, but no own core manufacturing activities)

Opportunities

- Become the pre-eminent initiator, orchestrator and enabler of CE-activities by combining design, material flow/logistics and enabling competencies (i.e. financing, planning)
- Become an important CE showroom and test-lab for CE-applications (i.e. CE-construction, CE-consumer product test lab, …)
- Define CE innovation and R&D frontier by aligning already existing initiatives at Luxembourg level with CE as core vision (i.e. Luxinnovation clusters).

Threats:

- There is a risk of replicating basic misunderstandings of CE science based on popular misconceptions about materials and cycles, which in turn might lead to large-scale investment misallocation or dilution of circularity down to 'waste management 2.0'
- Traditional forces blocking innovation and systems redesign (e.g. investments locked up in linear processes with little appetite to sacrifice return of investment, when moving to competing CE-set-ups, e.g. automotive sector's customer base).
- Potential lack of quick tangible results in some CE areas as Luxembourg's opportunity-rich environment could yield mega-trend opportunities which take more time to develop (e.g. biotechnology for aging population, big data investments, ….)

→ Overall, the CE fits extremely well to Luxembourg's S.W.O.T. profile because it will favour locally available subsystems and play to the specific strengths of Luxembourg. So a fantastic opportunity.

The following sections split S.W.O.T. into Strengths & Weaknesses, Opportunities & Threats by topic, as well as identifying sectorial challenges and potential solutions.

9.1. Strengths And Weaknesses By Topic

Materials & technologies

Challenge; Re-capturing goods exported from Luxembourg

About 80% of Luxembourg's exports and imports occur in an ~700-800 KM radius of Luxembourg, so it seems feasible to track and re-capture many of those materials. Balanced against that is the weakness that materials e.g. in vehicles sometimes end up being exported to e.g. Africa, which takes them out of range of economic recovery. Nonetheless, in cases like steel and glass, millions of tonnes of materials seem to stay in a recoverable range.

Strength; Absence of waste reprocessing technologies

- Due to limited economy of scale Luxembourg lacks waste reprocessing technologies like re-polymerization, re-pulping, most shredding, etc. so it exports most waste. Or does it? 'Waste' in some cases is considered 'secondary raw material', and *Luxembourg imports more secondary raw materials than it exports*; at least 2 million tonnes in steel and aluminium alone (Source ArcelorMittal & Eurofoil). The imports are scrap metal, and the reprocessing is steel and aluminium production. Glass is also a stream.
- The lack of reprocessing technologies occurs mostly in Municipal Solid Waste, (MSW) but also here there are exceptions such as local composting and biodigestion and there is a large knowledge base at for example SDK. The lack of MSW reprocessing technologies is an advantage for circularity, because Luxembourg is not stuck with subsidizing vested interests in waste reprocessing and instead its secondary materials reprocessing technologies are based with industries which see those materials as central to their competitive position. The incentive makes optimisation easier.
- Incineration is not considered a waste reprocessing technology under circularity, but rather a threat; see opportunities & threats. However, recovery of materials from incineration slag is an interim waste reprocessing technology. See highlighted section on incineration under Threats.

Challenge; Service sector seemingly not involved with materials.

- Approx. 75% of the economic outputs in Luxembourg are services, which on the surface suggests Luxembourg lacks critical mass to influence materials flows. However, the opposite might be true. Sectors like logistics, finance, R&D, and primary manufacturing exercise considerable influence over materials choices. The challenge is to positively inspire those sectors to act.

Governance

Strength. Government flexibility.

- Government is a big potential enabler in Luxembourg for the CE, and one advantage it has is, despite its inherent traditionalism it can quickly respond. The ability to rally private and public sector stakeholders quickly behind an emerging opportunity paired with the resolve and clout to carry them through to wide adoption in the local community is one of the most cited and most attributed strengths of Luxembourg's economy.

Challenge. Overlapping jurisdictions

- Agencies have overlapping authority on water, agriculture, bioresidues. The efficiency and scale-up of Biosphere processes like biodigestion and water recycling are apparently slowed by overlapping jurisdictions.

Challenge. Absentee decision-makers

- Absent decision-makers is a frequent complaint in Luxembourg business and government. For example, R&D centers often have their priorities dictated from head offices outside the country. However, if Luxembourg becomes known as a circularity competence hub, the approach might be used to inspire corporate decision-makers to see Luxembourg as "the place to be" for circularity decision-makers.

Strength & weakness. Traditionalism

- Traditionalism in the culture of Luxembourg is a recurring perceived barrier. Is it accurate? The present study found examples of circularity-inspired innovations in retailing (Pall centre, Oikopolis), property management (Ecoparc Windhof), primary manufacturing (secondary raw materials use) and alternative investment funds (solar storage agreements).
- *Being second.* Perhaps due to its traditionalism, Luxembourg is behind some countries in adopting circularity, but this is not necessarily a weakness. For example, Luxembourg has the potential to get the science right. The present study identifies areas where Luxembourg will be able to maximize benefits and minimise weaknesses by borrowing lessons from others.

The Greater Region

The Greater Region is arguably one of the great potential CE drivers in Europe due to its geopolitical position, diverse industrial output and services.

- A major strength is the connection of Luxembourg R&D institutions with Greater Region institutions because Luxembourg R&D groups are sometimes not accredited for certain tasks e.g. for PhDs. The Greater Region R&D network among up to 20 academic institutions is a powerful potential circularity enabler.
- Weakness & Threat. However, in some cases and especially logistics and recycling, the GR is sometimes perceived as a competitor to Luxembourg. Because of this the degree to which Luxembourg can leverage and benefit the Greater Region will depend heavily on governance approaches as well as the success of selected pilot projects, which integrate activities in Luxembourg and the Greater Region.
- To get the best from those contradictions, Luxembourg might focus on;
    - Academic co-operation
    - Empowering its government-controlled companies to compete more effectively in the Greater Region.
    - An example of a win-win might be supplier communities for secondary raw materials, described in Chapter 14.5.7.
- Challenge. There is yet no consolidated information on the value of goods bought and sold in the five regions, which comprise the Greater Region, and this is definitely a weakness. It is done region by region. See following sections on economic indicators.

Wallonie as partner

However, despite the lack of consolidated data for the GR, data available for individual regions is extremely relevant. For example, as part of a questionnaire submitted by the present study, Wallonie replied that the largest waste fractions are construction waste >14 million tonnes food waste >1.6 million tonnes and metal waste ~1.3 million tonnes (Source questionnaire response).

Those data suggest there might be diverse synergies with Wallonie, especially when combined with Wallonie's other circular initiatives in textiles http://www.agoria.be/fr/Economie-circulaire-comment-participer-au-programme-wallon-NEXT, wood construction http://www.wfg.be/francais/wfg/, and reverse metallurgy http://www.gre-liege.be/reverse-metallurgy-2/.

In general Wallonie seems to be a good candidate for greater co-operation with Luxembourg on circularity, also because as part of its earlier EU Presidency Belgium greatly advanced the circularity platform.

Finance & economics

For evaluation of economic indicators see Chapter 4 on raising industry competitiveness and job creation.

Strength & weakness; Economic diversification

- *How to do a few things well?* Luxembourg's greatest strength but also a perceived weakness is its diversity. While it the country is perceived as being dependent on the financial sector, its economy is actually more diversified, which makes a singular focus difficult to achieve on one hand, but provides a platform for cross-industry leveraging of high-level skills like prototyping as well as lower level skills like reverse logistics.
- The overall framework for achieving the mission described in the present study represents a way for the government to focus on a few priorities while empowering stakeholders to do the rest.

Legal & regulation

The EC scoping study has an extensive section on regulatory barriers to circularity, which is not repeated here. See Annex G.

Secrecy vs. transparency

- Emphasis is being placed these days on transparency in the circularity marketplace so the content of materials is known. However, the weakness of the approach is suppliers often will not give up their trade secrets to their customers for fear of losing them to the competition. Standard secrecy agreements do not solve the problem because leakage of trade secrets is difficult to prove in court.
- The solution is a third party knowledge trustee who holds the information and provides assurances to customers it has been evaluated. For example EPEA is a knowledge trustee for hundreds of suppliers. Luxembourg with its trusted position on confidentiality; which is also under pressure from the EU

presently, might leverage the strength of its confidentiality reputation to provide knowledge trustee functions. Usually this is done in collaboration with scientific organisations in order to know which information to ask for.

The other secrecy topic is the need to protect user data. As more users utilise service sharing sites for circularity, protection from illegal encroachment by security and other agencies becomes a priority. Luxembourg might convert the concern into a new database platform.

Procurement

- Procurement seems an obvious way to drive circularity. However, in practice factors such as central purchasing and anti-competition rules are perceived as barriers. Some of those perceptions are accurate and some not, and deserve careful investigation.
- In many instances, benefits are not attainable as desirable procurement practices are frequently hindered by;
    - Insufficient understanding of synergies and savings potential from a (centralized, siloed) procurement practice.
    - Anti-competition rules (e.g. avoiding pre-competitive agreement of suppliers on norms, terms and conditions).
    - Non-comparability of alternative service delivery models (e.g. how best to compare sales-based transactions with performance based contracts, incomplete LCA assessments, which do not use correct end of usage/revalorization prices/revenues).
    - Insufficient data and market transparency (e.g. pooling information of players with similar needs, inventory of competencies required for reverse network activities, non-existence of defined categorization, naming and search indices for circular economy activities)
- Nonetheless, many circularity studies see procurement as an important strength for driving circularity, and indeed organisations in the Netherlands after years of trying finally entered into a deal for circular procurement. However, the procurement departments have to implement those deals. Frequently procurement personnel are restricted by rules, which they see as preventing them from implementing green types of procurement (Source EPEA own experience as well as reports from various organisations). The challenge is more pronounced with government and public corporation procurement, which are subject to EU anti-competition rules.
- Despite the challenges, supplier consultation approaches are used successfully by public organisations like e.g. Venlo in the Netherlands for its

€45 million city hall and by the municipality of Ronneby for schools and archives construction. In those ways, procurement is a strength, but requires time to convince suppliers and purchasers.

- In the privately controlled sector, procurement is successfully used with suppliers. Circular supplier communities as educational tools are breaking down barriers of resistance when suppliers see there is something in it for them and not just another green requirement (source Park2020, Desso, Vanderlande Industries).

The implication for Luxembourg is; in order to leverage procurement, focus on creating, optimising and educating customer/supplier communities.

Strength. Total cost of ownership (TCO)

A low-hanging fruit for scaling up circularity is total cost of ownership financing, which is often practiced in Luxembourg by owner-occupiers of buildings. By contrast, building on speculation is more of a weakness because the developer has less incentive to build for operational savings. The potential for Luxembourg is to initiate pilot projects with institutions, which occupy their own buildings.

Weakness. Fossil fuels taxation and high trans-border commuting

- The IEA estimates Luxembourg's fuel consumption at 3.9 million tones oil equivalent, which makes fuel consumption one of the highest materials 'leakages' in Luxembourg, and quite high on a per capita basis. The leakage is not unusual for most countries but is pronounced for Luxembourg due to 'tank tourism' including 40% of the workforce living outside Luxembourg but filling up in Luxembourg. The strength of tank tourism is tax revenues. The weakness is Luxembourg's poor CO_2 profile. The weakness is further complicated by a seemingly widespread perception that Luxembourg is too small to do anything about fossil fuels. See section 10.10 The Elephants in the Room.

Marketing

National image

- The Haut Comité report & recommendations, as well as interviewees for the present study media reports agree; Luxembourg's identity as a craftsmanship and innovation hub is overshadowed by its financial reputation. As Luxembourg attempts to reduce its reliance on the financial sector, this misperception becomes a potential weakness. To rebalance the imbalanced image the present study puts forward a *national quality label* based on circularity. See Chapter 14.5.2.

Media presence

- A large part of leveraging CE involves communications and awareness. The presence of a leading European media headquarters in Luxembourg like RTL, as well as the presence of diverse internet platforms might offer special strengths, but also magnify weaknesses if those media are poorly informed.

9.2. Opportunities And Threats By Topic

> **'Black swans'. Disruptive technologies**
>
> If as forecasted 3D additive manufacturing unleashes a wave of near-shoring, it might transform Luxembourg's economy. One step to prepare for those 'black swan' opportunities and threats is to keep a watching brief on disruptive innovation via Luxinnovation.

Transparency of materials content

- How do you reuse or recycle materials if you don't know what is in them? It is the norm rather than the exception that most recyclers only have a general idea of what is in products with perhaps a manufacturers' Material Safety Data Sheet (MSDS). Exact content is usually unknown. The solutions include better separation, tagging technologies but primarily the solution is to require manufacturers declare the contents of their product to 100 ppm. Is it difficult and costly? Diverse manufacturers already do it so Luxembourg can learn from those. For examples see Annex B showing C2C-certified products for sale in the Greater Region and Benelux. Those methods represent an opportunity for new knowledge-based job creation in Luxembourg.

Licensing

- Waste licenses, construction licenses are often a barrier-to-entry for resource re-use innovations and companies. A systematic review at the Luxembourg and EU level of licensing practices is warranted perhaps as part of the EU Presidency.

Mixed waste incineration.

The largest loss of valuable resources throughout Europe is occurring due to incineration capacity, which misallocates investment away from recycling. It distorts markets due to overcapacity across Europe and putting upward price pressure on feedstock, which can erode the comparative business case for more material-preserving circular options.

About 51 million tones of waste are incinerated annually in Europe representing about 21 percent of total waste disposal. In Luxembourg incineration represents a higher percentage; about 35% or 240 Kg per capita (Source Incineration overcapacity and waste shipping in Europe). Countries like Sweden, Denmark, Germany and the U.K. already have overcapacity but nonetheless there are still plans to build more incinerators.

For comparison purposes, the amount of waste incinerated in Luxembourg annually, about 120,000 tones, rivals the tonnage of aluminium re-melted in Luxembourg.

Far from being on the decline, construction of incinerators is increasing across Europe and globally despite clear overcapacity and damage to circularity as well as to the environment Overcapacity negatively impacts recycling markets and waste treatment pricing.

Solutions for Luxembourg: Support technologies, which transform mixed waste incineration into modular incineration, which destroys materials not suitable for recycling. For example, older types of PVC are heavily contaminated and are best separated from newer types then incinerated.

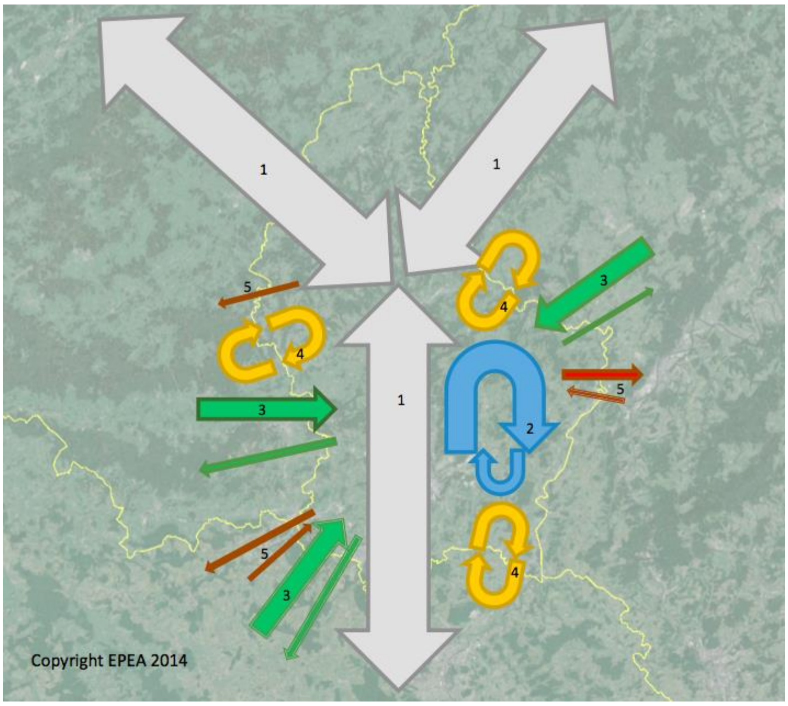
9.3. Inventorying Material Leakages

9.3.1. Defining leakage

Defining materials leakage in the circular economy requires knowledge of how CE materials flows are structured. For example, the term ‘leakage’ has different applications for the Biosphere than for the Technosphere.

Biosphere nutrients represent the largest portion of materials flows globally, and ‘leakage’ of those materials is often deliberate and desirable. For example, Biosphere-friendly-materials are returned to the soil as nutrients and are part of a continuous flow rather than a closed loop. Bio-cycle materials experience undesirable leakage through too-short use cycles. Frequently bio-cycle materials are burned after first use or as part of first use, whereas studies suggest the greatest economic benefits are generated when bio-cycle nutrients go through a cascade of uses, for example from wood to particleboard to paper.

For technical nutrients, ‘leakage’ refers to loss of materials, energy, and labor when products, components or materials are not reused, refurbished/ remanufactured, or recycled. For example, a floor covering has to be incinerated because its component materials are too expensive to separate for re-use.



Number + Colour codes;

1 GREY	**Freight:** 50 million tonnes transiting through Luxembourg hubs. (Luxembourrg Logistics Cluster 2013)
2 BLUE	**Inert waste** incl. excavation 10.5 million tones (EEA, 2010)
3 GREEN	**Fuel:** Imports 3.6 million tonnes
4 YELLOW	**Steel and Aluminium:** import/export 2.2 million tonnes (Arcelor Mittal & EPEA)
5 RED	**Waste**: 823,000 tonnes exported (Statec 2013)

Exclusions;

- 6.2 - 10.5 million tonnes CO2 emissions (World Bank, 2008).
- Freight transiting through Lux which does not pass through hubs.
- Wastewater, manure, Forestry products.

[Flows to individual countries are illustrative only.]

Figure 9.1: Leading materials flows in & out of Luxembourg. Sizes of arrows and flows to individual countries are illustrative only. Source EPEA

9.3.2. Materials leakage/ potential for improvement

For an overview of materials flows in, out and through Luxembourg see Fig. 9.1.

Despite a variety of circularity models operating in and near Luxembourg, leakage into the 'take, make, waste' pathway is substantial and it is safe to say the great majority of materials are not part of circular value streams. The outstanding leakages are;

Incineration. Luxembourg incinerates at least 35% of its municipal solid waste amounting to 120,000 tonnes annually (Source Graph 4. Total waste incinerated (in thousands of tons. (http://epp.eurostat.ec.europa.eu) and CEWEP (www.cewep.eu)) and number of incinerators in Europe in 2010, per country.). However the figure is probably higher because approx. 800,000 tones of waste is exported and some ends up in incinerators.

- **Construction excavation and roadside waste.** At 9.6 - 10 million tonnes annually, the largest solid waste fraction. Luxembourg is landfilling its excavation waste at a time when sand is becoming a limited resource competed for heavily. It is a high priority to do further feasibility analysis on the potential for re-use.
- **Fossil-fuels for energy.** 3.7 – 3.9 million tonnes annually are imported to Luxembourg and burned, generating substantial emissions. (source IEA) Although energy is not a focus of this study, fuel is a manufactured material, and because of this it is relevant for the evaluation. As well there are potential solutions on the horizon.
- CO_2 **emissions.** While the statistics are controversial due to 'tank tourism' in Luxembourg, the World Bank shows CO_2 emissions at 10.5 million tones in 2008, making it the largest leakage of material. CO_2 is often not regarded as a material but in practice it is used as an industrial chemical and qualifies as a material.
- **Downcycled fast moving consumer goods (FMCG).** Waste paper, wood, electronics, plastics, food waste are often exported where their ultimate fate is only generally known, or incinerated, or downcycled into lower quality products. Efforts are being started to upgrade those processes but these are only beginning.
- **Nutrients in wastewater.** Although more investigation is required it seems most nutrients, which end up in municipal wastewater, are lost to river

systems or incinerated. Technologies exist to extract e.g. phosphate profitably as well as save up to 15% of energy for processing wastewater.

- **Vehicles and appliances.** Most vehicles and appliances end up leaving the country for disposal although the steel and aluminium industries in Luxembourg are constantly looking for scrap.
- **Transnational nature of product flows**. Given Luxembourg's dominant role as logistics platform for many goods as well as its high share of cross-border commuting workforce, systematic collection and valorisation of products and material streams needs to address cross-border leakage.

However, quantities alone do not determine impacts of materials. Although no scientific assessment was found which compares these flows in Luxembourg, and while differing Life Cycle Assessments will result in differing ranking, the same list adjusted for negative environmental impacts like materials quality/integrity, reducing dependence on externalities, will be quite different. Among the main considerations for ranking those impacts are included in Table 9.1.

Table 9.1: Considerations for evaluating impacts of materials flows in Luxembourg

Material Flow	Positives	Negatives
Incineration 120,000 tones	• Marginal energy recovery 5 – 10% of embedded energy • Potential for repurposing	• Most embedded energy is lost • Materials integrity destroyed • Slag & ash contain contaminated mixed content hard to separate • Recycling investment discouraged • Toxic emissions
Fossil Fuel combustion. ~3.9 million tonnes.	• Revenues for government • Technical potential for CO_2 recovery from points sources • Energy for society	• CO_2 & Toxic emissions • Non renewable • Requires military infrastructure to secure oil reserves
CO_2 emissions ~6.2 – 10 million tonnes but skewed by 'tank tourism'.	• Potential for point source re-use	• Climate change risks

Material Flow	Positives	Negatives
Logistics. Transporting 50 million tonnes through hubs.	• Large revenues • Large reverse logistics potential • Potential large materials banking infrastructure	• Traffic noise • Land degradation • Large CO_2 emissions
Excavating and transporting, excavation& inert waste. ~10 million tonnes.	• Potentially materials asset. • Landscape & recreation potential • Re-use potential on sites	• Large fossil fuel emissions from extraction & transport • Landslides • Land use • Costs
Waste exports 800,000 tonnes destined for valorisation or incineration.	• Revalorisation	• Incineration (see incineration previously) • Transport costs & emissions
Steel & Aluminium from recycled sources ~2.1 million tonnes.	• Revenues • Saves emissions from primary extraction • CO_2 reuse potential • Practical products • Materials banking potential	• Still has emissions.

Statistics

While some positive and negatives are obvious and do not require extensive analysis to determine the right thing to do, still there is no statistical inventory classifying materials flows in those ways, and so there is only a rough basis for evaluating the potential.

Because Life Cycle Assessment (LCA) is not designed to evaluate the positive potential connected with those materials flows it is also challenging to do a comparative assessment of benefits.

In Chapters 8.6 and 14.5.5 of the present study on LCA the potential to solve the problem is described.

9.4. Solving Broader Barriers To The Circular Economy

Diverse barriers to the CE are already summarized in the EC scoping study. The following is a selection of barriers of particular relevance for Luxembourg, rather than a comprehensive inventory, which would only repeat what the EC and other publications have done.

Barrier
Perceived lack of large-scale circular business models.

Solution
Optimise models that exist already in Luxembourg and surroundings.

A review of the present literature as well as using the experience of EPEA with partners suggests there is a mis-perception that large-scale CE models do not exist yet so new models are required in order to scale up.

It is true that new models are essential for scaling up, but it is inaccurate to say large-scale models do not exist; they exist and are used in Luxembourg.

For example;

- *Secondary raw materials*. ArcelorMitttal, Eurofoil and Guardian Industries rely on secondary raw materials models to maintain and improve jobs and competitiveness. Those models are not perfect, but the basic business model is in place and functioning for years. In France, Germany and Belgium proximate to Luxembourg, large-scale glass re-use and recycling models are in place. Brewing companies globally reuse a substantial portion of their glass packaging up to 30+ times, and most every beverage company uses high levels of recycled glass cullet.
- *Product leasing*, *renting*. In the finance industry one of the most significant tools for scaling up circularity is in use for the past 75 years and since the 1990s is used to scale up solar and wind energy, and most recently is being used to implement renewable energy storage, which is a high level of circularity. The tool is variously referred to as Power Purchase Agreements (PPAs) or Equipment renting and is driving tens of billions of Euros worth of investments into renewables. These are not to be confused with Feed-in tariffs or tax incentives, which are distinct tools sometimes used in concert with PPAs. See Chapter 10.10.1 Elephant #1 Finance for more information. PPAs are essentially a form of materials banking, where a third party often owns the asset throughout its use period. In the solar panel industry those assets are often being recycled by individual manufacturers or as part of industry consortia.

Another tool used in Luxembourg is automotive and equipment leasing which keeps ownership with a third party provider. The challenge here is to link those schemes with the tracking, repair and remanufacturing of components.

- *Remanufacturing.* A significant portion of vehicle and heavy machinery equipment parts are remanufactured, and there is an international trade association devoted to remanufacturing. The system involves extraction of parts from products, reverse logistics back to the manufacturer, remanufacturing components, then reselling them into the marketplace. Remanufacturing accounts for billions of Euros in business. However it is not yet done on a large scale in Luxembourg. A reverse logistics capacity for capturing used parts transiting through Luxembourg might quick-start remanufacturing for Luxembourg, not just for automotive but also for machinery and furniture.

Solution to lack of knowledge about CE model availability;

Instead of spending funds studying only new models, invest in optimising and adapting existing ones starting with the steel, aluminium, speciality glass and automotive remanufacturing industries.

Barrier
Costs of increasing collection rates

Solution
New collection mechanisms

Luxembourg already has one of the highest European rates of collection for certain fractions, and interviewees for the study explain that extending the collection system further to catch the rest become more expensive due to remote location and reduced volumes. However for fractions like paper, electronics, and easily handled fast moving consumer goods, it might make sense to utilise existing capacity of carriers who already visit these areas, and one of those is La Poste.

As well, the cost effectiveness of existing collection is improved by improving separation of fractions. SDK is already working on this. Separation at the source has proven effective with methods such as in-office services like e.g. Ecosmart (source EPEA).

La Poste might be able to collect certain fractions especially in more remote areas more cost effectively than central collection providers.

9.5. Missing Links, Competencies

The EC scoping study performed a review of missing training expertise and competencies and for example in 13 sections describes potential for training. 'e.g. on refurbishment or remanufacturing, skills of food chain personnel) as well as in the future workforce (e.g. through young designer awards etc.' (Source EC scoping study, p.ix), as well as training future knowledge workers. The study also calls for attention to supplier/customer communities (p. 45).

Luxembourg missing links

Probably the most profound missing link or weak link across most every economic sector in Luxembourg and everywhere else is the mis-alignment of customer/supplier communities. In many cases the mechanisms are there but are mis-aligned, so might for example benefit from a coordinated effort towards a circularity goal like e.g. a quality label. Luxembourg industries might also learn from the existing customer supplier communities already functioning in Luxembourg and the Benelux as described in Annex B. If re-aligned, those communities have the potential to increase value capture for steel, glass, aluminium, paper, construction waste, and retailing in Luxembourg, as clearly emphasized by interviewees from those sectors.

Luxembourg missing competencies

Reflecting the preceding S.W.O.T. analysis, the study identified lack of;

- awareness and scientific knowledge of the CE. The lack of knowledge might be an advantage because Luxembourg might be able to avoid some popular misunderstandings of CE science contained in other training information.
- awareness of existing CE models,
- skills for designing for disassembly,
- real-time knowledge on amounts & quality of waste collected & recycled,
- knowledge about the psychology of source separation at households. The psychology of separation is an under-studied field but some recent studies shed light on its importance for effective source separation.
- systematic tracking of amounts and types of materials in buildings

SECTION II

INVENTORY & ASSESSMENT OF EXISTING & POTENTIAL CE ACTIVITIES

10. SECTORIAL SNAPSHOTS

10.1. Agriculture

10.1.1. Why, what, how & S.W.O.T.

Why

Agriculture provides relatively few jobs but has extensive land, materials, and environmental impacts, and much to gain from using circularity to improve competitiveness.

What

National quality label for marketing based on circularity.

Improve soil quality and productivity by optimising and adopting technologies.

Explore improving productivity with continuous loop greenhouse horticulture.

How

Leverage existing quality labels and strengthen the local retailer community.

Use best available soil improvement technologies. Solve inter-agency conflicts.

Re-explore greenhouse horticulture with a partner region dedicated to circularity; Limburg.

S.W.O.T.

S	**Local markets and bio-products are growing.**
	Active community of local farmers with own distribution network and strong links to local retailers
W	**Interagency conflicts.**
	Heavy focus on tradition.
	Generational change
O	**Improve markets with focus on local circularity.**
	Improve soil quality with new technology.

	Support professionalization and integration of small farms
T	**High labour costs, dependency on non-European fertiliser sources. Subsidies discourage innovation**

Takeaways

- A potential solution to Luxembourg's chronic high labour and production costs is to compete with a powerful combination of local production quality with a "grown in Luxembourg for circularity" label, and a strengthened community with retailers and their customers. Instead of attempting to compete on price. The potential is to work with retailers to consolidate and scale up quality labelling (see Chapter 10.7 Retailing).
- Luxembourg's soils are being depleted as in the rest of Europe, and the country depends heavily on imported fertiliser from unstable regions, but awareness of the problem is low. Circular solutions include;
  - Accelerate the availability of biodigestate as high quality fertiliser.
  - A soil manufacturing technology available near the Greater Region which promises a long-term solution to improving soil quality using locally available resources like roadside cuttings as well as agro-industry residues.
  - Use new technologies for extracting phosphate as a secondary raw material from wastewater and other sources to improve fertiliser quality and security.
  - To take advantage of those technologies, improved coordination between water agencies and the agricultural industry is a priority.
  - Greenhouse agriculture has potential for Luxembourg but was dismissed earlier due to failure of pilot projects cause by factors unrelated to agriculture. The technologies merit deep investigation for using circularity to recover nutrients and improve productivity.
  - Support local soil re-generation loops to maintain high quality soils without polluting with industrial processed residues, esp. if linked into non-destructive energy recovery options like anaerobic digestion.

10.1.2. Context and the present situation in Luxembourg

The industry was not directly prioritized by the Ministry of the Economy for the study. However, the industry is tied to retailing and a national quality label, which each received high ranking from the Study Steering Committee.

Agricultural impacts; a surprise awakening

Agricultural products as well as agricultural inputs like water and pesticides are materials, and those materials play a central role in the capacity of the economy to be circular. For example, if water cannot be re-used for drinking or other purposes, it impacts circularity.

The impacts of agriculture on the overall economy received high profile exposure in October and November 2014 when a pesticide spill brought national attention to the close link between agricultural practices and drinking water. Subsequent testing resulted in detection of a range of pesticides as well as in the closure of several drinking water sources (Source MDDI press release https://www.gouvernement.lu/4149737/04-pesticides?context=3393616).

Employment impacts

The potential of the agriculture sector might seem relatively small, but this is a question of perception of the future of agricultural technology in Northern Europe. For example The Netherlands also has a relatively small geographic area but an intensive agro-industry, which employs more people than thought possible 30 years ago, due to its extremely successful greenhouse industry.

Luxembourg is also in cost competition with the surrounding region due to its high labour costs. However land, labour and other production costs are also high in The Netherlands, and the country overcame the challenge. It is one example of how high labour costs are not necessarily a negative.

Impacts on geography and materials

The agriculture sector in Luxembourg is a relatively small employer but on the other hand occupies 50% of the geography of the country (Source Worldstat http://en.worldstat.info/Asia/Luxembourg/Land). It generates a large mass of materials in the form of crops and livestock, and utilises a significant amount of inputs in the form of fertilisers, pesticides, water, soil, fuel, equipment, and buildings.

Fertiliser dependence & topsoil depletion

According to agricultural experts interviewed for the present study (Sources: Chamber of Agriculture Interview Pol Gantenbein; Marc Demoulling, SoilConcepts), there is a lack of public and government awareness of agricultural soil depletion. As in most of Europe, agricultural as well as forest soils are being depleted due to erosion, compaction, and urbanisation as well as lack of soil regeneration.

As well, without phosphate and its underlying element phosphorous there is no agriculture and no life. For example every cell uses phosphorous to function. Because of this in 2014 phosphate was added to the EU list of strategic materials (Source http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm). Luxembourg and European agriculture also rely on phosphate imported from outside Europe from countries with a record of uncertain relations with Europe; for example Morocco, Tunisia and Russia (see Fig. 10.1 , Source INRA http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=13828&no=33). The present trade embargoes between Russia and Europe are a new and unexpected risk, which underlines the fragility of European dependence on fertiliser imports.

As well, rock phosphate often contains relatively high levels of trace metals including uranium which is radioactive as well as chemically toxic (Source J.Natn.Sci.Foundation Sri Lanka 2009 37 (3):153-165). While many studies describe the problem, it is invisible on the political and agricultural scene.

The triple risks of soil depletion, contamination and dependence on unstable sources is seen by some as a ticking time-bomb for European agriculture. The question; what might Luxembourg do about it in the context of the circular economy?

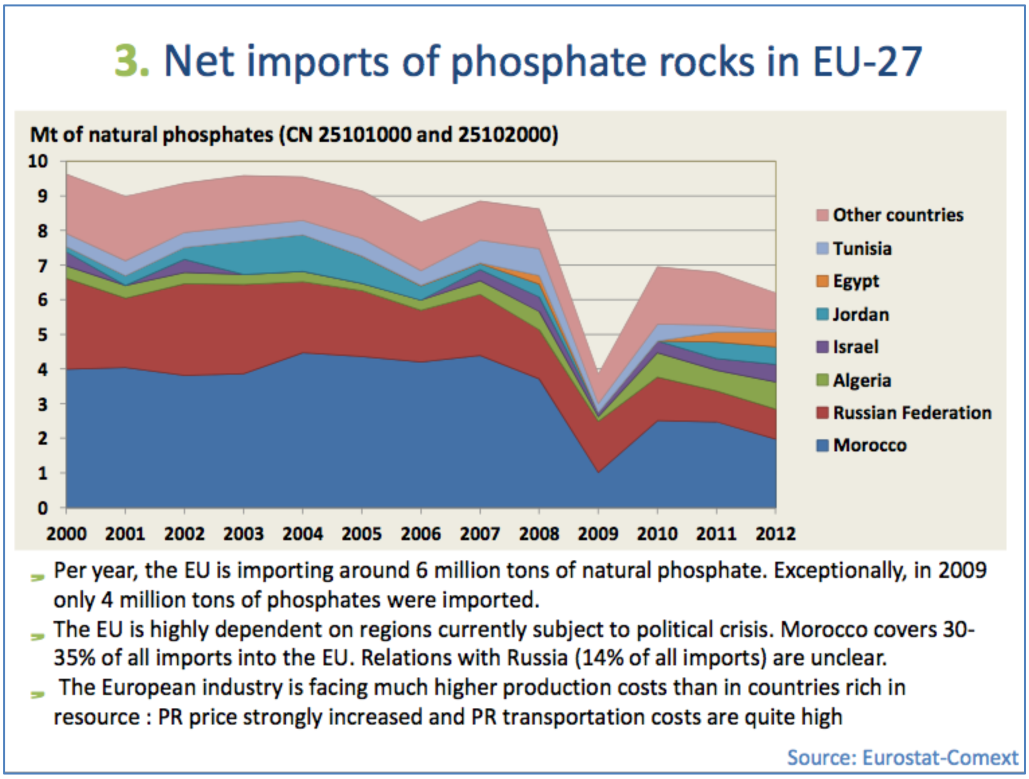


Figure 10.1: Net imports of phosphate rocks. Source INRA

10.1.3. Potential opportunities for organic farming in Luxembourg

Biobased agriculture is one way to improve the quality of Luxemburg's soils in a measurable way because biobased farms are required to maintain soil quality. However, organic agriculture accounts only for 5% of Luxembourg's otherwise industrialized agriculture; 5.000 acres vs. 130.000 acres total. The focus is milk, meat as well as some fruits and vegetables.

Generally Luxembourg agriculture is not competitive in any of the segments against competitors within 200 km radius resulting from up to twice the production costs due to higher land price, less productive soil, and sub-scale operations.

Oikopolis was formed as a buying and distribution consortium to secure the local bio-based agricultural community. Oikopolis has its own packaging and distribution operations and work closely with selected restaurants. The example of the Oikopolis local quality label is one of a few in Luxemburg, which might be used to improve competiveness. See Quality label under Chapter 10.7 Retailing.

The potential. Marketing & technologies for circularity

By using circularity, Luxembourg has the potential to rejuvenate its soils, increase its agricultural production and increase its competitiveness.

Marketing

An effective way to improve marketability of Luxembourg's local products might be to align the various quality labels used by wholesalers and retailers into a national 'buy local quality' label as described Chapter 10.7 Retailing.

The label might also generate stronger local farming community initiatives for the following circularity benefits;

Economic savings from phosphate capture & reuse

Various relatively new technologies are being used to capture phosphate economically from wastewater. On example is Crystal Green from Ostara. The advantages of the technology are;

- Reduced wastewater treatment costs due to;
    - Reduced energy required to treat wastewater when phosphate is removed prior to treatment. Up to 90 % of the phosphorus and 40 % of the ammonia load is removed from sludge dewatering liquid (Source: sswm http://www.sswm.info/content/fertiliser-sludge).
    - Reducing blockage of water treatment pipes which eliminates pipe-clearing costs and for example saved Thames Water €250,000 per year in the U.K.. (Source ITV http://www.ostara.com/sloughUK)
- Elimination of pollution risks from trace metals because the precipitation process separates the phosphate. Reduction of water pollution risks from fertiliser because the resulting fertilisers are formulated as slow-release, which keeps them in the soil.
- Improving yields from more effective and efficient source of nutrients than conventional P fertilizers.

The technologies are already being used in the U.K. at Thames Water Slough Sewage Treatment Works.

Topsoil manufacturing

Fertile topsoil can be manufactured based on lessons learned from soils discovered in the Amazon basin, called terra preta dos Indios. These man-made soils were generated by Indians some two thousand years ago and modern-day research captured some of the underlying principles. One company manufacturing fertile topsoil products based on terra preta is Palaterra (www.palaterra.eu) located Hengstbacherhof, Rhineland Palatinate in the Greater Region. Much attention is also given to biochar, which is a component of terra preta and the Palaterra product range, but also used on its own as a soil amendment product. Biochar can be produced in dedicated bioresidue processing facilities (see also SoilConcepts in Chapter 11. Upcycling). For more information see the International Biochar Initiative (http://www.biochar-international.org/).

These new soil manufacturing technologies promise a long-term solution to improving soil quality using locally available resources like roadside cuttings as well as agro-industry residues.

Improved biodigestion methods

Diverse second-generation biodigestion and dry anaerobic digestion and composting technologies are in the marketplace with high potential for Luxembourg. Those improve mechanization and the quality of digestate and compost for manure, municipal solid waste organic fractions, and industry.

- Aikan dry anaerobic digestion process http://www.aikantechnology.com/
- Eggersmann Kompoferm process http://www.eggersmann-gruppe.de/db/docs/einl-kompoferm-en.pdf.pdf
- Kompogas. http://www.axpo.com/axpo/kompogas/en/home.html A facility is operating in the Greater Region at Moorbach near Saarbrücken. Inbetriebnahme 2012 Kapazität 42.000 Mg/a MBA
- There are also two advanced biogas facilities in Luxembourg where biowaste, expired food etc. is processed and separated. These merit tracking.

However, barriers to systematic improvement of biodigestion in agriculture are the fragmented approach in the agricultural sector as well as overlapping jurisdictions between the different agencies and ministries including the water agency (Source interview with Pol Gantenbein, Chamber of Agriculture).

According to Mr. Gantenbein, nutrient recycling is made difficult because of restrictive legislation from water management authorities, especially on Nitrogen.

Nitrogen (N) is a limiting factor; often not enough other nutrients and fiber can be brought onto the fields because of N thresholds. The N problem is partially due to a definition issue in the regulations, which does not distinguish between types of nitrogen. Because of this, separation technologies for phosphate from biowaste streams are important so the phosphate might be used separately.

The greenhouse potential

Greenhouses are relevant for circularity due to;

- High productivity with reduced water and pesticide use per unit of production.
- Production 5 – 10 times higher than field-based open air agriculture.
- Potential recently being exploited for high recycling of nutrients.

The greenhouse industry is large and accelerating in Europe The Netherlands and Spain are greenhouse hotspots but other countries including France and Germany are expanding their industries. China has an enormous greenhouse industry, which is a response to its serious soil depletion problem. Those industries are largely not circular at the moment because they have not optimised their nutrient flows, but there are best practice "closed loop' greenhouses at e.g. Wageningen University in The Netherlands which demonstrate the practical potential using for example hydroponics (source http://www.hydroponics.com.au/wageningen-leading-the-way/).

Greenhouses in Luxembourg seem to suffer from a perception problem based on a few pilots tried a few years ago which failed due to conditions unrelated to agriculture.

One potential is to co-operate with the province of Limburg via the C2C Center and C2C Expolab, who have good circularity expertise and are looking to embed circularity into their extensive greenhouse industry.

10.1.4. Potential steps to support circularity in agriculture

Establish an *Agricultural Circularity Initiative* to investigate the following potential for using circularity to improve competitiveness and soil quality;

Improving competitiveness

- Investigate a national quality label based on circularity for local agricultural products.
- Request the agriculture ministry and an academic institute to re-visit the greenhouse potential and describe how to overcome barriers, which prevented earlier adoption in the Luxembourg context. Explore potential co-operation with the Province of Limburg via the C2C Center and C2C Expolab, who have good circularity expertise and are looking to embed circularity into their extensive greenhouse industry.

Soil quality and nutrient improvement

- Investigate new phosphate extraction technologies in co-operation with local municipalities for their own wastewater.
- Appoint someone with authority to resolve an apparent impasse between the water quality authorities and farmers regarding digestate.
  - Investigate the definition of nitrogen in regulations to see if it is possible to distinguish between the 'good' nitrogen generated by biodigestion and the non-viable nitrogen, which tends to runoff into water tables.
- In co-operation with companies who generate yard waste, do an exploratory visit to a biochar facility to investigate new soil amendment technology.

10.2. Automotive

Overview

The automotive sector in Luxembourg is at once one of the most promising yet complicated circularity candidates. It seems a natural for circularity due to its close relationship with automotive assemblers. Furthermore, resource security is a 'must-win' for Luxembourg automotive suppliers, and circularity is a solution. European directives on automotive recycling as well as take-back legislation are driving component suppliers to design for recyclability.

Stacked against those innovation opportunities are large barriers including price pressure, traditional and long lead-times for changes, out-of-country decision-making as well as limited economy of scale among Luxembourg companies, with a few exceptions like e.g. Goodyear.

In that context, the basic challenge for automotive and circularity is to identify a mechanism for systematic case-by-case as well as sector-wide analysis in an environment that is one step removed from the heavy daily pressures of meeting production demands.

10.2.1. Why, what, how & S.W.O.T.

Why

Resource security is a 'must-win' for preserving jobs for Luxembourg automotive component manufacturers.

Automotive components suppliers are extensive users of robotics as well as 3D prototyping, each which have substantial circularity potential.

Luxembourg has an automotive leasing industry, which might make a circularity partner, and a large logistics hub sector which might leverage parts replacements.

What

Resource Security Community to coordinate circularity pilot projects.

Explore how to organize supplier communities with willing automotive assemblers.

Life Cycle Assessment as low-risk circularity pilot.

Explore tracking of reusable packaging.

Explore how to benefit from a repair facility for logistics hubs.

Employ performance-based contracting for production equipment to improve resource productivity, reduce costs and maintain high flexibility required in dynamic markets.

Investigate biobased materials as pilot for non-critical apps.

How

Automotive innovation cluster;

- Identifies and prioritises biobased lubricants & cleaners.
- Explores new discoveries for slashing carbon composite costs.
- Participates in LCA task force for measuring positive impacts.
- Investigates new low-cost technologies for tracking packaging.
- Supports scaling up robotic 3D identification and use of parts in manufacturing being pioneered in the Greater Region.

S.W.O.T.

S **Diversified. Advanced technological capacities with highly flexible and modular production facilities. Geographic location.**

W **Serious barriers; Diversity limits scale. 2nd & 3rd tier suppliers face price pressure. Industry traditionalism. Manufactured parts often are not easily retrievable at end of use.**

O **Near-shoring jobs with 3D additive manufacturing.**

Biobased lubricants, cleaners, refrigerants & composites.

Redefining circularity benefits with LCA.

T **Competition for strategic materials.**

3D manufacturing is a 'must win' for components suppliers because automotive assemblers are already in-housing prototyping for parts, and the next step is in-house series production, which might render 2nd tier suppliers redundant.

10.2.2. The present situation in Luxembourg

The automotive industry in Luxembourg is presently developing an automotive R&D campus 'CAReVille' in order to generate savings from pooling services and reach critical mass for competitiveness. While the involvement of some major players remains open, the potential for circularity is high in, for example, at least one area; component packaging. Presently millions of automotive component packages travel back and forth between individual component suppliers and automotive assemblers. If the automotve campus becomes reality it might offer the possiblity for companies to consolidate and inventory component packaging logistics and tracking. As well, and as demonstrated at Ecoparc Windhof, other services like office supplies and waste management are easy to consolidate, and generate savings for users. In that context, CAReVille holds considerable potential for circularity if it happens.

In other areas of activity, the present structure and S.W.O.T of the automotive industry in Luxembourg is well known to the Ministry of the Economy and requires no repetition in the present study (Fig. 10.2). The defining characteristic of the sector is its diversity, which is a strength and weakness. Examples of activities with circularity elements are;

- Guardian glass is using 20% recycled glass in its speciality architectural products and is looking to increase that percentage.
- Since 2008 Goodyear and DuPont collaborated to develop BioIsoprene™ monomer – a renewable, cost-competitive alternative for petroleum-derived isoprene – and developed an integrated production system. Goodyear is also working on soybean and rice husk sourcing for tire materials (source Goodyear website). It is tracking dandelion-derived latex used by competitors and developed with for example Fraunhofer Institute in Germany (Source http://www.igb.fraunhofer.de/en/competences/molecular-biotechnology/industrial-biotechnology/rubber.html Goodyear is also investigating new pyrolysis applications for resource recovery. Those technologies each have good potential for circularity but require systematic evaluation.
- In 2012, Delphi launched instrument clusters remanufactured with 100 percent of parts (source Delphi press release), but the circular-inspired activity is not occurring yet in Luxembourg. It seems Delphi's component testing laboratory in Luxembourg does not test remanufactured parts (Source interview Etienne Jacqué). As well;

  Powertrain components. We have design for environment criteria, for example lead-free solder in electronics or other banned substances. These are largely directed by legislation and customer requirements. We do not have design for remanufacturing criteria…some products have design *criteria for service needs (f.ex. exchangeable rubber boots on ignition coils, re-programmable chips) which could in principle also apply in remanufacturing strategies.*

- Component suppliers use high technologies like 3D additive manufacturing for prototypes, and robotics. 3D manufacturing has a large job-creation up-side due to its near-shoring potential as described in the previously mentioned Haut Comité pour l'Industry report.
- 3D is a 'must win' for components suppliers because automotive assemblers are already in-housing prototyping for parts, and the next step is in-house series production.
- One challenge for circularity from additive manufacturing is proprietary feedstock which is a 'black box' preventing manufacturers from knowing exactly what is in their materials. For robotics, it is important to learn if most companies own their robots or some lease them, and if they are leased under which conditions. Leasing sometimes makes sense and sometimes not depending on the technology and economy of scale.
- Automotive and equipment leasing are circularity enabling tools. For example more than €1 billion in automotive assets are leased, rented and shared in Luxembourg (Source EPEA extrapolation from KPGM-derived Statec figures). In this sense, the 380+ jobs in the vehicle leasing, renting and sharing industry could be classified as on the way to circularity, as could repair jobs connected to those activities.

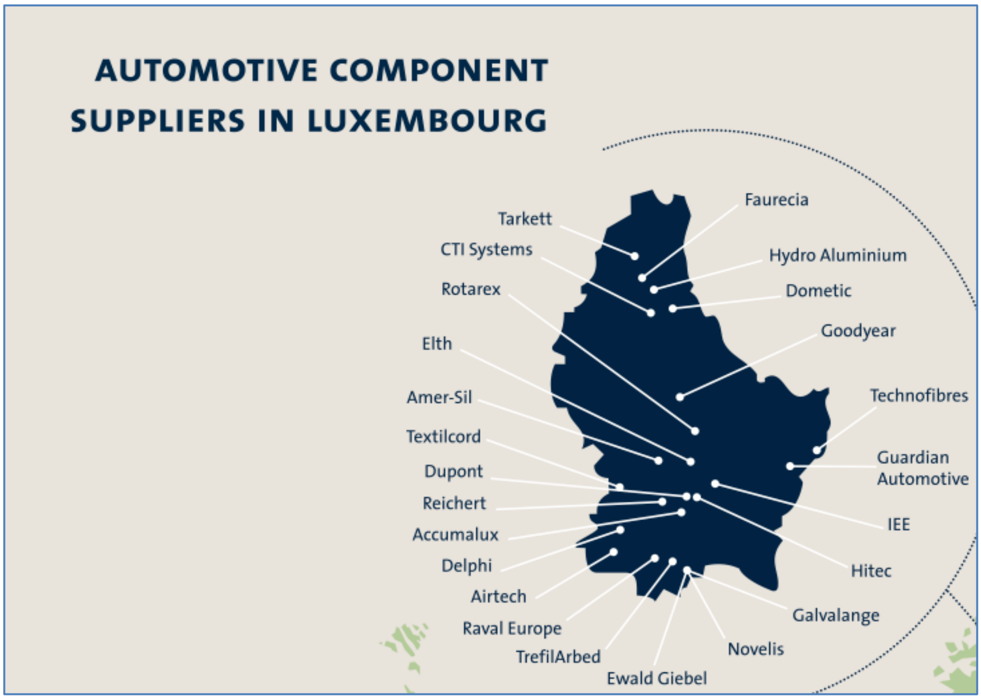


Figure 10.2: Snapshot of automotive component suppliers in Luxembourg. Source Automotive Cluster.

10.2.3. The potential

Due to the diversity of the sector, the approaches suggested here require careful consultation with individual companies in order to determine which if any might be practical for which suppliers. The Automotive Innovation cluster is the natural candidate for those consultations.

Framework approach

Resource security. Luxinnovation head Laurent Federspiel suggested the automotive sector in Luxembourg might use a resource security group to align R&D with regulatory compliance and strategic materials security to achieve circularity (Source Federspiel interview). To preserve existing jobs through security of supply for strategic materials, suppliers might work through the Automotive Cluster with primary manufacturers in Luxembourg and automotive assemblers to establish a *resource security community*. The community might focus especially but not exclusively on the transition from 3D prototyping to 3D series production, which might radically alter materials feedstock pathways.

- *Potential partners* include Renault, Mercedes, BMW, Audi and others serviced by Luxembourg suppliers. To determine which of those big assemblers is most tuned-in to collaboration on that level, the Automotive Cluster might hold an invitational workshop on resource security.

Potential activities to complement a resource security community

- *Secondary raw materials quality improvement.* Guardian Industries, Central Glass, Norsk, Eurofoil, ArcelorMittal participate in forming a supplier community for improving the quality of separation of scrap and cullet, as a way to increase the use of recycled content.
- *Near-shoring with 3D additive manufacturing.* Investigate circular 3D additive manufacturing as a way of 'near-shoring' more components manufacturing and establish continuous materials loops based on additive feedstock and 3D designs for disassembly. Luxembourg has a 3D printing industry, which is motivated to support near--shoring. Projections are for the industry to grow exponentially over the next years from €2.5 billion to €500 billion, bringing new jobs to Luxembourg. The 3D printing sector recently decided not to have its own cluster, but might welcome participating with the automotive cluster. A representative of the 3D industry in Luxembourg recently called on the government to develop a 'clear map' on directions for the industry. Materials security and onshoring for automotive suppliers in Luxembourg might be cornerstones of the map. (Source for paragraph; *No 3D printing cluster for Luxembourg,* Luxemburger Wort 25 Sept 2014.)
- *Lubricants, cleaners, refrigerants.* In order to comply with new EU regulations on HFC phase-out, as well as to further protect workers health, a potential quick-to-mid-term win across the automotive components sector is replacing lubricants, solvents and air conditioning gases with closed loop or biobased products. See Chapter 5. Improving Environmental Impacts.
- *Biobased polymers.* Luxembourg's automotive components manufacturers often rely on polymers. Those polymers will increasingly become biobased. It might be worthwhile for the cluster to establish close links to the biocomposites roadmap.
- *Biodegrading composites*. If biodegradation of composites becomes an established practice for the automotive recycling industry to recover materials, Luxembourg has the reverse logistics, scientific, automotive and other capacities to exploit the trend, and certainly those approaches are in line with the focus on automotive high technologies recommended by the High Committee for industry.

- *Pyrolysis best practices*. Goodyear might further investigate new tyre pyrolysis technologies developed in Switzerland and Germany.
- *Leasing & repairing.* End-of-use fate of most leased and rented vehicles is not presently circular, but the leasing mechanism is an enabler for repair, tracking and recovery of materials assets, especially for fulfilling the EU end of life directive for vehicles.
- *Logistics hubs.* There is a potential to establish repair facilities for trucks at logistics depots, but most companies already have their own repair facilities so the competitive advantage has to be investigated. Goodyear might be a significant player if it sees an advantage of offering direct sales to trucking companies at the logistics hubs. The sector has diverse inputs to the trucking industry, which might be integrated for a repairing capacity at Luxembourg's logistics hubs. According to Alain Krecké of CFL the logistics hub repair concept has merit but requires investigations on legal structuring (Source email from Alain Krecké .)
- *Packaging.* Automotive suppliers and assemblers exchange millions of reusable packages annually. Apparently a few million also go missing annually, and the barrier is the high tracking cost. Suppliers might work with assemblers to use new best available technologies for tracking. As well, many suppliers use one-way packaging. There is a potential to use memory-materials to develop generic one-way or returnable package to save costs. *See inroduction to this chapter for further description of the potential relating to CAReVille.*
- *Electric vehicles.* One of the unknowns is if or how Luxembourg automotive suppliers might participate in electric vehicles. A first step was taken in setting up charging facilities for hybrid buses being provided by Volvo. However, the buses (Volvo) and the charging equipment (ABB) come from outside Luxembourg. Might they be used as a training ground for Luxembourg to advise other municipalities on setting up charging stations?

Enabling tools;

- *Measuring impacts*. A mid-term win for manufacturers like Guardian Industries, Central Glass, and Goodyear is to participate in a Task force described in Chapter 14.5.5 for reformulating Life Cycle Assessment to measure the positive impacts of circularity.
- *Out-of-country decision making.* A frequent complaint in automotive is the lack of local decision-making authority. The Ministry of the Economy might organize invitations to decision-makers from outside the country to describe how Luxembourg is developing supplier communities, to improve links to decision-makers.

10.3. Buildings & Construction

Based on experience in the marketplace with building owners in the Benelux, Luxembourg building owners have hundreds of millions of Euros to gain in the near-term by designing for residual value.

10.3.1. Why, what, how & S.W.O.T.

Why

Construction is one of the largest employers and the largest generator or solid waste.

Materials start to lose value as soon as they go into buildings.

What

Training, training and more training in circularity.

Revalorise excavation waste & improve concrete recycling.

Explore how to improve residual value of construction materials (e.g. modularization, design for disassembly)

Establish material banks and materials passports to improve future stock management

How

Leverage existing construction products & circularity showrooms to kickstart training.

Explore materials banking & leasing.

Focus on owner-occupiers for Life Cycle Costing as low hanging fruit.

S.W.O.T.

Strengths

Strong construction sector with more than 3.200 companies (largely SMEs with high share of blue collar employees)

Active local market with strong pipeline of construction projects

Leading know-how on passive-house standards in high-demand in regional markets strengthening local construction companies position

Active research community with focus on high volume local flows and valorisation options (esp. concrete and steel recycling)

Weaknesses

Restrictive building regulations creating a high pressure to go deep and produce a large amount of excavation waste

Relatively low recycling rates for excavation, construction and demolition waste

High dependence on building materials outside of the country with potentially sub-scale influence to enforce improvements upstream (e.g. modularization of components, simplifying material pallet). Resulting limited attention to redesigning content of materials to be healthy.

Highly competitive sector, which will not favour total transparency on optimal arbitrage opportunities from establishing circular economy practices and closes loop operations

Opportunities

Improved source separation to increase valorisation of excavation, construction and demolition waste

Creating supplier communities to enable improved closed-loop operations in the Greater Region. This is particularly important in order to foster collaboration and standard setting, while catering for the competitive dynamics of the sector

Leading innovation, education and training in circular construction methodologies (i.e. design for disassembly and re-use, material innovation, performance-based building components provisioning, prefabrication and loss-less manufacturing (e.g. 3D printing), …)

Developing material databases and component/product registries for new buildings in Luxembourg to improve revalorisation of buildings in the future

Generate additional jobs and contribute to the diversification of Luxembourg's economy with a more re-industrialized construction sector, which can grow activities within the Greater Region

Threats

Inaction will lead to likely failing EU-targets and continued pressure on local landfills (esp. if due to poor source separation large quantities or re-usable feedstock is contaminated)

Continued pressure on labour costs could decrease competitiveness of Luxembourg's construction sector in the Greater Region (if not countered by improved quality and innovation as differentiator and the multi-lingual abilities of Luxembourg's construction entrepreneurs)

REACH non-compliance due to not knowing what is in products, leading also potentially to sick building syndrome which impacts productivity.

Takeaways

- The construction sector is an important sector for Luxembourg, esp. from a labour, material and waste volume as well as from value chain perspective, which is largely locally controlled.
- There is a potentially strong connection between steel, aluminium, architectural glass, flooring and concrete for circularity in construction in Luxembourg, due to existing platforms in Luxembourg, which use or develop those recycled or recyclable materials. There is an additional potential to develop a materials banking platform, based on some of those materials, by involving the financial industry in new financing mechanisms.
- There is a significant potential to improve the residual value of materials in buildings as well as productivity by designing for circularity. However, skills and awareness of best practices are often lacking. As part of the wider approach to training and education, a hands-on Circularity Training Space might be created for training the trades as well as architects and engineers in designs for modular assembly and disassembly, selecting circular materials, and other circularity skills. As well the use of modular recycled

steel and aluminium in buildings and temporary structures might be increased through training & education at e.g. University of Luxembourg.

- Due to the emphasis by the Ministry of the Economy on insulation materials for improving energy efficiency on buildings, and due to advances being made in new insulating materials, it makes sense to have an industry/academic/regulatory task force on healthy, efficient insulating materials.
- There is a potential to accelerate the use of excavation waste for landscaping and other applications in Luxembourg by creating a user/producer marketplace and integrating innovative designers into the process. However it also requires an evaluation of potential barriers presented by environmental and zoning regulations. There is also a potential to solve the landslide risk through imaginative uses of excavation materials.
- Luxembourg and the Greater Region seem to be facing a shortage of rock fill, stones for drainage; substances normally thought to be plentiful. The reuse of old concrete as well as the substitution of stones by geotextiles warrant investigation.

10.3.2. Context

Construction is an important sector for Luxembourg for a number of reasons.

- **Highest per capita construction and demolition waste volume in Europe**: With almost 6 tons of construction waste per capita and only 41% of recycling rate, reducing volume and value leakage represents a large and locally accessible opportunity to become more circular (see Figure 10.3). It is also important to step-up efforts in Luxembourg to meet the target of 70% (by weight) recycling rate by 2020 as articulated in the EU waste framework directive (2008/98/EC).
- **Largest waste fraction in Luxembourg:** With 8-10 mio. tons of inert waste in total it is factor 50 more significant by weight, not impacts, than the 0,2 mio tons of municipal domestic waste (Statec A3300, Inertabflälle im Großherzogtum Luxembourg 2003) and substantially above the average 25-30% range of waste streams in the EU.
- **Increased pressure on landfill space:** Esp. after the landslide at Mondercange and the following closure of the site, the pressure on avoiding inert waste flows has increased as space is getting scarce. In addition consequential damage to the economy due to delayed opening of University facilities and required road reconstruction add to the pressure to minimize excavation, construction and demolition waste.

- **Appearing scarcity in local building materials:** With the continued boom in construction in Luxembourg locally sourced feedstock has come under pressure, requiring the need for increased material substitution or recycling. Scarcity for stones and refill material (e.g. old ArcelorMittal sludge) for road bed construction has led already to substitution effects (e.g. synthetic geotextiles and filters by DuPont in drainage systems)
- **2nd largest non-services employer:** With almost 39.000 employees in the sector it represents 11% of the total employee force and is after the automotive sector the 2nd largest non-services sector and ranks 4th in overall sector employment (after automotive, financial services and public administration)
- **Local value chain and material stock:** As construction is by definition a localized business and materials are embedded in the structures to stay (and not to pass on after manufacturing for consumption on global markets, i.e. as is the case with automotive components manufactured in Luxembourg), it represents an ideal sector for embedding circular economy models with a high level of control over local value chains/cycles and the embedded material flows and stocks.
- **Focal point for many diverse locally controllable material streams:** Buildings are frequently made out of a high number of different materials and components, which are used at large quantities and therefore are an ideal starting point to embed circular economy models with enough scale to stimulate change quickly esp. for products with local manufacturing footprints such as steel, aluminium architectural glass, concrete. Moreover according to Annex B developed by EPEA for this study, a variety of other construction products designed for circularity are available in Luxembourg and the Greater Region. Recycled steel – for instance – manufactured in Luxembourg is used in modular temporary housing used on e.g. construction sites. Those units are potential models for designs for quick assembly and disassembly in the construction industry. See section on steel.
- **High relevance for energy and material consumption in use:** Buildings make up the biggest individual users of materials and energy. Humanity spends about 80% of our time in buildings and this is probably higher in northern Europe.

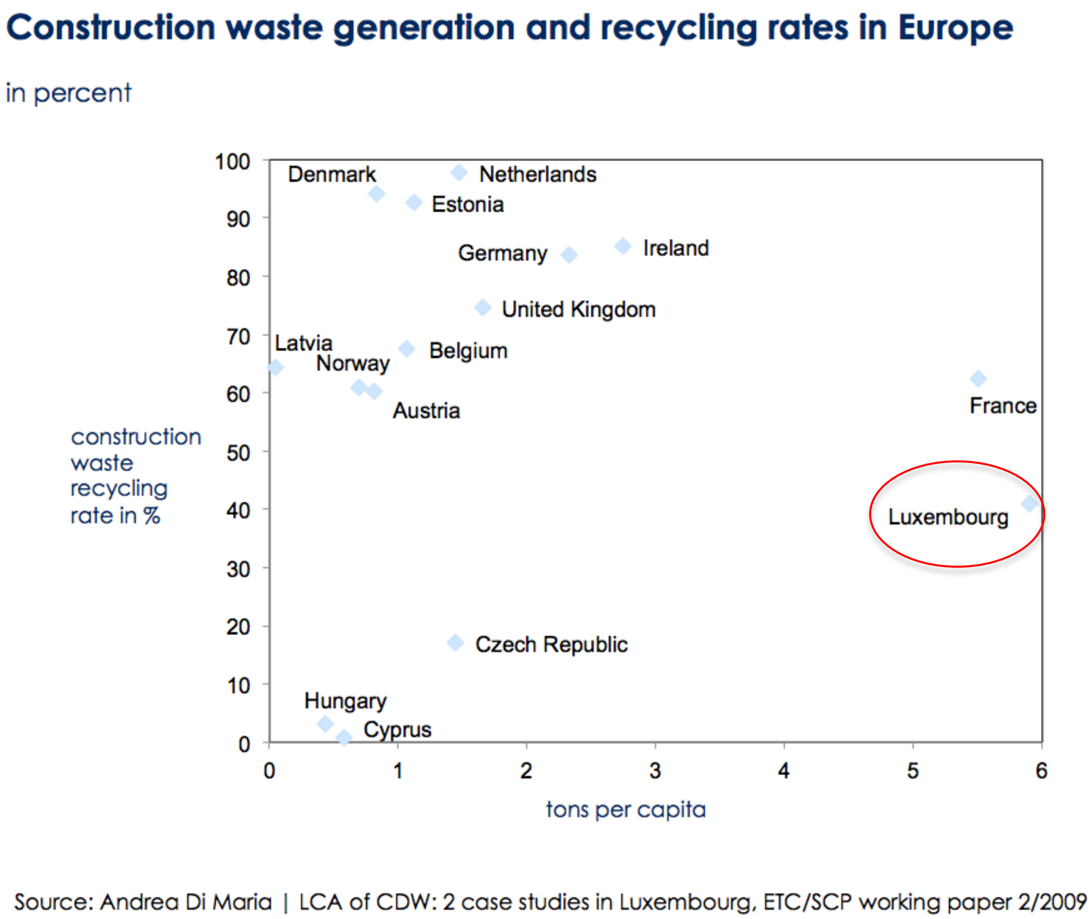


Figure 10.3: Construction waste generation and recycling rates in Europe. Source Di Maria

- **Excellent starting position**: Luxembourg already enjoys a formidable starting position by ranking amongst the leading nations on the eco-innovation index (see Figure 10.4) with a very strong footprint in eco-materials, eco-transport, innovative materials for passive and energy efficient housing, which are all geared to accelerate the transition towards a more circular construction and building sector.

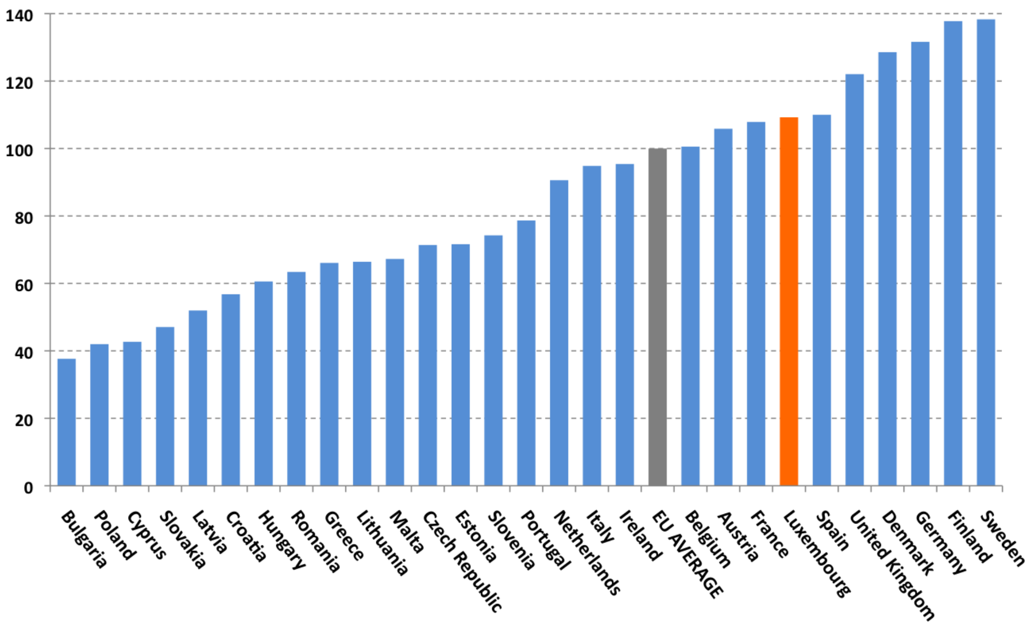


Figure 10.4: Luxembourg among leading nations in eco innovation. Source Eco-innovation Observatory

10.3.3. Total cycle perspective for construction and buildings

For circularity, buildings and construction have a beginning, a middle and an end before finding a new beginning. In order to systematically inventorize current practices and potential improvements to Luxembourg's construction and building sector the Total Cycle perspective is squared off against the classical building blocks of designing more circular systems: design (including material formulation and choice), business model design, reverse treatment processes and enablers (incl. regulation, financing, standard setting).

As a result the following structure emerges (see figure 10.5). The major functions relevant for circularity in those phases are;

Opportunity landscape for construction and building sector in Luxembourg

PRELIMINARY

Non exhaustive list of typical case examples

	Beginning	Middle	End / new beginning
Typical activities	• Planning • Regulatory approvals • Marketing, Purchase & Sale • Designing • Preparing the site, Constructing	• Furnishing • Operations • Maintenance • Renovation	• Restoration/Reconstruction • Demolition • Recycling • Component harvesting • Reuse
Design	• Pre-fabrication • Modular structures • Material choices and substitution • Energy efficient designs • Energy generation	• Energy efficient applications, installations • C2C furniture • Systems symbiosis (e.g. heat exchange amongst tenants)	• in-situ upgrades • On-site recycling centers
Business model	• Leasing of construction equipment • Material banking • Excavation waste valorization	• Performance based pro-visioning of light, furniture, technical installations, etc • Condition based renting schemes	• Secondary materials markets
Reverse activity	• Construction waste separation and recycling • Re-usable transportation crates	• Equipment maintenance • Recycling/reuse of furniture • Treatment of consumables (waste water)	• Debris/demolition waste sorting • Recycling of inert waste (e.g. concrete)
Enabler	• Material passports • Energy standards (e.g. passive house) • Building registers	• Building classifications • Safety standards	• Defined recycling grade standards • Material pools and balances

Source: EPEA, Returnity Partners

Figure 10.5: Opportunity landscape for construction and building sector in Luxembourg. Source EPEA, Returnity Partners

In order to generate more value out of moving towards more circular practices in construction a few key thrusts can and should be pursued;

- **Initial focus on owner occupiers.** In Luxembourg developers and contractors build for speculation and for owners. In general, building for owner occupiers is the low-hanging fruit for circularity, because capital and operating costs are combined for Life Cycle costing where investments up front pay back handsomely on the operating side. Owners are more likely to understand residual value of materials as well as healthy materials because they plan to occupy, operate and eventually decommission the building. As well they are more likely to consider improvements for facilities management.

- **Innovate designs and usage models with higher material productivity** right from the start (e.g. via pre-fabrication to avoid construction waste), investing into longer lasting consumables (e.g. LED-lighting), establishing loss-less manufacturing processes for components (e.g. via 3D printing), switching to more regenerative resources (e.g. increase usage of wood (without use of toxic, contaminating chemicals treatment).
- **Improve residual value of materials and components** by identifying and keeping track of embedded, well identifiable and separable components and materials. Considering buildings forms of long-term material banks with net-positive storage costs (i.e. rent from usage of the building) transforms the current perspective of needing to write off materials embedded in buildings to being able to recover them at point of renovation or demolition (see example calculation and figure in box)
- **Improve usability of existing structures** to maintain longer utilization periods and keep materials longer intact. Renovations and refurbishments allow to preserve a lot of the main structures (which is typically representing the largest share of materials in weight) while ensuring adherence to modern energy and quality standards.
- **Improve recycling and component harvesting rate** to avoid waste streams and valorise the embedded material streams. Concrete recycling or the re-use of insulation material (as is) represent already well established practices.
- **Interiors purchasing & leasing opportunity**? Luxembourg is enjoying a building boom recently. For most of those buildings it is too late to integrate circularity into most of the construction stage. However, purchasing of furniture and other movables is often left to the last. There might be a short-term possibility to exploit it.

The fate of materials in most buildings in Luxembourg

Although depreciation and tax write-offs hide the effects, the loss of value of materials for building owners still occurs;

Example;

Total building cost = €50 million

Fraction of costs represented by materials = 25-35% = €12.5 – 17.5 million

Value of materials for renovation and demolition = € - 0.3 million

Total loss at demolition = € 15.5 – 20.5 million

Those losses do not just occur at the end of 25 or 35 years of use; they start to occur when the building is renovated, which can be as early as 5 years after the building is constructed, as is often the case in Luxembourg.

It is difficult to accurately calculate the total original cost of materials in buildings in Luxembourg because builders are not required to include the information in building permits. However, it is safe to estimate the total building stock in Luxembourg loses hundreds of millions of Euros annually worth of materials value because those materials are not designed or installed in a way that maximises their residual value (see Fig 10.6).

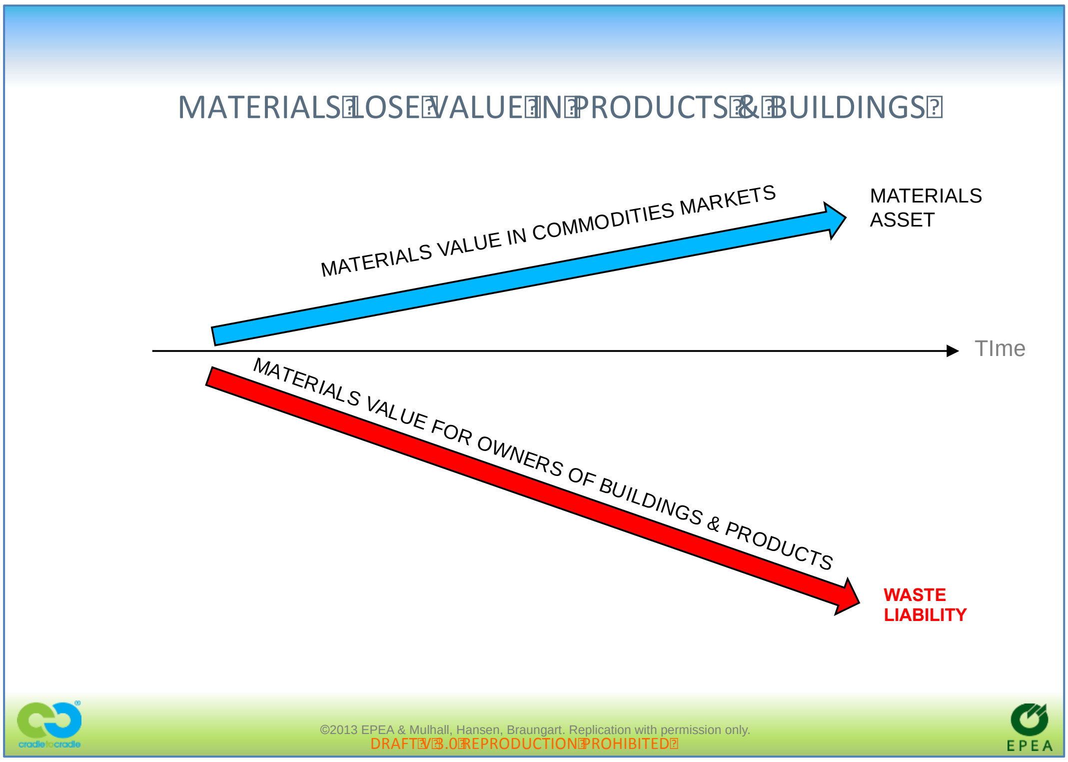


Figure 10.6: Materials lose value in products and buildings. Source EPEA

Generating savings at City of Venlo by putting the total cycle approach into practice;

Not far from Luxembourg in the Benelux is one measurable example of using circularity to generate cost savings; The new Venlo City Hall in The Netherlands (see Fig 10.7);

The municipality of Venlo is currently building a €50 million Cradle to Cradle inspired city hall planned to be delivered in 2015. The city hall integrates novel technologies, systems, materials selection and architectural decisions into a multifunctional building which is a front runner for a circular economy. Circularity Elements include; recycled concrete, a green façade with deconstructable recycled aluminium, aquifer technology, water and air purification by the building and green roofs, solar electricity, passive heating, and solar ventilation.

Even though the city hall is still under construction, already the financial benefits of Cradle to Cradle inspired architecture and design for circularity are apparent, and measurable. The building consists of materials designed to retain value even after the use phase of the building, whereas usually in buildings this value is zero or can be a liability. Defined materials will be used for new applications after being retrieved from the building.

Usage of those materials translated into combined savings from improved write-off values, which resulted in projectable end-value calculations especially for moveables, as well as supporting lower mortgage payments. The residual value of the building after 40 years of usage was assumed to be 5 million Euro, the total benefits over this period add up to nearly 10 million Euro, including a cut in the mortgage payments of 200 thousand Euro per year. However in order to achieve it the municipality still had to put up its land as collateral, so there are still steps to take to achieve an independent funding of residual value. (Source email message from M. Weijers, City of Venlo November 21, 2014 & phone interview Dec 17, 2014 summarising presentation at C2CBizz event Nov 20, 2014)

Figure 10.7: Architects illustration of finished building. Source City of Venlo

Energy savings and energy technologies. By applying on site renewable energy technologies such as solar power and heat and cold storage a total of 16 million Euro is saved throughout the use phase of the building. These technologies provide a ROI of up to 12% which means that during the use phase of the building the technologies are not only fully paying for themselves, but will continuously provide electricity, heat and cooling far beyond this point. In operating costs this comes out to a savings of €500 thousand per year. (Source City of Venlo Michel Weijers project manager).

The building is a frontrunner example of how owner-occupancy and life cycle costing play to the advantage of circularity.

It is also a flagship example of how educating suppliers led to improved materials quality and substantial savings. By achieving high materials quality through supplier consultations Venlo demonstrated that public tendering does not have to be a barrier to circularity.

[Transparency note; EPEA is an advisor and trainer for Venlo City Hall since its inception.]

10.3.4. Waste streams opportunities

Almost half of all resources used in Europe go into the construction and building sector. As shown in figure 10.3 Luxembourg leads the European statistics in terms of construction, excavation and demolition waste. The reason for this is explained by the fact, that Luxembourg provides a lot of workspace for trans-border employees and tends to dig deeper into the ground to create parking space for commuters than in other European countries, where space is less constrained. In addition local building regulations impose height restrictions increasing further the pressure for increased excavation to add space to new buildings. As a result the share of construction, excavation and demolition waste represents by far the largest share of waste streams. Within this segment inert waste streams account for a total of 8-9 mio tons. Of this roughly 6 mio tons are landfilled and 2-3 mio tons are recycled (2010 numbers).

The waste typically occurs during construction, renovation or demolition of buildings. While systematic reports on the composition of construction, excavation and demolition waste are systematically not available a recent LCA study performed by Henri Tudor provides a practical datapoint for the composition of construction waste and the preferred treatment options of the respective fractions (see following Figure 10.8).

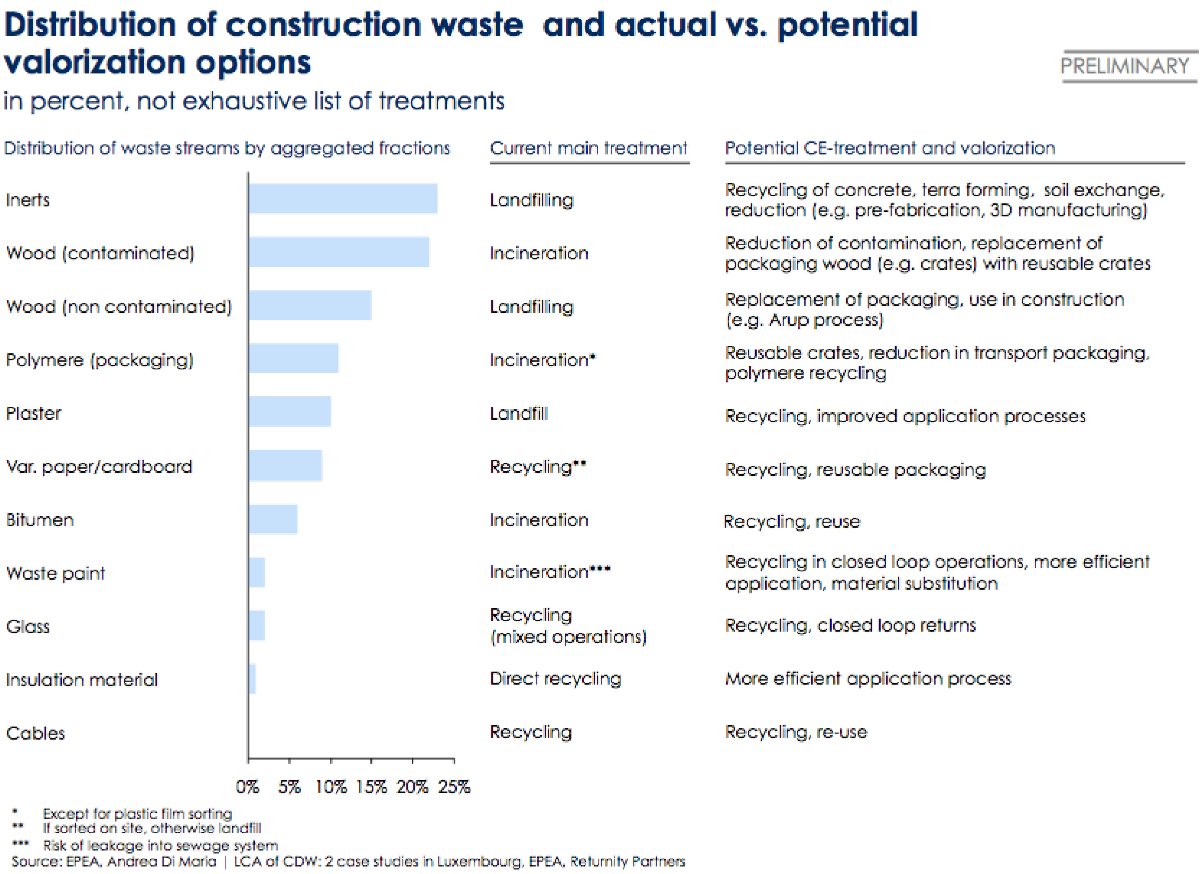


Figure 10.8: Case example of construction waste streams in Luxembourg. Source Compiled from various

As can be seen a large share of waste streams are bound for linear processing via incineration and landfilling without more circular valorisation options. The overview of potential circular valorisation options in Figure 10.8 displays that there is substantial potential to increase reuse and recycling rates. Luxembourg already possesses a number of critical competencies to improve the recycling rate. These include (without promise of completeness) for instance;

- **Recyma's** screening, crushing, sorting and selection (by contamination grades) and storage operation for inert waste streams in Hosingen and Brouch. From the 2,1 mio tons recycled materials however the reusable fractions for closed-loop recycling (i.e. concrete to concrete) is fairly limited and accounts for less than 10% today.

- **University of Luxembourg** has initiated research into the field of concrete recycling, which could yield higher valorisation options, esp. as with increased local sourcing existing feedstock might face material shortage rendering recycling options more cost competitive.
- **SoilConcept** offering composting services to provide regenerative soil from waste water and sludge treatment. Already today about 20% of the produced product is used by local construction companies. By being able to avoid gate fee and surcharges for landfilling and achieving revenues from sales creates arbitrage opportunities meriting the investment in these facilities.

In order to unlock those options for creating more circular treatment options a more detailed material flow analysis would be required as well as providing a platform for know-how transfer and opportunity sharing across key actors along the construction value chain (from planers to demolition companies).

Numerous case examples outside of Luxembourg confirm, that with improved sorting of construction and demolition waste substantial savings due to avoided gate fees for landfilling and revenues for recycled materials can be obtained (i.e. Hong Kong demolition case study). The most critical element is to do on-site separation and to ideally feed back the mined resources to the original component manufacturer to avoid contamination with impurity along the reverse loop or handing over materials to down-cycle activities (e. g. ground concrete for roadfill vs. as feedstock for concrete recycling).

10.3.5. Manufacturing materials & products for use in the built environment

Pre-fabrication typically allows reducing on site construction waste streams and improves ease of disassembly (frequently maintaining integrity of reusable parts). To this end the innovation around reusable temporary structures could provide further waste avoidance and reuse value creation opportunities (e.g. www.bauhuintegratedsupportsolutions.com/cubes.html).

Sheet pile leasing of ArcelorMittal reduces the need for construction wood and provides a material pool, which can be returned after construction is finished. See section on Steel for a description of ArcelorMittal's systems.

Tarkett as a manufacturer & user of diverse materials

> *When we think Circular Economy we don't think just end-of-use but also the quality during use.*
>
> Anne-Christine Ayed, Executive Vice President
> Research, Innovation & Environment, Tarkett

Tarkett is researching circularity since 2010 and scaling it up into markets. Tarkett's R&D division based in Luxembourg is quietly driving a materials transition across a broad product line with significant implications for ingredients, additives, coatings in diverse industries including automotive, floor coverings, but also most industries which use the same materials in their production. Tarkett recently acquired the leading Cradle to Cradle company Desso, which has a complete range of C2C products leading its flagship product sales. Together the companies constitute one of the leading R&D, manufacturing and marketing powerhouses for circularity. The new combination puts Luxembourg near the top of the circularity pyramid in terms of R&D capacities for a range of circularity-defined materials. R&D based in Luxembourg includes;

- Coatings
- Composite materials
- Colours and varnish
- Fine Chemicals, Dyes and Inks
- Fire Resistance/Safety
- Forming (rolling, forging, pressing, drawing)
- Hardening, heat treatment
- Jointing (soldering, welding, sticking)
- Joining techniques (riveting, screw driving, gluing)
- Moulding, injection moulding, extrusion, sintering
- Properties of Materials, Corrosion/Degradation
- Plastics, Polymers
- Rubber
- Surface treatment (painting, galvano, polishing, CVD, PVD)

Tarkett is especially focused on indoor air quality and on defining what is in its products.

Among the many competitive advantages Tarkett sees in pursuing circularity, Anne-Christine Ayed explains the motivations include;

- Savings when it comes to some recycled materials (post installation or post use) or energy /water management. There are products where Tarkett cannot make money if it doesn't use recycled material.

- Competitive advantage, goes with savings in certain cases e.g. the case in Brazil or our partnership with Walmart. In the US, the competitive advantage is also linked to the product composition and then the associated C2C certification/LEED points. In Europe, launching the phthalate free products (or better said, PVC flooring designed for indoor use) is also giving us a competitive advantage as an environmental leader but not in terms of price.

- Risk management when it comes to knowledge on materials that are suspected of being toxic to humans or the ecosystem and for which there is no regulations (hence Tarkett's partnership with EPEA).

She also observes that so-called green products also have many often-unknown interactions, so the traditional approach to green is sometimes problematic.

Tarkett recently launched an Environmental and Health Statement for its products as a positive response to other product declaration mechanisms which it sees as focused too much on the 'less bad' features of products.

Tarkett has an extensive corporate communications programme and publishes its KPIs in relation to its 2020 roadmap.

Tarkett is one of the largest users of PVC, a controversial polymer in the environmental community. Tarkett established a zero tolerance policy for harmful offgassing from its PVC products. The company also offers a wide range of materials for customers who prefer not to use PVC, which includes C2C certified linoleum and parquet.

Above everything else, Anne-Christine Ayed emphasises the priority for management leadership buy-in to circularity. In this respect the sustainability approach at Tarkett is part of a steering committee led by CEO Michel Giannuzzi.

For the construction industry Tarkett sees big room for improvement in the way residues are separated at construction sites; an observation echoing other interviewees from the industry in Luxembourg.

Considering those factors, Luxembourg has a special opportunity to leverage Tarkett's R&D, manufacturing and marketing knowledge and emphasis on circularity as well as its openness. See Chapter 14.5 Potential Quick Wins for pilot projects.

Tontarelli

Tontarelli manufactures a range of household goods used in buildings but also for other purposes. Its inclusion under the construction segment of the present study is for convenience only, and the following description is valid for other sectors where plastics are used.

Tontarelli manufactures polymer-based products (almost exclusively out of PP) for food-grade household products, (since recently) lego-style configurable furniture and industrial transport crates (used to be global supplier of Chep the pallet pooling company worldwide until recently. In Luxembourg Tontarelli operates its own manufacturing plant (10 million pieces a year) for the household goods division and distributes all products within in Europe except for Mediterranean Europe and the UK.

Tontarelli believes in a fully integrated value stream and hence owns design, tooling of machines and its own injection molding facilities. Distribution is done via internet, large retailers (e.g. Auchan in France, Cactus in Luxembourg) or large professional service providers (e.g. Chep)

Tontarelli believes in the economic potential of the circular economy and has already established practices; 20 - 25% of the plastic molded in Luxembourg stems from regrained materials (mostly own process waste, some returns and damaged products) equivalent to roughly 7,5 mio EUR savings in material costs annually. It has improved reparability of industrial crates and offers repair services. It aims to use re-generative energy where possible (e.g. in Italy it operates the single largest privately owned generation plant (8.9 MWatt)).

The potential

Tontarelli seems an ideal candidate for using positively defined polymers.

Going forward Tontarelli is interested in further creating value from circular activities and had preliminary discussion with LuxInnnovation on this for;

- Home appliances
  - Increasing access to food grade regainable feedstock (e.g. by setting-up closed loop plastic recycling with LuxPet, ValorLux and Cactus, offering take-back scheme with selected retailers) to increase feedstock of regrainable plastics.
  - Increase use of renewable energy for its manufacturing.
- Furniture
  - Innovative design of product with EML-film (idea is to build all furniture from lower grade, black PP and cover with separable film to provide coloring, haptics) to increase potential for using regrained material as feedstock.

- Offering after-sales services (i.e. repair services for furniture).
- Offering performance based solutions (e.g. for schools, offices, hotels)
- Innovating new grade of polymer with high recyclability and improved functionality (i.e. haptics, durability) together with Emped (also in Luxembourg)
- Build-out of spare parts, after-sales services to improve longevity of products already in use

- Crates
  - Improve access to feedstock of certified food-grade regrained material (e.g. collection of used components from users, certification program (labeling) of other products in parallel industries (e.g. food processing, catering,….).
  - Set-up more local pooling system (e.g. with Oikopolis) to reduce need for new crates and increase circulation of existing stock.

Barriers and solutions

Overall Tontarelli is confident to identify further possibilities but struggles to get systematic oversight on volume streams of (food-grade) PP in Luxembourg/Europe and finding suppliers willing/capable to certify food-grade quality of re-grained material.

SPECIAL NOTE; As part of the C2CBizz project the U.K. Institute for Sustainability has a food-grade plastics recycler on its business park site who might be able to support Tontarelli on the certification question. As well, Envision Plastics in the U.S. has FDA-approved PP for some years now and is profitable.

According to Tontarelli Luxinnovation/Lux government could support via;

- Providing oversight on players in sector
- Supporting identification of closed-loop opportunities (e.g. by providing inventory of expert companies for required reverse-value steps)
- Providing incentives / access to alternative, regenerative energy

Quote;

> *Luxembourg is ideally positioned to lead the transition towards a circular economy. In Luxembourg everybody knows everybody. Decisions are quickly implemented. And it's geographic position and logistics capabilities make it the ideal home for (reverse) distribution networks*
>
> Source Interview with Atilio Germano

10.3.6. Process opportunities for scaling up

In addition to optimisation of the material streams there exist substantial opportunities to improve material productivity of used construction equipment and installed equipment furnished into new buildings. A number of existing practices and future opportunities were highlighted in the interviews (again without completeness).

- **Floow2** offers equipment renting for large construction equipment (e.g. cranes, building machines) by matching demand and supply of heavy equipment. This improves machine and resource productivity by avoiding overinvestments into underutilized equipment.
- **Loxam** provides via its Luxembourg office - like other rental players in the market -equipment rental services based on owning a pool of manufacturing and construction equipment. This allows needs-based use of equipment and higher usage for underutilized equipment.
- **Lindab research on sustainable construction** aims to improve energy performance of steel structures and commercial buildings to reduce the energy consumption of the buildings during the usage phase (Luxembourg Wort, 4/09/2014).
- **Flexible use of buildings** becomes more attractive, esp. as many office spaces recently have been transferred to the Kirchberg region. This leaves empty office space behind, which could be re-used for multiple different purposes (incl. residential use). By offering multi-purpose designs at construction phase and providing flexible fitting solutions for re-configuration of long lasting building infrastructure

10.3.7. Proposed potential next steps

In order to accelerate the transition towards a circular economy in the construction and building sector in Luxembourg we recommend to pursue initiatives around three thrusts: a) building awareness and a network of practitioners, b) build up capabilities and a solid foundation of enablers, c) demonstrate potential by implementing tangible results quickly:

A) Building network and awareness amongst practitioners

- **Build awareness and local network:** In the context of potential value gains, it might make sense in early 2015 to hold a symposium focusing on *Circularity for Healthy Interiors with High Residual Value* to give interior designers the opportunity to learn how to improve value using circularity and take advantage of the many interior products designed for circularity which are in the marketplace today. Circularity frontrunners like the floor covering company Desso have 'Circles of Architects' including one in Luxembourg, which might serve as a platform for such a symposium.

- **Enable build out of material pools and local exchange platform**: Material market is frequently intransparent and as in many cases demand and supply need to coincide in time in order to find cost-effective re-use of construction or demolition material (e.g. using excavation waste for re-fill or terraforming typically only viable, if no intermediate storage is required) it is an important enabler to drive awareness within Luxembourg about upcoming pipeline of demand and supply and to connect players that sit on likely interchangeable material streams (linking demolition companies with project planers and supplier community). The newly opened LetzGreen platform for clean technologies could be enriched for a section on circular construction and material pooling (www.letzgreen.lu). Providing a central forum to inventories capabilities, providing direct access to actors, promoting Luxembourg's competencies in the Greater Region and providing a platform for continuous information exchange is an important enabler.

B) Building capabilities and solid foundation of enablers

- **Foster research and development:** The construction and building sector has undergone relatively little material productivity increases compared to other industries. This is largely due to a lack of research and development. As the local institutes have already started to investigate options to boost material productivity (e.g. Fab Lab on 3D printing, recycled concrete) creating a dedicated consortium with proper funding could fast-track the development of innovations towards more circular construction and building sector. .

- **Invest into training centre:** The construction and building sector in Luxembourg is largely made up of SMEs, who do not necessarily enjoy sufficient means to continuously keep their workforce informed and trained towards the latest standards. But the EcoInnovation cluster could play together with other sector relevant training centres (e.g. IFSB-training centre, Neobuild, University of Luxembourg) an important role to further the know-how about circular practices and offerings available in

Luxembourg (e.g. practical means on how to avoid construction/demolition waste by improved sorting)

- **Define reliable regulatory roadmap:** The construction business is as many project based businesses characterized by short-term focus and high fragmentation of responsibilities as the construction process is frequently carried out by a large set of small to medium companies (SMEs). As a result arbitrage opportunities from circular practices are frequently not pursued as the coordination effort is high and the distribution of the potential gains along the value chain unclear. In these instances government can step in and steer the sector to adopting more circular practices. On the energy side Luxembourg's forward-looking adoption of new standards has created a competitive advantage for the local construction and engineering companies vis á vis their regional competitors as their track record and higher learning curve are important differentiators for contracts in the Greater Region. (Source Chambre de Metiers). Creating the same stimulus on material productivity by enforcing standards on CE-construction (e.g. minimum sorting requirement, design for disassembly) could put a Luxembourg into a leading position without distorting local competition. For this to work however a clear and reliable roadmap needs to put in place, which protects the required investments and allows sufficient time for adjustment of processes.
- **Build out enabling services:** While the concept of material pools and banking is straight forward the actual establishment of these practices for complex structures made out of multiple different material streams, for asset classes which might transfer ownership during long usage periods (e.g. requiring legal frameworks, value assessment procedures) requires well designed support structures and services. Building out the required standards, material banks, material passports (e.g. as natural extension to the classical BIM-standard in construction), material markets would benefit from a concerted effort of existing players in these fields to form joint offerings. LuxReal could be an important player to provide the required delivery mechanism as they are already well interlinked with the different stakeholders in question.

C) Building tangible, practical impact cases

- **Perform detailed material flow analysis** for excavation, demolition and construction waste/material flows: In order to inform the other initiatives with a solid fact-base a more in depth material flow analysis for excavation, construction and demolition waste would be an important pre-requisite. Creating this know-how in a pre-competitive form as a knowledge trustee would allow to spot major points of leakages and allow to prioritize pooling and closed loop opportunities

- **Create light house projects:** a recent study by Henri Tudor on life cycle cost assessment proved, that Luxembourg could drastically improve its poor construction and demolition waste recycling rate by establishing betters sorting on site and feeding recovered material streams into more productive valorisation streams then landfilling and incineration. By picking one construction (e.g. Ernst & Young Kirchberg building, Hollerich Village) and one demolition site (e.g. European Parliament refurbishment/new build) and engaging the many practitioners in Luxembourg to show, what is possible with today's readily available means could create an important proof and inspiration point for the sector in Luxembourg
- **Establish closed loop operations for large-scale construction and demolition fractions**: Guardian Industries produces architectural glasses in Luxembourg. They achieve already a 20% recycling glass input ratio in their glass. The limiting factor is to find feedstock of sufficient quality. As glass is recycled in "mixed bag" operations via the classical glass recyclers the quality suffers due to contamination. Establishing more closed loop recycling, paired with design for disassembly and training of workers (and potentially paired with glass leasing to ensure ownership and tracking) could significantly increase the share of recycled content and hence increase circularity. Similar closed loop operations could be established for other locally produced building and construction materials (e.g. recycled steel, recycled concrete).

Given this long list of rich opportunities there is also a significant increase in job creation and positive development of economic indicators for the construction sector very likely (see Chapter 4 on raising industry competitiveness and job creation). To initiate, direct and oversee the different potential next steps the Conseil National pour la Construction Durable could play an important role to bring the required actors together

These content topics are also important components of the overall roadmap elements (see Chapter 14) to be functionally integrated into the respective working groups and processes for the capability-led approach recommended:

Table 10.1: Roadmap elements

Roadmap Category	Potential next step
Coordination framework	- Build awareness and local network - Enable build out of material pools and local exchange - Establish closed loop operations for large scale construction and demolition fractions
Education & training	- Invest in training centre for CE in construction
R&D	- Foster research and development for CE in construction - Perform detailed material flow analysis
Marketing & Messaging	- Create lighthouse projects
Regulation	- Define reliable regulatory roadmap
Investment, banking, insurance	- Build out enabling services (esp. material banking, secondary construction resource markets, …)

10.4. Information & Communications Technology

The following section provides only the briefest overview of the potential role of ICT in the circular economy.

10.4.1. Why, what, how & S.W.O.T.

Why

ICT is a central enabling technology for circularity.

ICT is a leading user of high value materials.

Luxembourg has a policy of attracting data centres and is looking for a way to keep them after tax advantages expire in 2015.

Protecting privacy is a major issue closely connected to circularity due to information about IP in materials, and personal privacy on sharing websites. Luxembourg might use its reputation for confidentiality to its advantage for circularity.

What

Identify core activities where ICT in Luxembourg adds value to circularity.

Develop a cluster roadmap to scale up those activities.

How

A circularity working group for the ICT sector in Luxembourg organised by the ICT cluster.

S.W.O.T.

S In almost every case ICT is central to enabling circularity.

W Large user of strategic materials

O Privacy protection for circularity sharing site users

T Tax status loss

10.4.2. The present situation

Remarkably, the 2014 EC Scoping study on the circular economy does not seem to have a section on the role of ICT, except for a few mentions of recycling computers and mobile devices as well as using databases and bar codes.

In many cases ICT is an enabling platform for circularity. Examples;

- The leasing and sharing economy requires front end user interfaces for customers and back-end databases to make them operational.
- Materials databases are essential for valorising and assessing the quality of primary and secondary raw materials.
- Reverse logistics require extensive mapping and inventory databases as well as front end user interface.
- Economic indicators for circularity require a range of statistics and inputs to and from databases.
- Product designs for circularity require integrating graphic user interfaces with data.
- Building systems, product integration into buildings and maintenance integration require BIM interface with databases.
- ICT itself is one of the leading users of high value materials.
- Luxembourg's ICT innovation cluster has a Green ICT working group focused on smart cities and mobility. Smart cities and mobility are closely connected to logistics, and logistics are enabled by ICT.
- Improve paper productivity by digitalizing work flows. The government could lead by example and start to introduce paper-less administrative processes. Notably digitization has been an important driver to dematerialize products into services (e.g. ebooks today represent already a larger share then printed books) and to provide powerful enablers for circular models (most notably via material and performance tracking). However it also involves optimising the underlying equipment for resource recovery due to the extended use of high value materials.
- ICT hardware and software are the heart of 3D additive manufacturing. Luxembourg companies and institutes already exploit it. For example;

  Laser prototyping http://luxprototyping.com/3d-prototyping?lang=EN

  The fab lab at Technopoort http://fablablux.org/

Because ICT was not a focus in the terms of reference of the study, but due to the pivotal role ICT plays across the circularity spectrum, the present study suggests a working group of the Luxembourg ICT be created to examine value potential from enabling circularity.

10.5. Metal Manufacturing. Aluminium

10.5.1. Why, what, how & S.W.O.T.

Why

Aluminium in Luxembourg depends partially on secondary raw materials for jobs and competitiveness.

Improvements to quality matching will improve recycled aluminium use.

Luxembourg's aluminium industry is investing in improving secondary raw materials use.

Aluminium recycling and reuse greatly reduces environmental impacts.

What

Explore mechanisms to achieve quality matching between scrap and manufacturing.

Explore materials leasing and banking by adapting the steel sheet pile leasing approach.

Start a Luxembourg competency programme for secondary raw materials.

Improve LCA methods for measuring the positive impacts of circularity.

How

Ministry of the Economy facilitates optimising a Greater Region circular aluminium community.

Financial community explores materials banking potential with diverse owners.

Tudor organises an LCA community to optimise LCA for measuring circularity positive impacts

S.W.O.T.

S Up to 50% of aluminium comes from secondary sources

W Scrap quality

O Improve scrap quality

T Competition for scrap

10.5.2. Overview

Hydro

Hydro depends heavily on secondary raw materials for its continued operations in Luxembourg. Hydro's largest aluminium remelting operation in Europe is located in Clervaux. The plant remelts aluminium scrap into extrusion ingot, with capacity topping 115,000 metric tons per year.(Source Hydro website).

Eurofoil Luxembourg SA

Eurfoil is in the process a multimillion Euro investment in upgrading its capacities to reuse recycled aluminium more effectively.

Eurofoil is the world leader in aluminium rolling and recycling. With industry-leading technology, it produces premium sheet and foil for high-value markets.

The Dudelange plant located in Luxembourg is one of the two Eurofoil Aluminium plants. The 1625mm wide rolling mill offers a comprehensive product range in terms of capacity, widths and technical specifications, and ensures the supply of high quality foil to customers in a range of sectors, including packaging, household foil, heat transfer and industrial applications such as insulation and pipes. At Dudelange, the four continuous casters help recycle the internal scrap and ensure the autonomous supply of all foilstock raw material used on site. The site also houses the headquarters of Eurofoil.

Products

- Converter Foil: a comprehensive product range of capacity, widths thicknesses and technical specifications for flexible packaging applications, food, pharmaceutical and aseptic, and also insulation applications. Household foil: in jumbo reels. Industrial Finstock. (Source Eurfoil website http://www.eurofoil.com/us/about_us/site_location/Dudelange_L.htm)

About 50% of Eurofoil’s production comes from recycled scrap.

Other manufacturers

Diverse automotive and building industry manufacturers in Luxembourg use aluminium to manufacture their products. For example ArcelorMittal manufactures Aluzinc® (55% Aluminium, 43.4% Zinc and 1.6% Silicon) mainly used in building, for instance, roofing, cladding, partitions, in petrochemical industry, electrical and in household appliances, deep drawing applications. (Source ArcelorMittal website)

The potential

Aluminium producers & users join the steel and glass industries to establish supplier communities with scrap dealers for metal banking, optimising quality and supporting training for competencies in secondary raw materials re-use.

10.6. Metal Manufacturing. Steel

10.6.1. Why, what, how & S.W.O.T.

Why

Steel in Luxembourg depends on secondary raw materials for jobs and competitiveness.

Improvements to quality matching might make the difference between profit and loss.

The steel industry has high competence in secondary raw materials.

The steel industry has excellent connections with materials leasing and modular designs.

Steel recycling and reuse has major impacts on reducing environmental impacts.

What

Explore mechanisms to achieve quality matching between scrap and steel manufacturing.

Align quality assurance departments more closely with purchasing departments.

Explore extending materials leasing and banking to buildings and other structures.

Start a Luxembourg competency programme for secondary raw materials.

Improve LCA methods for measuring the positive impacts of circularity.

How

Ministry of the Economy facilitates optimisation of a Greater Region circular steel community.

Financial community explores materials banking potential with building owners.

Tudor organises an LCA community to optimise LCA for measuring circularity positive impacts.

S.W.O.T.

S Steel pile leasing, steel scrap reuse, reverse logistics network

W Scrap dealers have variable quality assurance and volatile pricing

O Steel banking

T Continued dependence on volatile scrap for Luxembourg operations

10.6.2. Takeaways

- Circularity is already used for competitive survival by the steel industry in Luxembourg due to the absence of proximate primary raw materials sources.
- Sheet pile renting for temporary use is a high level, high-volume example of circularity which merits studying as a case for other industries, as well as for expanding to extended term uses of steel e.g. in buildings and structures.
- Recycled steel is integrated with modular construction of temporary accommodation units used e.g. on construction sites. The modules are designed for rapid assembly and disassembly, which is a core component for circularity. At the end of use the units are dismantled by scrap dealers.
- Incremental improvements to matching scrap quality with steel quality might improve margins, and in a low margin industry might in some cases make the difference between profit and loss. The challenges include; smoothing scrap volatility as well as incentivising scrap dealers to have a consistent level of separation, and incentivising purchasers to align more closely with their own quality assurance departments.

10.6.3. Introduction & overview

The industry needs no introduction or overview for the Ministry of the Economy or most segments of the Luxembourg economy. Luxembourg's history is built on steel and while the industry's participation to the economy has declined in relative terms, ArcelorMittal remains the largest company employer in Luxembourg.

Steel-related development relevant for circularity in Luxembourg;

- ArcelorMittal's total operations in Luxembourg including beams, steel piles, and other products generate a total of 2 million tonnes of steel annually and are totally dependent on steel recycling.

- The company is investing €35 million in 2014-15 on upgrading its sheet pile manufacturing in Luxembourg. Sheet pile renting is a significant business.
- In 2012 the company rolled out a line of organic coatings to make its products more environmentally compatible; a consideration for circularity.
- The company has its own logistics hub capable of handling 1 million tonnes annually (Source ArcelorMittal websites http://luxembourg.arcelormittal.com/Our-sites/Distribution-solutions/European-Logistics-Centre/). The harbour of Mertert is an important partner in scrap logistics for the steel industry.

10.6.4. Steel & circularity

The steel industry generally and ArcelorMittal specifically have high relevance for circularity due to these factors (Fig. 10.9);

- Steel is a recyclable and reusable metal.
- Steel is bankable.
- Steel is rentable.
- Steel is still being innovated and is not stagnating.
- Steel use is expanding globally.

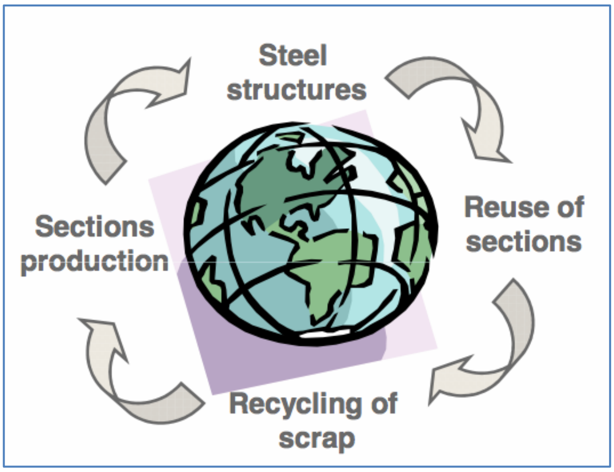


Figure 10.9: Steel and circularity. Source ArcelorMittal

In the case of ArcelorMittal and Luxembourg there is an elegant example of circularity as well as potential for improvement. There is already in place a well-established customer-supplier circular community consisting of ArcelorMittal, secondary manufacturers, demolishers, scrap dealers and logistics companies who deliver steel throughout that cycle. The loop is not closed because the steel leaving ArcelorMittal is not the same steel scrap that comes in. However, according to ArcelorMittal, most of the steel manufactured by its Luxembourg operations is used in EU countries, and most of the scrap steel that comes back is collected in a 300 km radius. The majority of the steel manufactured in Luxembourg is for the construction industry; therefore it is relatively easy to track where it goes.

Steel renting

In one case, sheet piles, the steel is not only tracked but ownership is maintained by ArcelorMittal in a leasing scheme where the piles are used for temporary purposes such as retaining walls during construction, then are recovered in an extraction and reverse logistics loop (Fig. 10.10). At the end of their use they are remelted and become new products. In other cases where piles are sold to contractors, the contractors themselves will use the piles for repeated jobs before returning them to ArcelorMittal or scrap dealers for recycling.

The competitive and job preservation advantages of the approach are described in Chapter 4 and do not require repeating here, except to say that the steel pile renting system represents a powerful example of how a company in Luxembourg has used materials scarcity to its advantage out of necessity by converting from primary raw materials dependence to secondary raw materials.

As primary steel production becomes more expensive due to the rising costs of extracting iron ore and as scarcity starts to bite in the steel industry, the model might gradually be used to convert the overall steel industry to circularity.

Figure 10.10: Sheet pile removal for reverse logistics and re-renting. Source unnamed youTube.

However, there are some challenges to be solved in order to optimise the approach. Foremost is the challenge of matching scrap quality with steel quality. The way the scrap system works today, scrap dealers basically dictate price as well as separation quality based on marketplace conditions (export prices). If market prices are high, separation quality is high and for example contaminants like copper are extracted prior to remelting. If market prices are low separation quality is reduced. The variation in quality is a challenge for quality assurance personnel in the steel industry who have only limited control over purchasing. As well, the purchasing departments internally are naturally under pressure to perform based on price, and do not have a so big motivation to match scrap quality with intended outputs. In this external and internal structure, there tend to be variations in matching input quality with intended output quality.

As well there is the challenge of where the steel goes after it leaves ArcelorMittal. Frequently steel is coated with surfaces to give it added functionality. In buildings various products are attached to steel, which are sometimes difficult to remove. Those features represent contaminants, which ultimately have to be removed or are burned off during remelting or separated before as in the case of concrete. While there is a difference of opinion over how toxic the resulting emissions are, resources are still lost or quality reduced due to coatings and other materials, which are not designed for recycling.

Designs for circularity

Steel housing modules designed for rapid assembly and disassembly are manufactured using ArcelorMittal steel. Companies like Luxembourg-based Astron as well as Germany-based Modular Construction Solutions use ArcelorMittal steel. The modules are great examples of using recycled materials to construct reusable systems, which are then disassemblable and recoverable (Fig 10.11 + 10.12).

Figure 10.11: Circularity in practice. Modular steel units being constructed from recycled steel. Source Modular Construction Solutions GmbH.

Figure 10.12: Circularity in practice. Modular steel units constructed from recycled steel. Source Modular Construction Solutions GmbH.

Expanding the steel banking potential

Because a large portion of construction steel is relatively easy to track and stays in a fixed radius of Luxembourg, the potential is to adapt the steel piling rental system to steel banking, where ArcelorMittal or a third party keeps ownership of the steel, and customers who lease the steel follow a set of design parameters like e.g. design for disassembly and coatings designed for recycling. For example, ArcelorMittal, third party banking groups in Luxembourg, and building owners might enter into agreements where steel is provided for buildings at a fixed interest rate. As part of the deal, quality specifications for modular construction to guarantee high quality of the returned steel would be included. The incidental loss of steel in that cycle is compensated for just as banks compensate for bad loans; through an interest rate differential. Despite the challenges, steel sheet pile renting provides a great model for the approach. As well, the presence of a vibrant insurance and finance industry in Luxembourg provides the enabling tools necessary to develop the overall system. Insurance and finance companies are used to dealing with leasing due to experience in the automotive, aircraft and other industries. In total, Luxembourg has the tools in its own hands or in the Greater Region.

The business and employment implications are largely in the service sector. If steel banking is expanded into segments other than steel sheet piles, Luxembourg companies will be the leading experts in how to organise the approach, and will be hired in other parts of the world to implement it. As well, Luxembourg might be recognised as the lighthouse for steel banking, thus enhancing the image of its financial and other partner industries.

At a competitive level, competitors to ArcelorMittal such as Tata steel are already investigating other types of steel leasing. There might be room in the pre-competitive space for ArcelorMittal and its competitors to examine the pros and cons of steel banking. However, ‘steel banking’ has large implications. While such a mechanism is being investigated, other mechanisms for optimising the existing system might be undertaken like e.g. optimising purchasing between scrap dealers and manufacturers, as well as optimising the internal connections between quality assurance and purchasing departments.

Improving scrap quality

Another potential is to improve the matching of steel scrap quality with intended steel output quality. ArcelorMittal believes that with some improvements in the process, margins and quality might be improved together. However it might require a different type of relationship between scrap dealers, ArcelorMittal and possibly providers of scrap to dealers. Anti-competition authorities might cast a careful eye on such an operation in order to watch for price fixing and exclusionary practices. However the reality is that there are relatively fixed players in the relationship between e.g. scrap dealers and steel producers. As well, in a materials banking situation the role of demolishers and scrap dealers might change and not necessarily to their liking, because they might become logistics organisers for the steel owners. In a steel banking situation the leading players might be the steel manufacturer, perhaps third party asset owners as exist today e.g. in the solar systems industry, and the steel users e.g. building owners. Demolishers and scrap dealers would serve as logistics intermediaries. In some cases with e.g. building demolition this is already happening, and for example the Dutch-based waste management company Van Gansewinkel pioneered a materials management tool, which slashed the costs of demolition for building owners by more than 40% (Source EPEA co-development training with Van Gansewinkel.)

Potential actions

- *Steel Circular Community.* The Ministry of the Economy and EcoInnovation Cluster organize a workshop on 'Steel upcycling potential' to explore how the system works now and how existing supplier/customer links might be adapted to a steel circular community. Include;
  - ArcelorMittal,
  - Selected building owners like for example insurance companies and banks in Luxembourg,
  - The main scrap suppliers from the Greater Region; ECORE (Aubange, Belgium), SRP (Homburg, Germany), THEO STEIL (Trier, Germany) and DERICHEBOURG (Gandrange, France).
  - Companies, which construct temporary modular units as well as more permanent buildings to determine how coatings and attachments might be adapted to designs for disassembly to improve the quality of the returned steel.
  - European anti-competition experts from e.g. KPMG Luxembourg might support the work by exploring how to achieve a roadmap to steel banking without contravening regulations.
- *Measuring Environmental Benefits.* CRP Henri Tudor as well as MDDI lead an initiative with ArcelorMittal to improve measurement of environmental benefits for steel reuse. The CO_2 and resource savings of steel recycling & reuse are well described in the literature and do not require repeating here. However, companies like ArcelorMittal as well as the construction industry recognise that LCA scoping parameters might have to be revised to reflect the full savings throughout the cycle. LCA usually does not account for example for quality improvements or multiple re-use except e.g. in the glass

bottle industry, which might be taken as a case example for multiple re-uses of steel. In this respect, MDDI and CRP Tudor might play a leading role.

- As well these aspects of steel recycling merit further investigation;
  - Using renewable energy to run electric remelting processes. Recently for example LaFarge cement began running its cement kiln operations in Morocco from wind energy (Source Lafarge).
  - Recovering CO_2 as an industrial resource from steel smelting emissions. For example Mitsubishi Heavy Industries does this already in the chemicals industry (Source Mitsubishi).
- *Education & Training*. Steel renting & leasing as it is presently practiced is also a model for other industries to consider; not for wholesale adoption in their industries, but as examples of how circularity is being practiced on a large scale based in Luxembourg and the Greater Region today. The model might be featured for example in the Training Space described in Chapter 14.5.1, and might be included in circularity courses at University of Luxembourg. As described earlier it is also an excellent case example for piloting new approaches to LCA and might be a focus for student case studies on LCA methods.
  - *Competencies for secondary raw materials.* Along with Eurofoil, Guardian, Tarkett, Tontarelli, and others, ArcelorMittal might make a powerful partner in a Luxembourg programme for competency in secondary raw materials technology.

Sources; information for the preceding segment was gathered as a result of an interview with Jacques Hoffmann at ArcelorMittal as well as from EPEA own experience in the steel industry.

10.7. Retailing

10.7.1. Why, what, how & S.W.O.T.

The segment focuses on groceries but describes other fast moving consumer goods (FMCG) e.g. clothing as well as selected take back systems for other goods.

Why

Luxembourg retailers have successful local labels, which support circularity.

Retailing centres are ideal 'de-shopping' locations to support circularity.

Food and food residues are a focus for many circularity studies due to the impacts of agro-industry and opportunities for value capture.

What

A national quality label using local products & partnerships to improve competitiveness.

How

Integrate existing quality labels and run pilots.

Use Luxembourg as a test market for existing circularity-designed products.

S.W.O.T.

Strengths

Local partnerships built over years and decades.

Partnerships along local value chains.

Flexibility due to servicing multicultural community with varying and changing needs.

Relatively short supply chains for local products.

Potential test market for new products (Luxembourg's position is well established).

Weaknesses

Few local products, most products are imported from abroad.

Dependency on imports of foreign products.

Comparatively small-scale market reduces competitiveness in negotiations with wholesalers.

Opportunities

Affluent clientele.

Daily commuters add considerable business.

Growing awareness of customers toward local and regional products.

Threats

Competition from large foreign retail chains which can afford to invest in loss-leaders to get a foot in the Luxembourg market.

10.7.2. Grocery retail sector in Luxembourg

Sectorial overview relevant for circularity

Luxembourg's grocery retailing sector services a large number of customers from the Greater Region, and domestically enjoys a customer base with one of the highest per-capita incomes in Europe. Examples of retailers shown here include Cactus, Oikopolis and Pall Center. There are many others.

CACTUS

Overview

Family-owned Cactus is the largest Luxembourg-based retailer with stores of various sizes in Luxembourg ranging from large 15,000 m2 shopping centres to small 50-100 m2 quick stop shops at gas stations (Cactus is not operating the gas stations). Cactus also operates two home decoration DIY stores. More recently, they introduced Cactus@home for online shopping and home delivery. This is cost-intensive but has a small fan circle.

Cactus core business is groceries. Three-quarter of their turn-over is in food and one quarter in non-food items. They employ approx. 4,000 people.

Almost 80% of the goods come from abroad, about 20% from the local market, e.g. LuxLait.

Local partnerships

If circularity is considered to include short distribution chains and 'buy local' then Cactus is on the way in these areas;

- Local products get preferential treatment on store shelves. It has a niche market for local products and as well clearly wants to be different from discounter stores by providing 'good selection, good quality, good prices'.
- It processes meat, which is mostly local, after butchering.
- It has a wholesale operation for fruit and vegetables. It has an exclusive label with a Luxembourg-Saarland fruit farmer cooperative (~10 farmers).
- It is organizing theme weeks at shops to inform customers. For example, local producers present their products. CE has not yet featured but they would be open to it.
- Next year, Cactus plans to organize farm visits with selected customers to show them where the products come from. Customer surveys have identified strong customer interest in understanding where their food comes from.

Cactus does not have written purchasing criteria.

Being a Luxembourgish company gives Cactus better access to the local market to source local products "Aus der Regioun fir d'Regioun". However, it requires building trust and long-term relationships, which cannot be established overnight, especially in a conservative farming community. They have been cooperating with Luxembourg bio-cooperative Oikopolis for the past 20 years, did a lot of pioneering work and built confidence in the past. For Cactus, this is a differentiator to the large retail chains pushing into the Luxembourg market.

Oikopolis is supplier, also have their own stores Naturata. Cactus is also getting supplies from Altnatura.

They work with local farmers for meat, but also aquaculture where they source trout, as well as local oils, honey from local beekeepers, fruit, vegetables, cheese etc. Cactus helps with packaging and marketing aspects. See a list of producers see http://www.cactus.lu/page.asp?id=2972&langue=4.

Cactus has its own, state-authorized meat label guaranteeing quality - „Rëndfleesch vum Lëtzebuerger Bauer" [http://www.cactus.lu/page.asp?id=2413&langue=DE]. Producers are monitored strictly and controlled by an independent third party.

One clear example of the competitive and economic advantage of local supply chains is that during the BSE crisis, Cactus-labelled meat only showed very small reductions in sales. Meat label on packaged meat also identifies the farm producer.

Figure 10.13: Cactus quality label for meat products. Source http://www.convis.lu/abteilung/fleischrinder/qualitaetsprogramme/cactus-rendfleesch.html

Greater Region sourcing

Many products come from the Greater Region, not in a targeted way, but because the distribution centres are located there. They have purchasing co-operations with REWE for some typical German products, which are cheaper than sourcing them elsewhere, and Hagebau for non-food in Germany, and with Casino in France.

Circular-oriented activities

- Cactus is offering products close to expiry date to staff at special price. The practice is relevant because right now there is strong criticism of the EU 'best before' labelling policy which critics claim is one of the leading causes of food waste.
- Additionally, some materials go into biodigesters.
- Cactus supports forestry and agriculture projects – 50 ha forest and old fruit tree plantation.
- Also to prevent waste Cactus is giving away products to 1-cent stores and organisations for people in need (similar to Deutsche Tafel e.V. in Germany) who come to pick up products in the evening (dairy, bread etc.).

- Batteries are collected at stores.
- Lions Club organizes mobile phone collection.
- Also, they take old white goods back when they deliver new products.
- In March every year, Cactus has a bicycle fair where people can put used bikes up for sale and then get Cactus shopping voucher for sales price. Cactus is brokering the sale.
- Packaging waste is separated and pressed, then picked up by disposal contractor. Sometimes they pay, sometimes they get paid depending on market.

For Cactus, CE is not a commonly understood term yet, but like sustainability several years ago it will most likely become commonplace.

Opportunities for improving materials and products quality in retailing are in own labels, e.g. coffee. The coffee-to-go is sold in biodegradable cups. Fresh herbs (Cactus Bio) are in biodegradable packaging.

Cactus has their own proprietary inventory control system/ merchandise planning and control system, which also contains general information about the packaging type. This could be expanded to trace packaging compositions and quality in the supply chain, but maybe also other material flows like waste.

Environmental activities

Cactus undertakes a variety of environmental activities, some which might be considered circularity-oriented;

Shopping bags are sold instead of given away only to encourage people to bring their own.

There are 2-3 e-vehicles in the fleet and charging stations at the shopping centres. Cactus initiated training for truck drivers to save fuel, emit less CO_2 . It has no plans to convert Cactus fleet to biodiesel or e-vehicles.

PV on roofs at three locations.

Flyer going to 220,000 households informing them about their environmental activities.

Competitors

Large retailers and discounters are competitors, but Cactus has build several niche approaches based on local sourcing, quality labels and activities that differentiate them from those.

Pall Center has similar approaches, especially with the focus on local products and partnerships and is a small competitor. However, due to their size Pall Center has to fight harder for market share. Cactus has more possibilities due to their size and trading volume. Pall Center and Cactus each have respective advantages due to their size.

Quote Laurent Schonkert, Cactus:

> *"Building trust in partnerships doesn't happen overnight. We have made a longterm effort to build these relationships."*
>
> *"Foreign retailers often do not realize how important it is to cater to Luxembourg's multicultural demographics."*
>
> *"Speaking Luxembourgish can be a clear advantage in building local partnerships."*

PALL CENTER

Overview

The Pall Center concept store offers a wide range of shops, including fashion, shoes, household, decoration, design, art and other items as well as groceries and a selection of restaurants.

Pall also offers a catering service.

The owner regards Pall Center as a pilot and test ground for new things to influence the future. This fits well with the overall perception of Luxembourg as a test market for many products due to its multiculturalism and diversity. Though sometimes smiled at for her projects and initiatives, she has a clear view of where she wants to go. This makes the Pall Center an ideal partner for pilots, e.g. C2C store or De-shopping.

Twenty percent of their customers are green sensitive and young with kids, and Pall Center is constantly developing ideas for and adapting to this growing marketplace.

Leveraging and servicing the Greater Region for circularity

Due to its geographical position at the border, 50 percent of customers come from Belgium. Thirty years ago the Pall Center started with cross-border fuel-tourism, which in those ways was an economic necessity but today is problematic for circularity as described under the 'Fuels' section. However, it has since leveraged that business to become a shopping attraction on its own with strong circularity components; an example of turning a circularity negative into a circularity positive.

For example, Pall Center advocates Locavorism, favoring local and seasonal products over imported ones, e.g. by giving them prominent shelf space, displays etc. (see Fig. 10.14). In an interview, Mr Geoffrey Debertry, Manager, Pall Center, winner of the Green Entertainment & Leisure Award 2013, described it this way;

> *Pall Center has decided to favour short distribution chains in order to support our greater region.*
>
> *The economic repercussions are clear and direct.*
>
> *On the one hand, our customers are happy to find different products, of high quality and which touch them 'geographically'. Let's not overlook the sensitive side of the act of buying.*
>
> *On the other hand, our 'new' suppliers, (or should I say, Stephane, Kim or even Manuelle), with whom we maintain a relationship of partners, enables a certain social cohesion to be reinforced.*
>
> *Q. What are the different partnerships that you are maintaining? What are the bases of a win-win situation in a local economic scheme?*
>
> *A. The produce that comes from French Lorraine, from Wallonia, from the Saar Basin and Rhenania and naturally from the Grand Duchy of Luxembourg can be identified by the presence of an explanatory label on the shelves of our grocery shops.*
>
> *Our total independence and unique shareholding allow us to say who is being favoured …*
>
> *A direct proximity with the* ***producers from Luxembourg*** *and partnerships with the German and French market accompanied by an excellent relationship with the Walloon Export Agency enables us to be quite effective.*

Source http://en.pallcenter.lu/sustainable-development/17-locavorism-sustainable-development-thanks-to-local-commerce#article

Figure 10.14: Pall Center label for local product choices Source http://en.pallcenter.lu/sustainable-development/17-locavorism-sustainable-development-thanks-to-local-commerce#article

Local partnerships

Local partners and producers from Luxembourg are important players in the Locavorism approach (see above).

The Pall Academy currently provides educational courses for schools grades 1 to 6. Students are introduced to entrepreneurship and sustainability acquiring insights into seasonal fruits and vegetables, learning new vocabulary related to the retail business as well as experiment in culinary classes. [http://en.pallcenter.lu/sustainable-development/14-pallacademy#article]

This could be expanded to also involve older students. Initially, students came mostly from Belgian schools and the uptake in Luxembourg schools was more reserved.

Pall Center was among the first to support the Beki, a local currency aimed at supporting local partnerships and cooperation in the Redingen Kanton. When the Beki is exchanged into Euro by retailers or organizations which received it as payment, two percent goes to financing the non-profit organization de Kaer who created the Beki and three percent goes to charitable project which can be selected. [http://www.beki.lu/fr]

Pall Center is also very engaged in the professional training of young people. It just took on 15 apprentices who will be trained in retailing with all facets associated. The owner is actively involved in the training because she wants to change the perception that jobs in retailing are the last resorts and demonstrate that these are valuable jobs for Luxembourg.

"One must start by remaining alert to what already exists. For instance, we are truly in need of very positive initiatives like that of the Chamber of Agriculture with the campaign "Sou schmaacht Lëtzebuerg". I am convinced that many restaurateurs and retail traders act in this way and do not make it sufficiently known."

Source http://en.pallcenter.lu/sustainable-development/17-locavorism-sustainable-development-thanks-to-local-commerce#article

Current circular activities

Supporting local biodiversity

Pall Center is participating in the "The Place to Bee" initiative aiming at supporting local bee keepers by offering locations to place their hives. [http://www.theplacetobee.lu/] This has been a success because the honey bees produce good amounts of honey due to regional biodiversity and no stress (Fig. 10.15).

Bee important!

The bees, which Pall Center is keeping as part of The Place to Bee, are travelling back and forth between Luxembourg and Belgium ('Bees without borders', 'bee biodiverse'). In this way they are an important symbol of material flows in the Greater Region, and a geographical delineator of the local bioregion.

Figure 10.15: Label for local honey produced at Pall Center. Source http://fr.pallcenter.lu/

Pall Center launched “Fox, the Pall label (La Griffe du Pall)”, for “outstanding-quality textiles at unbeatable prices.” Working directly with the manufacturer, the origin of the textiles is checked and come from sustainable factories [http://en.pallcenter.lu/articles/9-fox-the-pall-label].

Pall Center staff is wearing uniforms from the Swiss brand Switcher (in part labelled Fairtrade and 100% traceable by respect-code.org). Pall also sponsors local sport teams with these shirts.

For some of its stores, e.g. youth fashion, Pall Center recovered and reused old furniture for store decoration.

Waste

Pall Center has a ValorLux Re-box station where customers can return plastic products for re-use and recycling. This includes collection of plastic foils and bags, blister and box packages, and cups and pots. The collection station also collects textiles and shoes, which are given to charitable organizations via GreenCityPoint and TEXAID-Luxembourg. [http://valorlux.lu/sites/valorlux/files/CP_StationsCollecte_DE.pdf]

Pall Center also has cooperation with Superdreckskescht for sorting and recycling collecting. Batteries go partly through Ecobatterien in collaboration with SDK.

Careful inventory management reduces the amount of food residues from the grocery store: perfectly good, close to but not yet expired food from the grocery store is used in their restaurants onsite. Some products also go to cent stores as well as biogas facility operated through Hein.

Planned circular activities

Pall Center;

- is planning a new gourmet restaurant in a restored and expanded building on site, which will use produce from an organic garden surrounding the restaurant.
- does not currently have written purchasing criteria, the owner directs purchasing and trains her buyers based on personal experience and preferences. However, the owner expressed interest to develop written criteria, possibly as a Master student project.
- is open to discuss CE/ C2C training for apprentices and other staff.
- supports the idea of renting/leasing fashion and is planning to set-up related activities. They are also developing the sale of ethical, solidarity-promoting textiles with the Swiss brand Switcher.

- is currently exploring switching to LEDs in their stores including the possibility for light leasing. First contacts have been made with Luxembourg-based ECRES.
- is thinking about smarter logistics, where retailers and suppliers share transport logistics in a smarter way.

Environmental activities

- Pall Center clearly acknowledges the need for sustainability with positive impacts and has been a leader in supporting and implementing activities.
- Pall Center installed the first solar panels on their roof in 1999 and has expanded since. They generated both, heat and electricity.
- The Pall Center air conditioning system uses a water-cooling system.
- Pall Center has efficient systems for light and electricity management.

Quote Christiane Wickler, Pall Center:

> *"Luxembourg is too small for quantity so we have to compete on quality."*
>
> *"Luxembourg is a country for entrepreneurs but there aren't enough of them."*

OIKOPOLIS

Like the founding BIOG-coop, OIKOPOLIS Participations SA main objective is the development of agriculture, which is sustainable in the mid- and longterm, including the associated businesses along the value chain.

Oikopolis acts both as a wholesaler for Cactus as well as a retailer with their Naturata chain of stores.

Thus they have unique experience linking the production with the product sales side, including packaging.

Although they specialize in organic agriculture, a lot of their experience can be extrapolated to the agricultural sector in general.

Local partnerships

Already in 1994, Oikopolis' daughter Biogros signed a trade agreement with Cactus and the Demeter Luxembourg Group to provide Cactus with biological and bio-dynamic products of certified (Demeter) quality. This contract was renewed in 2014 after 20 years.

A core element of the contract were the so-called MarketTalks, a roundtable with participants from the whole value chain, from farmers to processors to retail to end consumer, to discuss frame conditions. This unusual arrangement was intended to raise the awareness for respective needs along the value chain, and reduce the influence of price pressure (Source http://www.naturata.lu/de/aktuelles/458/, last accessed Nov 7, 2014).

This is a model for similar value chains in Luxembourg and should be explored in more detail.

Oikopolis underwent some restructuring (Fig. 10.16) and in 2013, OIKOPOLIS Participations SA issued a public call for co-investing options raising €1.5 Mio (Source http://www.oikopolis.lu/de/oikopolis_finanzierung/).

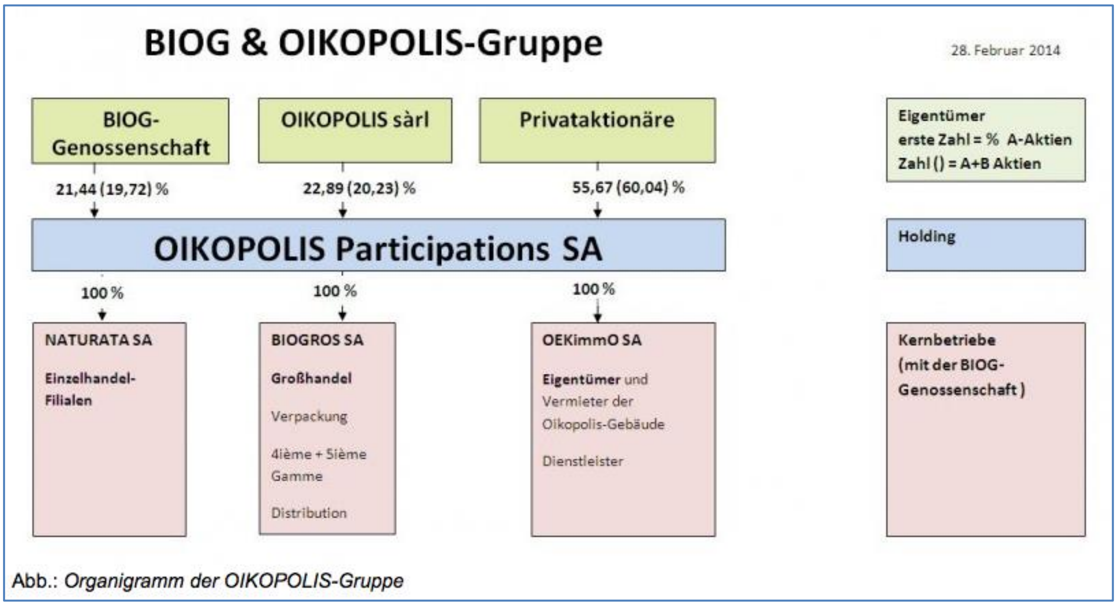


Figure 10.16: Organogram of Oikopolis Group, Source http://www.oikopolis.lu/de/oikopolis_gruppe/

When selecting products, Oikopolis focuses on regionality, regional products are given preference over imports wherever possible. With its revenues Oikopolis supports local organic and bio-dynamic agriculture in Luxembourg, so even products that don't originate in Luxembourg support local agriculture.

With CRP Tudor, Oikopolis has developed a tracking program for various sustainability factors, including CO_2 footprinting, energy consumption, waste streams etc.

Background; Organic farming in Luxembourg

Biobased agriculture accounts only for 5% of Luxembourg's otherwise industrialized agriculture; 5.000 acres vs. 130.000 acres total. The focus is milk, meat as well as some fruits and vegetables.

However, generally Luxembourg agriculture is not competitive in any of the segments against competitors within 200 km radius resulting from up to twice the production costs due to higher land price, less productive soil, and sub-scale operations (see also sectorial snapshot on agriculture 10.1).

Oikopolis was formed as a buying and distribution consortium to secure the local bio-based agricultural community (see agreement with Cactus and their own local stores Naturata).

> Oikopolis has its own packaging and distribution operations and work closely with selected restaurants. The close connection might be a mechanism for piloting a circularity quality label by gathering existing labels around the theme.

Current circular activities

With Oikopolis' background and roots, the Circular Economy is a well-understood concept reflected by a number of initiatives, e.g.:

- own vehicle fleet is leased on performance based contract. This does not apply to packaging machines since they are too specialized.
- uses bio-degradable film for packaging.
- organized their own pallet/crate pooling system to reduce wood and used paper streams.
- set up a collection system for food residues. Along the value chain, harvesting, packaging, distribution, in-store presentation, approx. 5-10% is lost at each step. Those residues waste go to anaerobic digestion facilities.

Further potential to reduce leakage and increase value chain coverage within Luxembourg (for less well-trained personnel):

- more active soil re-generation from dedicated bio-based digestion and composting units. Currently, streams from facilities are not pure enough since inputs include conventional agro-industrial residue streams.

- Increase amount of land under organic management. A target of doubling the share is deemed possible by Oikopolis. Like many European countries, Luxembourg suffers from a lack of succession at farms. Oikopolis actively supports succession, transfer and start-up processes at farms.

As a community, Oikopolis is open to more advanced Circular Economy-C2C inspired (re-)valorization opportunities, esp.

- CO_2 and excess heat valorization
- Soil re-generation
- Improved energy efficiency by better pooling/utilization of assets and machines (sharing economy)
- Enabling cross-region collaboration (to grow market segment, procure in larger area to compete against price pressure)
- Experimentation with other sectors (e.g. construction on algae-based feedstock, vertical gardens etc.)

Quote André Schanck, Oikopolis:

> *"We have identified excellent local partners along each of our value chains. This allows us to offset the disadvantage in size via improved collaboration and reduced transaction costs."*
>
> *"We must make smart choices and guide the people. Entrepreneurs not necessarily spot the opportunities along the value chain beyond their immediate activities."*

10.7.3. The potential

Principally, Luxembourg is well positioned to maintain and expand a strong local bio-based agricultural and retailing sector because;

- Customers from in and outside Luxembourg are willing to pay premium for local products (Luxembourg factor).
- Network of small but committed partners within Luxembourg along each step of the value chain (e.g. LuxLait, small mill, Cactus)
- Ministry of Agriculture is starting to realize that agro-industrialization push twenty years ago did not work since agriculture in Luxembourg will not be able to compete against nearby competitors with more productive soils, less land pressure, large scale operations (esp. in Netherland, Germany).

However, in order to achieve these advances Luxembourg will need to:

- More clearly identify the direction for a potential CE journey as described here. A roadmap to a national branding, which gathers existing labels around a circularity theme might be a first step.
- Provide more guidance and setting-up of consortiums for entrepreneurs to group together.
- Ensure the ability for protection of bio-based farms against consolidation pressure from industrial players.

In order to maximise the strengths and opportunities while minimising weaknesses and threats, and based on experience gained with local labels, Luxembourg has the potential to build a national quality label for local products which more strongly links producers, retailers and customers in a community which competes with other regions and foreign chains on the basis of quality rather than just price.

The components of a national label might be;

- Gathering and strengthening existing labels around a brand concept of circularity rather than replacing them.
- Partnerships along local value chains so parties understand respective needs and price is not the only driver (see MarketTalks as instrument).
- Comprehensive, trustworthy quality definition and guarantee, via transparency, traceability and external auditing (see meat label as example for definition and verification).
- Education and awareness campaigns along value chain and in schools to root the Luxembourg quality label.
- Review of existing quality labels in Luxembourg and choosing the best practices from each, e.g. „Rëndfleesch vum Lëtzebuerger Bauer“,“The Place to Bee”, or “Fox, the Pall label (La Griffe du Pall)” (textiles).
- Building the Luxembourg quality brand through outstanding pilot and lighthouse projects, which tell the story about Luxembourg quality.
- What can be learned from the Beki where local people can express their preference for local partnerships and products.

Other potential for circular activities in the grocery and retail sector

- Optimize workwear sourcing, consider workwear as a service.
- When planning renovations or new builds of retail stores, consider options for service concepts (light leasing, furniture leasing etc. - see Chapter 12.4.1).
- Use regular return trips of customers for de-shopping activities.
- Consider dating service for circularity entrepreneurs and designers. Luxinnovation might act as matchmaking broker.
- Build purchasing communities to increase purchasing power in foreign markets.

10.8. Reverse Logistics

10.8.1. Why, what, how & S.W.O.T.

Why

Luxembourg is at the heart of Europe's logistics crossroads.

Freight passing through Luxembourg exceeds the weight of materials generated in Luxembourg.

Logistics has large environmental impacts, which might be transformed to positive impacts.

What

Undertake a literature filtering of studies on reverse logistics most relevant for Luxembourg.

Improve efficiency of existing logistics by using under-utilised assets for reverse logistics.

Improve impacts and costs by replacing HFCs in logistics refrigeration & air conditioning units.

How

Co-operation between the Logistics Cluster and CRPs on reverse logistics literature reviews.

Pilot project with La Poste

Paper recycling logistics

Vehicle repairing connected to logistics

S.W.O.T.

Strengths

Very nimble and well connected to get going quickly.

Relative rapid change of legislation, if necessary.

Well placed on pan-European logistics trade-lane with large facilities in Luxembourg, that could be used as hubs for reverse logistics systems.

Excellent and complementary skill base (physical, financial and information flows).

Weaknesses

Missing key data on types and purposes of in/out flows. Might be available confidentially.

Pressure on margins & competition from Greater Region hubs.

According to some industry observers the government is too focused on concept and not implementation. Industry wants it to invest more in supporting the implementation with project leaders and bringing in external experts.

Under-represented with too junior, inexperienced people to move the needle on important decisions fast enough.

Opportunities

Leveraging existing assets with only incremental costs to generate increased revenues.

Government should take an active lead and provide project management (and not only a roadmap to implementation)

Threats

Greater region & other country competition.

For Luxembourg the significance of expanding its reverse logistics is the following;

By using its existing logistics infrastructure Luxembourg will facilitate transformation of the European economy to circularity and near-shoring to generate jobs.

Context

Reverse logistics is sometimes presented by circularity advocates as a new business model but it is already occurring on a large scale for many years, including in Luxembourg. There is a large body of published studies on reverse logistics with high relevance for Luxembourg. For example;

- Since 2010 approximately one thousand research titles were published with the term 'reverse logistics', in the title, and 375 papers were published examining “reverse logistics networks,” signalling a rapid acceleration of attention to the topic. About five thousand titles cover the topic of “Green Logistics”, which are not necessarily related to reverse logistics but cover associated topics.

- In 2014 a study was published on *A Classification Scheme for Planning Problems in Reverse Logistics* (Source Nuss et al International Journal of Management Reviews). The study provides an up-to-date systematic approach for identifying and overcoming barriers to reverse logistics.
- A 2014 overview of case studies on reverse logistics gives a picture for many types of products shipped through Luxembourg (Source J. Chem. Pharm. Res., 2014, 6(7):1916-1921) (Fig. 10.17).

Battery recycling [24]

EOL electronic and electronic products [25]

EOL vehicles [10]

Original equipment manufacturers [17]

Paper recycling [26]

EOL computer products [27]

Metal-mechanic company [14]

Carpet recycling [28]

Automotive industry [29]

Sand recycling [30]

Electronic waste [31]

Spent batteries [32]

Computers and home appliances [22]

Electronic equipment remanufacturing company [23]

Photocopiers [6]

Figure 10.17: Examples of numbers of case studies for reverse logistics network. Source JoChemPharRes

There is a range of opportunities and barriers to reverse logistics for each of those industries, and Luxembourg based logistics companies are undoubtedly familiar with many of them.

Among those publications none carry the term 'Luxembourg' and 'Logistics' together in the title, suggesting that the potential role of Luxembourg in reverse logistics is significantly under-stated given the country's strategic location and present logistics capacities.

However, a recent PHD thesis on last-mile reverse logistics published in Belgium might be relevant for La Poste for example (Source. Evaluation of Innovations in B2C Last Mile B2C Reverse & Waste Logistics).

10.8.2. The present situation in Luxembourg

Reverse logistics is already occurring in Luxembourg on a reasonably large scale for some years;

- Transport of scrap metal and glass to manufacturing facilities. The inland waterway port in Luxembourg plays a central role in secondary raw materials reverse logistics (Source ArcelorMittal email).
- Companies like Amazon have reverse logistics managers operating in Luxembourg (Source Amazon online job postings). Large logistics companies in Luxembourg such as Kuehne & Nagel have reverse logistics managers on staff (Source Kuehne & Nagel website.)
- Hundreds of thousands of reusable parts containers from automotive assemblers come back to automotive component manufacturers in Luxembourg (source EPEA/BMW).

10.8.3. The potential

As described in Chapter 4 Raising Industry Competitiveness and Job Creation, the capacity of Luxembourg to generate new jobs from reverse logistics depends on its capacity to capture value from the high numbers of products and materials passing through Luxembourg on their way to other destinations.

Information on reverse logistics shipments is probably in the data somewhere, kept by companies doing reverse logistics or by Statec. Big players in Luxembourg like Kuehne & Nagel and Amazon have reverse logistics managers on staff and at least two thousand studies are published on reverse logistics.

- For example there is a NACE code for reverse logistics but it is combined with other items.
- There is a NACE code for goods returned but it also covers goods being reprocessed.

It is worthwhile to investigate who has the information or might be able to generate it from raw data.

Potentials for reverse logistics in Luxembourg might be divided into the following categories;

- Trade running through Luxembourg commercial hubs, which accounts for most of the volume going through the country.
- Trade going directly between Luxembourg companies and the Greater Region without passing through Luxembourg hubs.
- Domestic or 'City' logistics for Luxembourg.

La Poste

In the domestic logistics category, there is an opportunity where the control over returning goods fall more in the physical borders of Luxembourg and the Greater Region. The opportunity is at the post office.

The following information is sourced from an interview with Mrs. Hjoerdjis Stahl, Director of Logistics at La Poste.

The reverse logistics and other circularity potential at La Poste includes;

Internal services

Establishing CE-business models for their own material intensive businesses (e.g. performance based contracts for vehicle fleet, procurement of CE-content rich services, products, improving durability re-use of equipment (e.g. pallets)

External services

Enabling CE-business model shift as core player with dominating physical transportation network, superior intelligence on business community and material flows, trust-based relationships and complete capability base to offer outsourced reverse services.

For example;

- Pick-up and delivery of new and used paper from banks and government institutions,
- Setting-up re-commerce platform for SMEs to increase re-distribution of pre-owned products, components,
- Leveraging active tracking devices to boost productivity and utility of shared products.

Immediate opportunities

- Paper collection and re-distribution.
- They serve large senders twice a day. Morning delivery and afternoon pick-up.

  Therefore they have an empty trip every day to/from the large paper users and could imagine to use current fleet at incremental costs to provide the physical transport and handling required for this system to work.
- Potential for an e-re-commerce platform
- Currently no e-commerce platform active in Luxembourg to their knowledge, which is noteworthy because the largest e-commerce business Amazon, has high-profile headquarters in Luxembourg.
- SME platform could provide opportunity for others to establish re-distribution services powered by La Poste (IT-backbone, physical transportation network, fulfillment).
- Potential for company-specific pilots to show feasibility.
- Establishing closed loop operations with big brand customers to showcase ability to collect, valorize and re-distribute. La Poste already identified large shippers in the region for establishing closed loop operations and potential suppliers with local presence for performance-based contracting
- Stop leakage of high valued WEE-waste in cooperation with Ecotrel.
- Avoid leakage by orchestrating pick-up at consumers' homes.
- Collaboration with e.g. Ecotrel on re-distribution of products.
- Improving the percentage of waste fractions collected where existing waste management providers see it as too expensive due to low density. La Poste goes to those locations as part of its regular deliveries.

La Poste's perceived strengths of Luxembourg for reverse logistics

La Poste believes, that Luxembourg extremely well positioned to take the lead in the Greater Region;

- Very nimble and well connected to get going quickly.
- Relative rapid change of legislation, if necessary.
- Well placed on pan-European logistics trade-lane with large facilities in Luxembourg, that could be used as hubs for reverse logistics systems.
- Excellent and complementary skill base (physical, financial and information flows).

- Government should take an active lead and provide project management (and not only a roadmap to implementation)
- Logistics Cluster is great initiative, but not very well known and unclear on what the direction should be.
- Ministry has strong track-record in getting things done (e.g. GDP-Luxembourg pharmaceutical initiative).

La Poste's perceived weaknesses of Luxembourg for reverse logistics

> *'In Luxembourg there is always great willingness to go forward, but big hesitation to take the lead.'*

The perception of some players is that government too focused on concept and not implementation and should invest more in supporting the implementation phase with project leaders and bringing in external experts. Too junior, inexperienced people to move on important decisions fast enough.

Present situation and potential actions

La Poste is at the beginning of their CE-journey and still have to develop a plan for investing resources to systematically identify, evaluate and implement CE Business models.

Overall the CE initiative will require;

- Connecting the dots to evaluate opportunities end-to-end
- Setting up partnerships amongst private sector players to close the loop quickly

Steps to get there;

- La Poste would actively support the evaluation and piloting of showcase initiatives (e.g. high-quality paper up-cycling)
- La Poste is willing to be actively involved in further discussions with the initiatives arising from the present study

Savings from circularity warehousing technologies

One Benelux logistics company has extensive experience using circularity for energy and materials efficiency. Vanderlande Industries services many airports and warehousing facilities internationally with its conveyor systems. In 2010-11 Vanderlande Industries redesigned its conveyor systems for circularity, creating energy savings of more than 50% for it customers, cutting weight by 70%, and using modular designs to cut maintenance downtime costs (Fig 10.18). It might be worthwhile for the logistics cluster to organise a workshop on "circularity warehousing technologies for savings" inviting Vanderlande Industries to make a presentation.

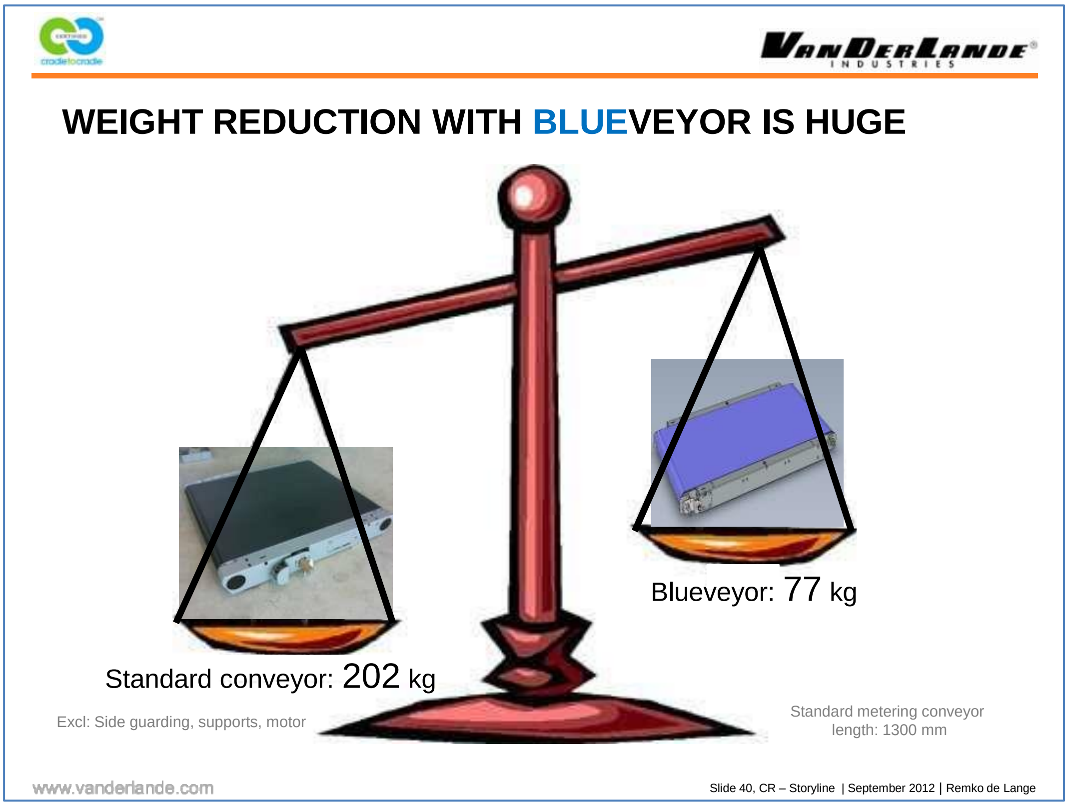


Figure 10.18: Example of weight savings from redesigning for circularity. Source Vanderlande Industries

10.8.4. Potential logistics actions

- *Circular warehousing technologies for savings.* As part of the Green Logistics initiative of the logistics cluster, it might be worthwhile for the logistics cluster to organise a workshop on "circularity warehousing technologies for savings" inviting Vanderlande Industries to make a presentation.
- *Coordination*. Reverse logistics might be an early focus for the *National Circularity Initiative* in collaboration with the Logistics Cluster. Reverse logistics might be established as a central focus for the Cluster if it has not been already as part of Green Logistics.
    - *Reverse logistics community*. It might be productive to organise a workshop of reverse logistics managers from e.g. Amazon, Kuehne & Nagel and others to examine potential collaboration and who is doing what.
    - *Resources.* According to the Ministry for the Economy, substantial support funding is available for new logistics initiatives. Those are important leveraging tools for adapting the present infrastructure for reverse logistics. A first step might be to identify resources available for reverse logistics planning.
    - *Statistics*. Identify which terms used for statistics might be utilized to identify reverse logistics movements and opportunities. The statistics challenge is identified in Chapter 8.7.2 Product Statistics and is not described further here.
- *La Poste.* The pilot for La Poste seems to be already in the planning stages and will be valuable for the logistics cluster to track and support. The Ministry of the economy might consider soliciting support for the pilot.
- *Inventory of studies.* A large body of studies on reverse logistics is being published and if not already tracked are worthwhile tracking. CRP Henri Tudor is already working with the Logistics cluster and might take on the task.

10.9. Transportation, Energy & Water Infrastructure

10.9.1. Why, what, how & S.W.O.T.

Why

Among the most valuable materials assets in Luxembourg are in the transportation, energy & water infrastructure & some of those assets are actively turning over.

Materials theft is becoming epidemic in Europe.

What

Inventory the real-time value of materials assets in those infrastructures.

How

New commodities & secondary raw materials valuation tool.

S.W.O.T.

S **Large bank of high value material assets with strategic materials**

W **No accounting for the residual value of those assets**

O **Secondary raw materials valuation tool**

T **Disruption from materials theft**

10.9.2. Context and the present situation in Luxembourg

One of the leading materials banks in the world is usually overlooked by most studies on circularity. It is the high value materials, including those on the EU critical raw materials list, found in the rail, highway, water, and energy generation & transmission infrastructure.

In Luxembourg alone, millions of tonnes of steel, copper, aluminium, manganese, and rare earth metals are sitting in road barriers, rails, rolling stock, barges, electricity transmission lines, buildings, bridges, canals, terminals, generators, and dams. Perhaps because those assets are seen as long-term, they are not perceived as ‘quick wins’ by circularity experts so are not high on the priority list. However, in reality, they are the heart of a materials bank for Luxembourg. Those assets don’t sit unchanged for decades; they are constantly being maintained, switched out, remanufactured, demolished, and recovered or discarded. Those are referred to as ‘active stocks’ as opposed to longer term ‘inactive stocks’ (Source Johansson et al An Integrated Review of Concepts and Initiatives for Mining the Technosphere: Towards a New Taxonomy).

The question is especially relevant because the government might be taking over a leading energy provider in Luxembourg; Enovos (www.enovos.lu). In this case the government will be further consolidating operations with the existing large materials bank owned by the grid owner Creos http://www.creos-net.lu/start.html. However no inventory seems to be done of the current value of those materials on commodities markets.

The relative availability and turnover potential of those stocks is described in the following diagram Figure 10.19, using copper and iron as examples; (Source Johansson et al).

For the water infrastructure, pumps are a particular focus. There are thousands of pumps across Luxembourg containing high value materials.

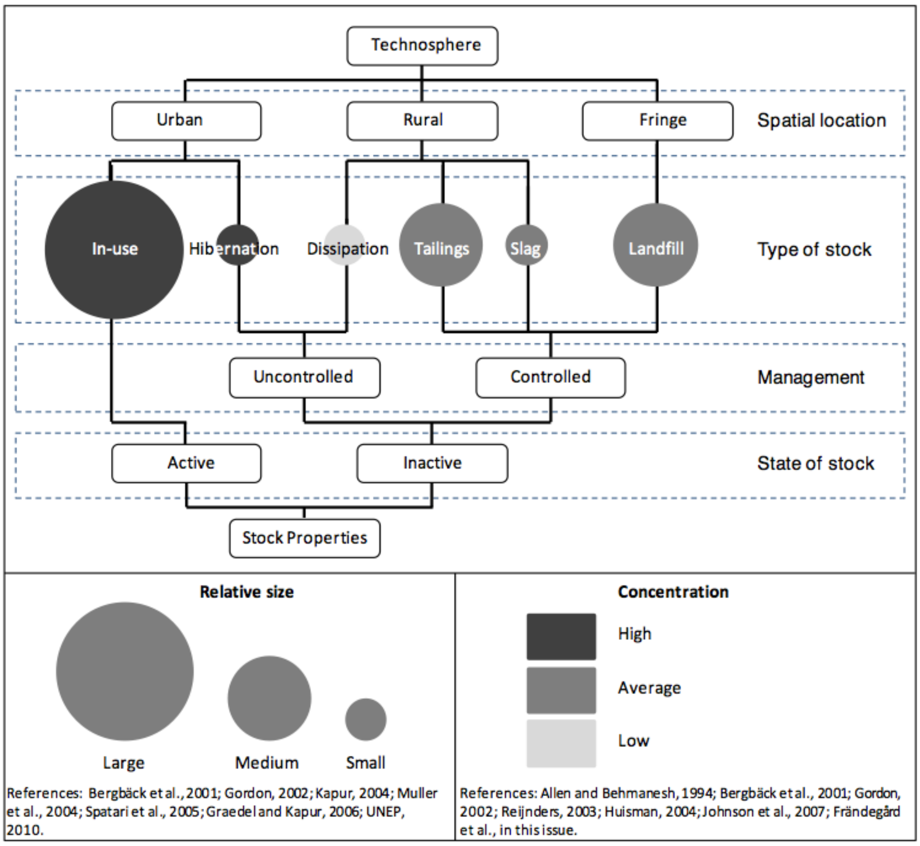


Figure 10.19: Relative availability and turnover potential of Technosphere stocks, using copper and iron as examples. Source Johansson et al.

The current value of those assets is demonstrated by the rapid increase in metal theft from infrastructure. Since 2013 at least 114 academic studies were published on the rise in metal theft from infrastructures. Everything from wires to roofing, manhole covers, connectors, solar panels, and generators is disappearing at an accelerating rate, causing serious disruptions to transportation and communications. The level of occurrence is sometimes astonishing. In the U.K. for example, between May and October 2013, there were 25,400 theft offences on the railway network (Source Ashby et al, The when and where of an emerging crime type. 2014).

The following diagram Figure 10.20 is one of many examples of the content and vulnerability of infrastructure.

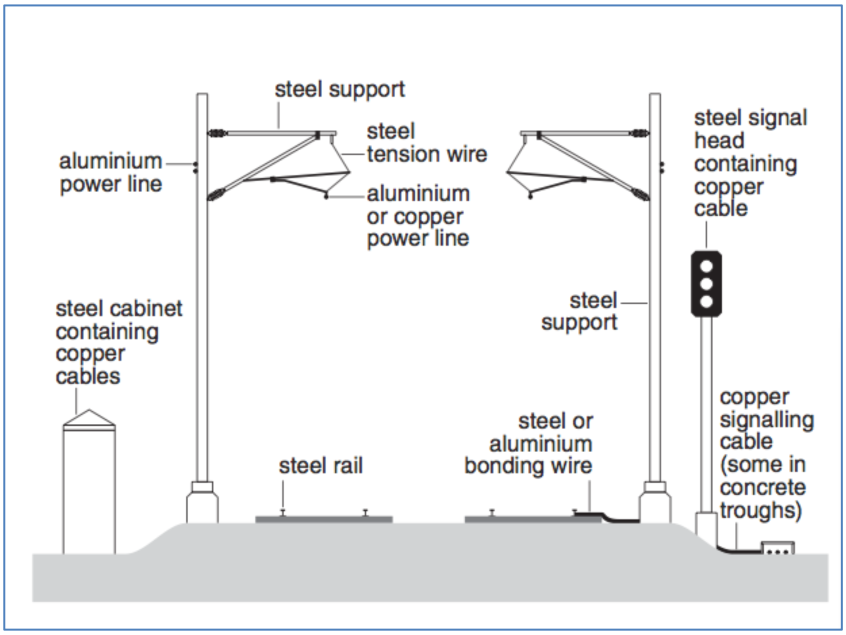


Figure 10.20: Metal vulnerable to theft on railway lines. Source Ashby et al

While criminals clearly recognise the market value of infrastructure assets, presently, there seems to be no government statistical inventory of the present value of those materials. Instead they are often valued as depreciating assets, or at book value.

10.9.3. Potential actions

- First know what you have. As part of the activities of the National Circularity Initiative establish an inventory of Luxembourg's metals infrastructure assets, and link it to a commodities value index to get a general estimate of the value of EU-defined strategic materials sitting in Luxembourg's infrastructure.
- As well, know what you are losing. Investigate how serious the metal theft problem is in Luxembourg and the Greater Region, and explore methods being used internationally for controlling the problem. Perhaps those investigations are underway, but these are not part of the terms of reference of the present study to investigate.

10.10. The Elephants In The Room. The Challenge Of Positive Potential

'Elephant in the room' is an English metaphor for an obvious truth that is being ignored or going unaddressed.

A small herd of elephant-sized opportunities is standing in the room of circularity in Luxembourg.

The elephants are;

- Finance
- Healthcare
- Fossil Fuels

On one hand, the advantage of ignoring the elephants is minimizing risks of making mistakes. However, the flip-side risk is Luxembourg losing opportunities to achieve materials security from exploiting new trends.

The good news is that in the case of circularity for Luxembourg the elephants in the room are often on the positive side of the equation. The following sections describe the present situation as well as the potential for those elephants.

The question is if Luxembourg organisations want to be frontrunners in harnessing the power of those elephants?

10.10.1. Elephant #1. Finance

Why, what, how & S.W.O.T.

Why

Circularity often requires investment and as presented previously up to 9 trillion USD might be generated from investments in circularity and renewables. There are already compelling cases of generating good returns.

There are up to €3 trillion in Luxembourg financial institutions

The finance industry is under some pressure to improve its image

Investors lose money on materials in buildings starting on day 1 of occupancy.

Productivity improvements from healthy buildings are becoming measurable.

What

Standards for circular materials and organisations so institutions know what they are investing in.

Clarify diverse opportunities for diverse segments of the financial industry.

Potential quick win for walking the talk with paper upcycling.

How

Symposia planned in February, April, June 2015.

S.W.O.T.

S **Large capable financial industry sector with experience in alternative investments**

W **Understanding CE potential and risks as well as measurements.**

O **Develop standards for secondary raw materials, circular LCA, as well as quick wins.**

T **Competition is already snapping up low hanging fruit. Perception of risks.**

Context; Finance as an enabler for performance-based circularity

The implementation of circular business models frequently requires or enables innovative financing and management solutions.

The most frequent requirements by companies pursuing circular economy business models comprise the need to;

- fund additional re-valorization processes and installations
- fund additional R&D and set-up costs (i.e. own legal entities, comprehensive contractual frameworks)
- build up higher working capital (e.g. when moving from a sales-based to leasing, performance based contract)
- cover potential risk exposure (i.e. the pre-mature cancellation of long-term contracts, changes in input prices and boundary conditions)

The advantages of moving to performance-based approaches typically include stabilizing and de-risking cash flows. This is primarily due to the fact, that;

- when an inventory or register of products/components/materials is created it can be used as security against market prices and projections.
- the long-term nature of some contracts increases the predictability of cash-flows and reduce customer churn.
- circular business models, which rely on continuous-loop activities or re-use of materials without market interface, reduce the volatility of material input prices, and hence exhibit a lower volatility and better predictability
- circular business models achieve substantial net-material savings, which lower the cost to serve and increase competitiveness, hence improve resilience of companies and default risk

While those are general observations the specific requirements and needs of transiting towards circular, performance-based business models varies and is highly case specific. A good synopsis of likely required financial services and opportunities can be derived from the table Fig 10.21 *Where financial services and circular economy meet*

The present situation and potential in Luxembourg

In October 2014, a special circular economy workshop was held in Luxembourg with representatives from the financial industry, facilitated by an MOU between the EcoInnovation Cluster and KPMG to organise circular economy events. The following information is partially taken from a presentation made by EPEA for that session.

A healthy chunk of European assets is in Luxembourg, generating consideration benefits for Luxembourg, and influencing how funds are invested globally. Alternative investment funds based in Luxembourg are already advanced on sustainable investing, and these provide a platform for circularity investing. A few might justifiably claim to be doing it already.

The finance industry is a potentially large enabler for circularity, and might be able to use circularity to 'upcycle' its image. The industry is understandably seen as conservative but there is low-hanging fruit to support innovation. The sector is motivated to identify new business models and improve its image.

Resulting from the October 9, 2014 circular economy workshop, the following context as well as potential were identified;

Takeaway messages on the present situation and potential;

- Circular Economy finance is *not yet working* in Luxembourg & the Greater Region on a large scale.
- However big gains are to be made for the finance sector from new models.
- Upscaling the CE on a national level needs involvement of the financial sector.

Why is circularity important for Luxembourg finance?

- Figure 1.1 summarizes the value capture potential; One trillion USD from circular supply chains, and up to 8 trillion from renewables.
- In the circular economy materials security is becoming as important as energy security. For example, the 8 trillion USD potential for renewables depends on secure supplies of large amounts of high value materials for energy-generating equipment.
- Because of that, in the circular economy the quality of materials is as important as the quality of the product. The materials are an investment.

Materials are a new type of investment;

- In the linear economy materials are depreciated and become expensive waste. In the circular economy materials are depreciated but also become valuable assets.
- In the linear economy materials are purchased. In the circular economy materials are leased or pay interest.
- In the linear economy dividends are extracted from the spread between cheapest purchasing practices and highest selling price. In the circular

economy products & buildings with materials designed for healthy use, deconstruction & high residual value pay greater dividends.

Which building would you buy?

See Construction segment for calculations based on the following example. See also positive case example of Venlo City Hall under Construction.

Conventional building

25 – 35% of building costs today are materials costs. These lose their residual value after ~15 – 20 years and become demolition liabilities.

Suppliers provide cheapest materials at lowest bid. Building owner finds out too late; materials contravene REACH & air quality is unhealthy.

Circular building

Products in buildings are designed for residual value. 25 – 35% loss becomes 30 – 100% gain based on historical commodities pricing.

Certified healthy materials with high residual value provide healthy air quality & risk management.

Circular portfolio models

- Most sustainable investment portfolios today focus on a combination of energy efficiency, CO_2 mitigation, CSR. Not many portfolios focus on materials quality, materials security or residual value.

Business potential for investment banking;

Investments in & dividends from;

- Companies that generate greater profits by using materials with high residual value.
- Reverse logistics companies.
- Specialized recyclers who know how to up-cycle materials.

- Companies that lease products & materials and generate interest or dividends on them.

Fees from;

- Materials leasing and banking transactions.
- Setting up reverse logistics financing.
- Packaging 'materials banks' as securities.

For private investors & funds

- Focus on companies who use innovation to improve savings and efficiencies with circular value streams.

Business potential for service banks

- Interest rate differential from borrowing from central banks then charging an interest rate on materials as part of materials banking.

Business potential for Insurance

As regulations on producer responsibility become more strict;

- Offer insurance discounts for businesses who know what is in their products
- Offer insurance products with higher premiums for businesses, which face unknown liabilities from using unknown materials.
- Offer insurance for materials leasing. Perform risk management assessments by evaluating the traceability of materials.
- Offer insurance for reverse logistics.
- Buy buildings designed for high residual value and healthy materials that generate healthy air quality.

Business risks

Risks of doing it;

- Tracking materials. Solution; materials passports.
- Unknown performance. Solution; mimic models already working.

Risks of not doing it;

- Competition locks in scarce resources.
- Materials supply interruptions already happening.
- Liability exposure REACH, air & water quality

Example of improvement in ROI & market share using circularity;

'...market share jumped by 8%'

'Profitability increased from 1% to 9.2 %'

CEO attributed gains to Cradle to Cradle in Financial Times Interview.

Desso is one of Europe's leading floor covering manufacturers. Circularity powered by Cradle to Cradle was the core business model after management buy-out. In October 2014 Desso was acquired 100% by Tarkett whose R&D department is based in Luxembourg and is committed to circularity powered by Cradle to Cradle. Statement in the press release;

> *“We are very excited to join Tarkett with whom we share the same vision and entrepreneurial values, as well as a strong commitment to sustainability, both applying the Cradle to Cradle* principles at each step of the product’s life and supporting the development of the circular economy.”*

Planned next steps with the financial industry

Results were reported by KPMG from the October 9 2014 workshop and are included as Annex I. The next step is to use these results to prepare a wider symposium in February 2015.

In preparation for the February 2015 symposium, to start describing the potential role of diverse financial players in the circular economy, EPEA developed the following table Figure 10.21.

The table might also serve as a template for a potential roadmap to circularity for the financial industry.

WHERE FINANCIAL & CIRCULAR ECONOMY ACTIVITIES MEET DRAFT V 1-1 011114

CIRCULAR ECONOMY ACTIVITY	Buildings Designed for Residual Value	Companies Manufacturing Products for Circularity	Remanufacturing	Reverse Logistics	Specialized Recycling 2.0	Materials Banking	Materials Leasing	Software & Databases	Renewable Energy Equipment	Fertilizer Extraction from Water Recycling	Biobased Materials R&D
FINANCIAL ACTIVITY											
Investment Banking											
Securities		✔	✔		✔			✔	✔	✔	✔
Real Estate	✔					✔	✔				
Corporate & Institutional	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔
M&A		✔							✔	✔	
Analysis	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Risk Management	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Socially responsible Targets	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔
Banking											
Financial Products	✔	✔								✔	
Financial Services	✔	✔	✔	✔		✔	✔	✔	✔	✔	
Insurance											
Re-Insurance	✔				✔	✔	✔		✔	✔	
Property	✔			✔		✔	✔				
Liability	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔

Figure 10.21: Where finance & circularity meet. Source EPEA.

One particular segment of the finance industry warrants focus.

China

Luxembourg is aggressively courting investment from China and with good reason; China is the largest manufacturer, the largest consumer of materials, and has one of the largest middle classes, which are generating trillions of Euros in investment opportunities.

China also has one of the oldest circular economy traditions embedded in its environmental and other legislation. One of the modern day impacts of circularity on China is that the nation recognised the importance of its own raw materials base and started to put export controls on strategic materials. As well, China is aggressively locking in foreign supplies of materials and for example is a major competitor to Luxembourg industries for secondary raw materials.

Luxembourg faces a high potential as well as a contradictory challenge with China. Chinese industry competes with Luxembourg industry for secondary raw materials, but Chinese forex trading as well as investment in Europe is being funnelled through Luxembourg. At the same time, China embarked on a €400+ billion programme to address its large environmental challenges, which is also at the top of its domestic political priority list due to the risks of political destabilisation from environmental health effects. As well, China started to restrict the export of its strategic materials and is investing heavily in securing those materials in regions like Africa.

There might be a tendency for the financial community to 'not talk about' circularity when it comes to Chinese investment, for fear of alienating Chinese investors, but looking at the changing priorities in China the situation might be the opposite; China might welcome initiatives from Luxembourg to promote investment in circularity.

Chinese foreign investment, environmental improvement, and materials security might converge in Luxembourg to the benefit of Luxembourg.

The attraction is not limited to finance. In July 2014, Luxembourg hosted a delegation from China (Source Luxembourg, China's hub in Europe) describing the logistics as well as data center benefits of Luxembourg for China.

Figure 10.22: China & Luxembourg sign airport co-operation agreement Dec 2014.

Potential Actions

As this topic is of great importance to Luxembourg being one of the preeminent financial centers of Europe it is highly advised to continue the work on this front, potentially involving more actively research expertise from the EIB and the sector via e.g. facilitation by KPMG in its MOU with the EcoInnovation Cluster.

- Preparations for a March 2015 financial industry symposium on the circular economy are underway as described. The results of the present study for the Ministry of the Economy will also be presented.
- The High Committee for industry recommended establishing closer links between the R&D community and industry in Luxembourg. It makes sense to add the financial sector to that group, due to links between finance and R&D in Luxembourg requiring improvement. See section 14.5 Quick wins.
- As a potential quick win, investigate the feasibility of organising a customer & supplier community around high quality paper recycling, including destruction of confidential paper;

Procurement as a financial tool

The establishment of CE-business models require the coordination of suppliers and business partners of upstream and downstream activities. Frequently these activities are outside the companies' area of direct influence. Therefore the need exists to strike agreements with partners involved to agree on terms and conditions on how to integrate the different activities into (closed-loop) circular value cycles. The usage of standard procurement tools therefore seems to provide the required set of instruments to;

- specify distribution of responsibilities of business partners along the value chain (including reverse network activities).
- enforce (design) standards and norms, that reduce overall costs along the value chain (e.g. material passports, defined material pallet, designs favoring disassembly, separability, modularization, etc.).
- establish incentive and benefit re-distribution mechanisms along the value chain (e.g. rewarding an enabler (e.g. via improved design) of cost savings with a portion of the proceeds of later stage savings (e.g. reduced costs of disassembly, higher yield of component recovery).
- build out non-existing skills and supplier markets (e.g. dedicated supplier development for infield maintenance, reverse logistics expertise, remanufacturing capacities).

- re-direct seed volumes into circular and away from linear business models to allow new entrants, new business models to reach break-even faster or back-up selected trials to fast-track innovation and adoption of practices.

However in many instances these benefits are not attainable as these desirable procurement practices are frequently hindered by;

- insufficient understanding of synergies and savings potential from a (centralized, siloed) procurement practice.
- anti-competition rules (e.g. avoiding pre-competitive agreement of suppliers on norms, terms and conditions).
- non-comparability of alternative service delivery models (e.g. how best to compare sales-based transactions with performance based contracts, incomplete LCA assessments, which do not use correct end of usage/revalorization prices/revenues).
- insufficient data and market transparency (e.g. pooling information of players with similar needs, inventory of competencies required for reverse network activities, non-existence of defined categorization, naming and search indices for circular economy activities).

Potential actions on circular procurement

From a government point of view the establishment of reliable framework conditions and potentially incentive structures to redirect investment flows into more circular economy activities typically comprise;

- shifting tax from renewable resources (like labor) to non-renewable resources like material throughput (e.g. via landfill tax, energy tax)
- re-distributing tax income to finance the establishment of critical skills (e.g. slightly increasing corporate tax an then re-distributing the proceeds into CE-based training for certain sectors)
- providing government guarantees to attract private sector or foreign direct investments to support large scale investments (e.g. for setting-up of FabLab, concrete 3D printing hub for construction industry in Luxembourg)

It is suggested that the Ministry of the Economy start a task force to do a ‘deep dive’ into the feasibility and implications of those mechanisms.

- The government will overcome those barriers more quickly by providing information to procurement authorities on best practices already in the marketplace, as described in Chapter 12.4.2 and by holding workshops focused on circular procurement.
- Especially pre-conceptions about anti-competition rules are possible to solve in existing regulatory frameworks. Public and private stakeholders are

to be included because procurement departments in large companies have similar challenges as governments.

Paper. Potential quick win for the financial industry

Every financial organisation in Luxembourg has one thing in common regarding materials; they each generate large amounts of high quality graphic paper. The potential is to establish a customer & supplier paper community with the goals of improving recycling quality & environmental impacts, reducing costs, visibly communicating intentions, and learning to ‘walk the talk’ with circularity.

Circular paper communities are already working in and outside Luxembourg. For more information see section 14. Roadmap and 14.5 Potential Quick wins.

10.10.2. Elephant #2. Healthcare

Why, what, how & S.W.O.T.

Why

Healthcare consumes large amounts of strategic materials for equipment & ICT.

Hospitals are leading contributors to water pollution and have large water treatment costs.

Nutrition is a major part of healthcare and a leading cost factor. It is connected to food waste, which is one of the primate focuses for circularity experts.

Infection control is one of the fastest rising cost in hospitals and is closely connected to materials management.

What

New technology for wastewater management integrates front end product designs with back end waste management to generate clean water and reduce infection risks.

New food preparation methods based on circularity show 30% cost savings.

How

Investigate the technologies and methods.

S.W.O.T.

S **Home to strong healthcare cluster and R&D units**

W **Heavy bureaucracy and rules.**

O **Savings on infection control and food preparation costs. Enabling secondary leasing and re-use market**

T **Already well-established grey market for re-used medical devices. Resistant infections & spiralling costs.**

Takeaways

Resistant infection is the fastest growing cause of patient morbidity in hospitals today and one of the biggest costs. However the connection between materials and infection is often under-stated. There are economically positive solutions.

Hospitals are among the most expensive and materials-intensive structures to build due to their high equipment requirements, and they are significant contributors to degrading water quality due to their concentrated emissions of pharmaceuticals and other chemicals. As well, healthcare technology is one of the leading users of materials on the EU list of critical materials, due to the growing use of sophisticated diagnostic equipment, robotic surgery, and extensive use of datacentres for storing and interpreting patient information. Hospitals also have excellent examples of circularity enabling tools because their linen and uniforms are often rented and their large diagnostics like MRIs are leased and remanufactured.

Elderly care is increasingly materials intensive for disposables. For example in mid-2014 consumer goods giant Procter & Gamble entered the adult diapers market in the Benelux because adult diapers are beginning to outsell baby diapers as the population ages. As Luxembourg's population ages the percentage and real expenditures on healthcare are rising as in every nation globally, with the burden on public finance especially high in Luxembourg because it has one of the highest public contributions to healthcare. The cost, which is rising faster than caring for the elderly is infection control, as drug-resistant infections cause increasing patient morbidity and mortality.

However so far none of the leading publications on the circular economy attempted to tackle the healthcare question despite the large implications for materials, jobs, cost savings and competitiveness, each of which is a focus of this study.

There are clear quick wins for circularity and healthcare, and some of these are already found in the marketplace. For example;

Pharmafilter & related sanitary products

Luxembourg is already a member of the PILLS project, a consortium of six partners with the aim of developing local treatment systems for hospitals to eliminate pharmaceuticals. It seems that the Pharmafilter technology is part of that project:

Removal of solid waste through the sewer system, for a cleaner hospital; removal of medicinal residues from waste water for a cleaner environment. This, in short, is what the Pharmafilter system promises. Shredders are used in the hospital in place of the traditional bedpan cleaners and at places where waste is generated. Almost all types of waste are shredded by the Tonto and flushed through the existing sewer system. An installation is set up outside the hospital, which digests and decontaminates the solid waste, thereby producing biogas. All waste water is purified and cleaned of medicinal residues. The Pharmafilter system makes it economically and environmentally feasible to address processes in the hospital through the introduction of biodegradable, single use disposable products instead of products that need to be sterilized after each use, such as bedpans, urinals and cutlery. (Source Stowa Evaluation report Pharmafilter 2013)

It is strongly advised that the Ministry of Health investigate how the Pharmafilter potential for preventing infection and saving costs is being integrated into hospitals as a result of Luxembourg's participation in the PILLS project.

10.10.3. Elephant #3. Fossil Fuels.

Why, what, how & S.W.O.T.

Why

At 3.9 million tonnes, fossil fuels generate the third largest materials leakage in Luxembourg and seriously skew Luxembourg's CO_2 profile.

What

As part of the biomaterials program investigate algae-based biofuels.

How

Ministry of Economy commissions a study by the biomaterials group at university of Luxembourg and the CRPs.

S.W.O.T.

S Cheaper fuels generate tax income for Luxembourg.

W As a result Luxembourg's CO_2 profile is seriously skewed.

O Leverage state-of-the-art to solve Luxembourg's wastewater & fuel problem together.

T Inaction due to perception that nothing can be done.

In the earlier-referenced 2014 EC scoping study, fossil fuels are not covered in depth because according to the study they are covered by other initiatives outside circularity (Source EC scoping study, Executive Summary). In the view of the present study this is a mistake.

As described in Chapter 10.10.3 Elephant # 3 Fossil Fuels, one of the largest leakage of materials, which challenges circularity in Luxembourg is fossil fuels, with more than 3.9 million tonnes annually imported (Source IEA) then consumed, resulting in substantial emissions of not just CO_2 but also nitrous oxides and particulates which degrade air quality.

It is almost taboo to talk about the fossil fuel challenge in Luxembourg due to a triad of factors; The dominant perception that Luxembourg is too small to do anything about it, the heavy dependence of logistics on trucking, and Luxembourg gaining large revenues from 'tank tourism'.

It is certainly true that Luxembourg lacks the economic or technological clout on its own to transform the transport industry from fossil fuel to another form of fuel. However, Luxembourg does have the capacity to participate in a range of multi-year innovations already underway globally; for example biobased fuels, and electric vehicles combined with renewable electricity generation and storage.

Burning e.g. biologically derived fuels grown without fossil-fuel fertilizer and without depleting soil, creates a CO_2 metabolism through carbon management. Algae are the best candidate because they are fast-growing and combinable with e.g. water purification. The US Renewable Energy Lab (USREL) as early as 2007 published studies showing that algae have the capacity to absorb up to 50% of the emissions of US power plants, and when integrated with wastewater purification have the potential to generate biofuels at €25 per barrel. A later study calculated 100% CO_2 capture for coal-fired plants in India due to high solar income. Because 50% of Luxembourg is agricultural land, and Luxembourg has a wastewater problem, there are opportunities for leveraging algae, and it is expandable to the Greater Region where there are large brownfields, which are good environments for converting non-productive contaminated land into algae production. However, the underlying question is; does the energy department of the Ministry of Economy want to consider those options, or is it just convinced Luxembourg has no chance to adopt the technologies in a significant way? The present study suggests the Ministry investigate state-of-the-art algae-to-oil technologies before making final determinations on this pivotal topic.

10.10.4. How to approach the elephants?

One approach is to just leave them alone until later. However, by doing so Luxembourg might miss opportunities which others will exploit, and might also incur unnecessary costs in areas like healthcare.

A preferred approach might be to actively study the challenges to determine where to start with each of them.

Those elephants each are connected to different Ministries in the government, but generally they cut across multiple ministries because they involve construction, transportation, environmental impacts, finance, foreign relations, etc.

Because of this the question of these elephants is probably best dealt with by the National Circularity Initiative working group described in Chapter 14.5.1.

<u>It is suggested here that under the National Circularity Initiative, Task Forces be set up to address each of those elephants and report back to the working group in one year. In some cases like biomaterials and composites, those task forces already exist, so it is just a question of aligning them.</u>

10.11. Other Circularity Candidates

Due to time and budgetary limitations as well as priorities requested by the Study Steering Committee it was not possible to interview some companies, which have good circularity potential. Among those, which merit further attention are;

- *Hydro* for aluminium as well as scrap dealers who supply the industry.
- *Avery Dennison*, whose reversible adhesives technologies are good candidates for other reversible products. Avery also reportedly has a reverse logistics running from Switzerland to Luxembourg.
- *Umicore,* one of the most important metal recyclers in Europe.
- *Rubbermaid,* which manufactures toys. Various toy companies incurred losses a few years ago when their products were found to contain contaminants. Rubbermaid has a good record of including safe materials in its toys and might have a circularity claim.
- Manufacturers of prefabricated structures.
- Logistics companies like Amazon, Kuehne & Nagel..
- Maritime shipping. Millions of tonnes of materials are moved in millions of tonnes of ships. The sector merist a study on its own. .

11. UPCYCLING

In a circular economy there is no waste, so in the present study there is no section on waste management. Instead the present study examines how Luxembourg might leverage its present residue management systems to become an upcycling frontrunner especially for knowledge-based capacities.

Luxembourg has a compelling circularity advantage over other countries; it has no significant Municipal Solid Waste (MSW) reprocessing industry like e.g. shredding, depolymerisation, pyrolysis, re-pulping etc., although it upgrades waste streams by separating them at source. In this way Luxembourg is more flexible to determine its own materials destiny. Luxembourg has a secondary raw materials industry distinct from waste management. It transforms secondary raw materials into high quality products like steel, aluminium foil and specialty glass. As well, a few reprocessing technologies like biodigestion and composting are stepping stones between waste management and raw materials, and are easily upcyclable into high quality soil amendment products. In total, there is a high potential for upcycling across a range of materials.

11.1. Upcycling Defined

Upcycling occurs in these ways;

- **Improving on Tradition.** Improving systems for reprocessing materials. For example, methods for separating plastics from organics as with Aikan technology from Denmark, or systems for improving return rates of returnable glass bottles as with the Carlsberg Circular Community improve quality, save costs, and are often more profitable.
- **Facilitating Transition.** Redesigning ingredients or additives in products, or the products themselves to improve the quality of recycling. For example, when coatings or inks are improved to be compatible with paper recycling as with Gugler inks, or when systems are redesigned for rapid maintenance, replacement, repair, removable and disassembly as with Vanderlande Industries conveyor systems used in airports and warehouses.
- **Accelerating Transformation.** Material is transformed when it is given added functionality to support biosystems. For example, designing packaging labels or cardboard to be composted as topsoil. Floor and wall coverings that actively clean the air.

11.2. Why, What, How & S.W.O.T.

Why

Secondary raw materials are already important for Luxembourg's economy and will continue to gain in importance as competition for materials increases.

Waste is one of the largest sources of materials leakage in Luxembourg. For circularity it pays to know more about the fate of the waste and take steps to make sure it becomes a high quality secondary raw material.

What

Competency programme for valorising secondary raw materials, including technical competencies.

Customer /supplier communities for continuous loop recycling, cost savings and valorisation of materials, for example on paper.

Licensing new valorisation and quality assurance methods for secondary raw materials from The Netherlands.

Map biowaste residues with a view to a national topsoil manufacturing programme.

Positively designed polymers for Luxembourg manufacturers.

How

Switch from waste to products in the classification and the mentality. The re-classification is something Luxembourg might support during its EU Presidency.

Announcing Luxembourg will phase out mixed waste incineration in favor of valorizing waste streams as well as re-purposing incineration for materials, which are too complex or contaminated to be safely recycled.

Address leakages, improve efficiency/cost effectiveness of collection and handling system, and improve design of packaging.

S.W.O.T.

S **Excellent technical knowledge on collection and specialised reprocessing.**

W **Luxembourg usually does not have its own waste reprocessing facilities.**

O **Competency in valorisation, tracking and quality assurance systems.**

T **Mixed waste incineration disguised as energy recovery.**

11.3. Takeaways

- Integration of the following elements is a priority for a competitive secondary raw materials sector generating new jobs and minimizing negative environmental impacts;
- Construction & Excavation waste, covered under the construction sector.
- Industrial scrap steel, aluminium and speciality glass, covered under those sectors, although with reference to glass here.
- Reverse logistics covered under logistics.
- Traditional waste management, covered here.
- Paper, bioresidues and food waste, covered here. (see also sectorial snapshot on Agriculture). There are substantial cost and waste savings to be made by borrowing from institutional practices in Denmark. There is also a potential to integrate bioresidue flows for high quality topsoil manufacturing also to rejuvenate Luxembourg's depleted soils.

There is a potential for Luxembourg municipalities to benefit from a new programme for tracking and valorising secondary raw materials.

Luxembourg has a high level of recycling technology know-how, despite not having household or office waste recycling facilities. The know-how for re-using and generating added value from secondary raw materials is found for example at ArcelorMittal, DuPont, Eurofoil, Guardian Industries, Norsk, SDK, Tarkett, and Tontarelli, each which recycles its own primary residues or uses secondary raw materials sourcing.

ArcelorMittal and Norsk compete with each other on claims about the LCA value of recycled aluminium vs. steel, but in the non-competitive space there is room for the metal industry in general to improve its LCA and other claims based on leasing and same-quality recycling.

Overall, there is substantial potential to upgrade valorisation technologies and methods especially if further integration between partners is achieved and lessons from a few other countries are assimilated.

11.4. The Present Situation In Luxembourg

Waste management is a highly regulated field with many regulatory barriers as well as misaligned incentives. Because of this and because Luxembourg exports most of its waste, implementing innovations for circularity might seem problematic. However there are ways to rapidly improve quality and save costs.

At approx. 800,000 tonnes annually (Source Statec), materials classified as waste constitute Luxembourg's second or third largest export by weight, (depending if fuel purchased in Luxembourg is counted). It is also one of the largest materials leakages from the value stream out of Luxembourg.

Luxembourg is the highest per capita generator as well as one of the highest per capita collectors of Municipal Solid Waste (MSW). However it is also one of the highest exporters because it lacks the recycling facilities for e.g. plastics, paper, etc. Because of this, the fate of most of Luxembourg's waste is either not well known or not under the control of Luxembourg; a phenomenon not well reflected in the statistics.

11.4.1. Luxembourg's existing competencies and advantages

- At the industrial level Luxembourg has high competencies in reprocessing and manufacturing secondary raw materials like glass cullet, aluminium & steel scrap into high-quality products. It also has an extensive logistics infrastructure for sourcing secondary raw materials from the Greater Region. There are many valuable lessons to be gained as well as optimisations to be made from this competence, as described throughout in Chapter 10 Sectorial Snapshots.
- CRP Henri Tudor and Ecoparc Windhof recently conducted a study of the Cradle to Cradle practice and potential for transforming waste into a secondary raw material at Ecoparc Windhof. The study contains a good summary of the present state of waste in Luxembourg as well as describing an innovative approach to savings and valorisation through the creation of customer/supplier communities inspired by cradle to cradle.

- The Tudor study demonstrates how at the Municipal Solid Waste (MSW) level, the lack of local waste processing facilities might be an advantage for circularity because Luxembourg is not 'locked-in' to specific technologies with their own interest groups, as is the case in most European countries. The exception is Luxembourg's incinerators. The absence of a reprocessing infrastructure allows Luxembourg to identify best available circularity technologies and enter customer/supplier relationships to maximize recycling quality for e.g. paper, polymers, textiles, wood, and other fractions, as the Tudor study describes.

- Companies like Superdreckskescht (SDK), Valorlux, Ecotrel and many others are well-known to the Ministry of the Economy so there is no need to provide an extensive description here. However, it is relevant for the present study to highlight their competencies relating to circularity.

  - **Superdreckskescht** (Source; Following information is from interview with SDK board)

  - SDK is not a waste disposal company per se, but primarily works on coaching and waste avoidance. As a government-sanctioned company the waste fractions they deal with are only those not handled by other collection schemes. SDK conditions collected materials (sorting, separation e.g. packaging from content) before they pass them on and they provide a product quality guarantee with every material shipment leaving their facility. Transparency is key for them.

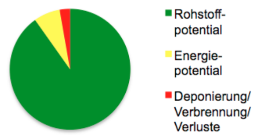
  - SDK has a traffic light indicator showing potential for residues to be secondary raw materials, waste-to-energy resources, or waste to be disposed of. For the example of PU-foam refrigerators, it found 90 % of the materials have secondary raw material potential (Fig. 11.1) (Source SDK presentation. Produkt Potential.)

Produktpotential Berechnung der
SuperDrecksKëscht®

Rohstoff		Menge 2013 [kg]	Energie		Menge 2013 [kg]	Deponie / Verbrennung / Verlust		Menge 2013 [kg]
Flachglas	0,9171%	411	ölver-schmutzte Betriebs-mittel	0,0045%	2	Hg-Schalter Beseitigung	0,0022%	1
Elektro-schrott	0,0379%	17	Reststoff	0,2946%	132	Kältemittel-gemisch R12, R22, R502, R134a, R600a	0,2700%	121
Kupfer	0,0848%	38	Reststoff	0,1227%	55	Kon-densatoren	0,0134%	6
Hg-Schalter Verwertung	0,0112%	5	Kunststoffe	1,7294%	775	Kunststoff Beseitigung	0,0045%	2
Kunststoff Verwertung	0,1517%	68	EBS	0,9461%	424	Wasser	0,0469%	21
Grundöle	0,4686%	210	Reststoff	0,0937%	42	Wasser	2,1221%	951
Eisenguss	3,9630%	1776	Staubrück-fang	0,0402%	18	Müll	0,3012%	135
Eisenschrott	14,8592%	6659	Ausschuss	0,3169%	142	Kunststoff grob Beseitigung	0,0022%	1
Kupfer	0,9908%	444	EBS	2,2716%	1018			
FCKW R11 / Kohlen-wasser-stoffe / Treibmittel-gemisch R11 / Kohlen-wasser-stoffe	0,5132%	230	EBS	1,2429%	557			
Fe-Shredder	39,6215%	17756						
Polyurethan	12,2216%	5477						
Eisen	1,3523%	606						
Alu	1,9369%	868						
Kupfer	0,2388%	107						
Kunststoff fein	0,2187%	98						
Alu-Feinstaub	0,4217%	189						
PS-Regranulat	11,3938%	5106						
Metalle	0,0179%	8						
Metalle	0,2745%	123						
Metalle	0,2834%	127						
Kunststoff grob Verwertung	0,1964%	88						
TOTAL	**90,1749%**	40411	TOTAL	**7,0625%**	3165	TOTAL	**2,7625%**	1238

Kühlgeräte / PU-geschäumt

Rohstoffpotential: 90,2 %



SuperDrecksKëscht®

Figure 11.1: Calculation of product potential for PU-foamed refrigerators by Superdreckskescht. Source SDK

- In order to avoid confusion with traditional waste recycling, which it says is a much-misused term and is usually down-cycling, SDK developed its own terminology *'re-consumption' / 'Rueckkonsum',* which it says more accurately reflects intentions. For example, it offers 'Thinner re-consumption' where companies make contracts for used thinner waste being processed and returned to them. SDK manages the process and offers frame contracts. Re-consumption is a potentially valuable connection to a co-branding label.
- Because there are no reprocessing facilities for materials recycling fractions in Luxembourg due to economy of scale, SDK have selection criteria for recycling facilities where the materials are shipped for processing so SDK is sure certain quality parameters are being observed (ISO 9001, ISO 14001, EMAS, RAL). SDK conducts quality checks on those facilities.
- SDK established reverse logistic for needles (pharmacies are serviced by, needles collected and taken back to pharmaceuticals distribution center and then to SDK) and lighters (collected by tobacco distributor when servicing stores and gathered at distribution center for SDK collection) - no extra transportation.

- Pilot project with Cactus "Drive-In" cardboard box, which people take home to collect products for re-consumption and return to Cactus when shopping. According to SDK it is a positive experience and very successful - less than 1% contamination, very clean because the box is open and people transport it in their own cars.
- SDK pushes for managing waste material flows in companies differently, i.e. cleaner more differentiated separation has led to a change in the services requested by customers from the classical waste disposal companies who had to acknowledge in their offers that clean residues have value.
- **Valorlux** is experienced in especially packaging materials and has many suggestions for improvements to increase valorisation (see section on Potential later in this chapter).
- As a compliance-driven scheme **Ecotrel** collects *Waste Electrical and Electronic Equipment* (WEEE) and eco batteries (via sub-contractors incl. SDK). Since only very small volumes are collected in Luxembourg, these are subcritical for own valorization. Disassembly is done locally into 30 different value streams, which is very labor intensive and does not offer no on-site valorization (all ideas on that were disregarded by local industries due to insufficient scale and stability of feedstock (i.e. concrete industries). Value streams are exported to facilities within 300 km radius (i.e. Greater Region) for processing. WEEE flows suffer high leakage due to illegal exports for potentially profitable streams (e.g. functioning computers, devices and mobile phones). On the other hand, there is no second hand distribution network for still-functioning WEEE appliances as vendors shy away from liability risks (esp. warranty and ensuing damage (e.g. fire due to improperly working devices).

Is the system maxed-out on efficiency?

A general perception in the waste management community is that collection rates for most fractions are quite high and to increase those further would lead to diminishing returns due to distance and density (Source interview Valorlux). While this might be correct, other potential players like La Poste who service remote areas of Luxembourg might have the existing capacity to cost-effectively collect materials which other waste collectors find too expensive to do. In addition the fact, that Luxembourg is subject to high transit and daily shuttling traffic, a large number of packagings are bought on one side of the border and collected on the other side. These structural leakage points will require effective collaboration with partners to achieve the increasingly strong targets proposed by the European Commission.

11.4.2. Bio-residues

Prevention and re-use of bio-residues is a hot topic these days due to attention focused by the EU on food waste, the recent declaration of phosphate as a strategic resource, and as the political pressure to valorise bio-residues instead of just burning them.

SoilConcepts

One Luxembourg company that is focusing on valorisation of bioresidues is SoilConcepts (Source: the following information is based on interview with Marc Demoulling, SoilConcepts).

SoilConcepts, a PPP working with waste water (WW) syndicates in the North of Lux, started as disposal contractor for sewage sludge and its hygienization as well as disposal of unproblematic biomass. They have a 2 ha composting facility where they treat 10,000 t/y communal sludge and 10,000 t/y green waste producing 10,000 BGK certified compost (Bundesguetegemeinschaft Kompost - Germany). The compost remains in Luxembourg, approx. 80% goes to agriculture and 20% is used by building contractors.

- SoilConcept is currently building new gasification facility (based on Synkraft technology developed in Austria) on site to adapt to changing market condition, driven by the discussion about contamination of sludge/compost products so they are ready if the compost product cannot be used as fertilizer/soil amendment any more.
- The new facility may also give the option for producing biochar, which is being discussed.
- The goal is to become a Center of Excellence for gasification technologies in Luxembourg.
- In line with the aim to valorize the nutrient in the bio residues, SoilConcept is planning to work on phosphate recovery from ashes (~15 kg P per ton compost) with thermo-chemical treatment (based on SUSAN project [Sustainable and Safe Re-use of Municipal Sewage Sludge for Nutrient Recovery – SUSAN - **http://www.susan.bam.de/eng_status-of-the-project_wp3.htm]**).
- They are also planning a pelleting facility for processed bio material as additional option for storage which is easier than storing electricity or gas.
- Even with the new gasification facility in operation, they will continue composting as a drying step, and valorize the fine fraction of compost as a high quality compost product. Ratio of how much gas/energy and compost will be produced will be market depending and also seasonal.

- SoilConcepts says synergies among biomass collectors and processors are not being explored biomass streams in Luxembourg are not fully catalogued, although the Environmental Agency is collecting data, see reports on composting facilities, WW facilities, fermentation etc. [**http://www.environnement.public.lu/dechets/statistiques_indicateurs**]. So biomass data is there but seems segmented.

- Work on biomass nutrient cycling would require cross-sectorial alliances (e.g. via a National Council for CE) to get beyond finger-pointing discussion on pollution of soil and water etc. Political leadership is required.

11.4.3. Reducing food waste

Especially the creation and fate of food waste is a focus of 2014 EU and FAO reports showing that an estimated 100+ million tonnes of food waste are generated in the EU. (Source http://ec.europa.eu/food/safety/food_waste/index_en.htm). Heavy blame is put on the 'best before' labeling regulations.

The good news is that cost-savings are already being generated at the institutional level by a circular approach to food preparation in hospitals. A May 2014 study was carried out by the independent accounting firm BDO on an integrated approach, developed by former Michelin four star chefs who started a new catering company *Enspire*, to food preparation at Herlev Hospital in Denmark. The study *found cost savings of up to 30% were achieved through preparation methods, which also reduced food waste.* (Source Okonomisk afdaekning af hospitalskokkener kostconcept BDO May 2014).

Perception of potential gains from improved bio-separation

A 2010 survey conducted by Administration de l'Environnement of households found that about a third of respondents thought separate collection of bio-waste will improve their household budget (Fig 11.2).

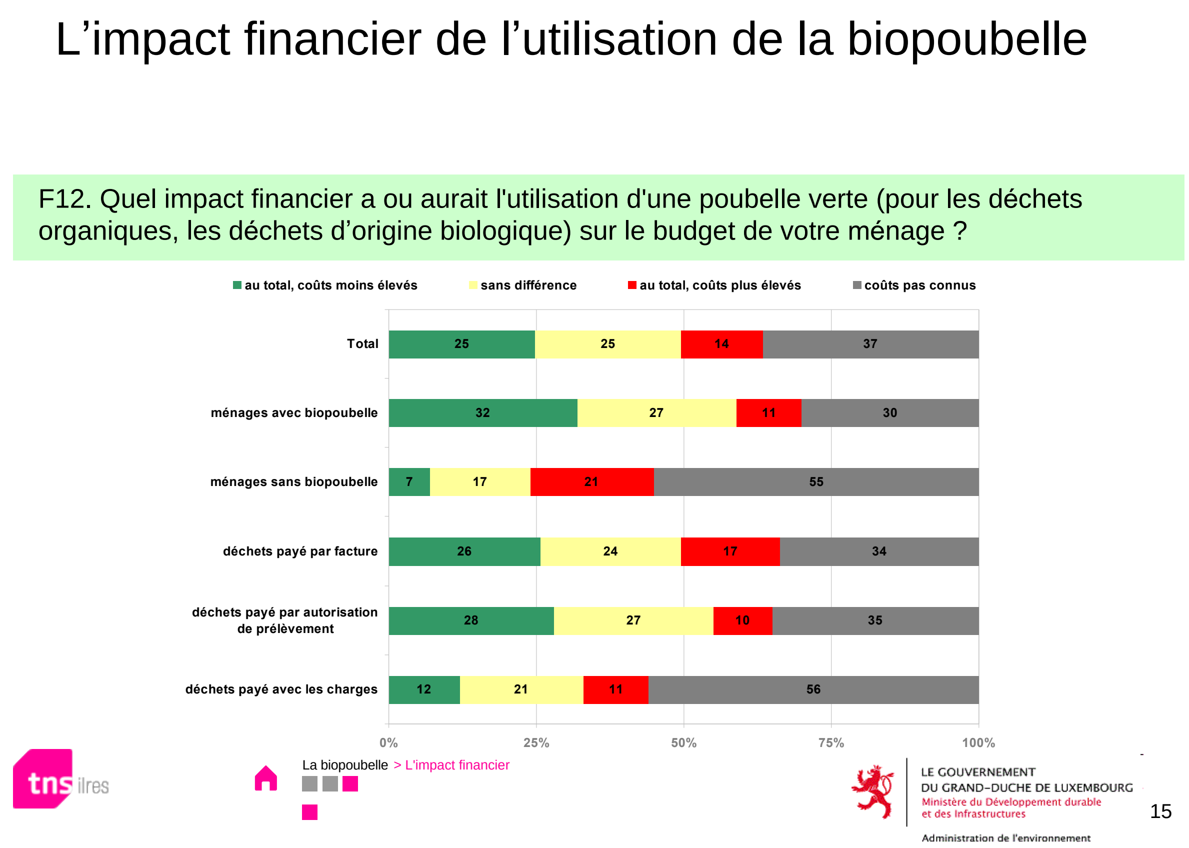


Figure 11.2: Results of household survey on separate collection of bio waste. Source Administration de l'Environnement

11.4.4. Incineration

Incineration was not among the priority areas selected by the Study Steering Committee because it preferred to focus is on revalorising materials. However EPEA has done extensive work on incineration for 20 years so has sufficient background to make general remarks later in this section.

Luxembourg incinerates at least 35% of its municipal solid waste amounting to 120,000 tonnes annually, generating 50,000 tonnes of ash & slag (Source (http://epp.eurostat.ec.europa.eu) and CEWEP (www.cewep.eu) which is largely lost for circularity. Those figures are probably higher because approx. 800,000 tones of waste are exported and some end up in incinerators.

11.5. The Potential

- Creating customer/supplier communities through initiatives identified in the Tudor/ Ecoparc Windhof study seems a powerful potential to improve source separation and valorisation of waste streams.
- SDK favors a *competency center* in Luxembourg with Luxembourg as test market as new brand/ qualification to export/ franchise from Luxembourg.
- Because the industry is highly regulated, companies like SDK emphasise the requirement to switch from waste to products in the classification and the mentality. The re-classification is something Luxembourg might support during its EU Presidency.

According to Valorlux, further improvements to the waste management system could be generated by;

- addressing leakage,
  - e.g. film, foils, plastic cups are not collected via blue bag and end-up in regular municipal waste streams.
  - secondary packaging (e.g. wood from wine boxes).
- improving efficiency/cost effectiveness of system.
  - harmonizing service levels (e.g. frequency of collection, usage of containerized vs. individual pick-up solutions) across different municipalities.
  - fostering collaboration within Greater Region (benefitting of scale effects, improved valorization of collected materials and increase in revenue stream).
  - further increasing participation and collaboration of consumers (e.g. collection and separation rate/quality).
- improving design of packaging:
  - single material products, clearly labeled (e.g. transparent film vs. M&M highly complex bag)
  - (re-)introducing reusable packaging (e.g. beverages, fresh-products)

Potential barriers;

- packaging designs are not under the control of Luxembourg companies.
- new targets of EU directive are not feasible without further investments and increased cost to the system (as addressing additional leakage is very costly (e.g. 11-18% of glass bottles sold at (transit) gas-stations) with very little return rates

- harmonization of service levels across communities (or alternatively community-based pricing schemes for provisioning of non-standardized services) e.g. higher frequency of doorstep-pick-up.

11.5.1. Systematic real-time valorizing and tracking

Valorizing and tracking secondary raw materials is a core activity for the circular economy. Diverse organizations including Groene Zaak, Ellen MacArthur Foundation and Circle Economy are engaged in activities to do this. Perhaps surprisingly many municipalities do not have the tools in place to know in real time the secondary materials fractions they are collecting or reprocessing, nor do they have a mechanism for tracking or valorizing them in the marketplace, based on a long term roadmap. The absence of the capacity is a barrier for conforming with new national and EU legislation on recycling rates and qualities. The SDK re-consumption traffic light system is a start towards such a system, but the real-time valuation is still open to development.

The good news is that due to de-regulation in The Netherlands in 2014, one group already put it in place with municipalities , and there is an opportunity for Luxembourg to take advantage of the mechanism. The company FBBasic with partner Kunststof Hergebruik developed a tool and entered into agreements with municipalities to implement it. The tool represents a potential for Luxembourg to leap over other countries to a frontrunner position and avoid trial-and-error.. FBBasic and its partners are run by experts with circularity training and more than 20 years experience in waste management and other industries.

11.5.2. Using bioresidues for topsoil manufacturing

Due to its convenient size, Luxembourg has a good potential to optimise the variety of bioresidues generated in the area for topsoil manufacturing to improve the quality and value to Luxembourg's agricultural soils. Topsoil, representing the top 20-50 cm of soil, is a complex material requiring diverse inputs to manufacture. Recently, new technologies such as biochar manufacturing brought the reality if high quality cost-effective topsoil manufacturing into reach.

However, there does not seem to be an overall mapping of bioresidue flows in Luxembourg from sources like; households, restaurants, supermarkets, institutions, roadside and yard trimmings, wastewater facilities, agro-industry. The information is scattered among various agencies.

It might be relatively easy for the existing agencies, which handle biowaste to consolidate the data and physically map the fate of bioresidue flows, and from this it might be possible to optimise the logistics for a national soil manufacturing programme.

11.5.3. Where to co-operate with the Greater Region?

The Greater Region is at once a source of secondary raw materials at the industrial level, as well as a re-processor for MSW generated in Luxembourg, so there is a substantial flow of materials back and forth with the region.

As described in Chapters 10.5 and 10.6, it makes sense to have continued close co-operation with Greater Region scrap dealers on providing raw materials for primary and secondary industries.

However, there are mixed views on other co-operation because there is also an entrenched waste management industry with a technology infrastructure in each of the surrounding countries. There is some scepticism by companies in Luxembourg about broadening the co-operation on MSW reprocessing. Instead, local companies seem to perceive they are best qualified to develop and implement second-generation valorisation methods and technologies.

For example SDK argue that the Greater Region has different cultures, much more dominance by large WM companies (who make money by being un-transparent) so should only be invited to participate after Luxembourg establishes frontrunner role.

But Luxembourg can be considered opportunity-rich. The ability to reconfigure waste management and re-valorization options more rapidly via contract renewal is a structural advantage vs. other countries locked more into their infrastructure which has to recover benefits on long term investments. Overall the total amount of waste requiring export could be reduced in the first place, if Luxembourg aggressively implements redesigns with its own industries as well as more inner loops (i.e. reuse, re-commerce, remanufacturing) which keep components and products longer in use and hence reduce total end of use streams.

11.5.4. A national paper upcycling campaign starting with the financial industry

As a potential quick win, investigate the feasibility of organising a customer & supplier community around high quality paper recycling, including destruction of confidential paper. See quick wins section under reverse logistics with La Poste.

Paper. A potential quick win for the financial industry

Every financial organisation in Luxembourg has one thing in common regarding materials; they each generate large amounts of high quality graphic paper.

The potential is to establish a customer & supplier paper community with the goals of improving recycling quality, improving environmental impacts, reducing costs, visibly communicating intentions, and learning to 'walk the talk' with circularity.

Circular paper communities are already working in and outside Luxembourg. For more information see section 14. Roadmap and 14.5 Potential Quick wins.

Special Note; The study did not interview Avery Dennison which has significant paper labelling operations in Luxembourg. The company is a potentially significant participant in a paper upcycling campaign. It was also reported to the study that Avery Dennison uses reverse logistics for transporting paper back after delivering products but this still has to be confirmed.

11.5.5. Incineration

Luxembourg might make a powerful statement to the EU by announcing it will phase out mixed waste incineration in favor of valorizing waste streams as well as re-purposing incineration for materials which are too complex or contaminated to be safely recycled. As a step to optimize traditional incineration before phasing it out, there are new technologies for improving recovery of resources from slag instead of losing those by landfilling or as roadbed material. A short study might be launched into how extensively the incinerator owners investigated best available technologies for recovering resources from incineration slag.

12. EXAMPLES OF SYSTEMS, SERVICES & PRODUCTS ON THE WAY TO CIRCULARITY

12.1. Why, What, How, S.W.O.T.

Why

Identify best candidates to scale up in Luxembourg.

Benefit from experience and avoid costs of re-inventing the wheel.

To maintain quality and avoid dilution it is good to distinguish circularity from waste management.

What

Inventory & map products certified for circular cycles, and available in the Benelux.

Inventory of circularity-inspired systems with potential for Luxembourg.

Inventory of circularity aggregation websites.

How

Use inventories from the present study to develop a database platform, which takes the best and leaves the rest.

S.W.O.T.

S Diverse examples of circularity exist for scaling up.

W Universal agreement on what is circular does not exist yet.

O Luxembourg might benefit from scaling up examples and co-developing standards

T Examples diluted by Greenwashing, glorified waste management, or Sustainability 2.0.

12.2. Introduction

The challenges of providing definitive circularity examples include;

- Because there is still no national or international circular economy at scale and hence defined that way, every example of circularity is considered a building block in the system rather than a complete embodiment of a circular economy.
- Due to the lack of broad acceptance of circular economy definitions, multiple websites are providing examples of resource efficiency, sustainability, biomimicry, blue economy, biobased economy, passive buildings, closed loops, zero waste, performance economy and green economy. Those each have elements that cross with circularity but only at certain inflection points.

> However, one criterion to use without question, is examples of circularity where products or systems are designed to account for the Technosphere & Biosphere cycles, which are described extensively in each of the leading publications about circularity.

In that context the following hierarchy of examples is presented;

- Products designed or certified for Biosphere and Technosphere cycles, with a focus on products and systems in Luxembourg, the Greater Region or Benelux. Luxembourg already has examples of products designed for circularity and available through distributors. Examples of those are found in Annex B. *The Annex represents a significant portion of the inventory work performed for the present study, covering more than 125 products, systems and supplier communities, and is structured to allow updating by the Ministry in the future.*
- *Value stream systems and services* presently functioning, which are designed to achieve circularity although still imperfect. In some cases like e.g. paper, those are built around products certified for circularity. Includes examples of circular procurement.

There is a third category; aggregation websites. Examples are; the aggregation webpage offered on the Ellen MacArthur Foundation website, a table prepared by Circle Economy showing more than 100 examples of products and systems and how they relate to circularity, and the C2CCentre website showing C2C-certified products globally. Aggregation sites sometimes mix products certified for circular cycles with other types of products certified or optimised according to other criteria. Still other aggregation websites describe green chemicals and materials, but these are at another level and would require extensive analysis before presentation.

Links to the mentioned aggregation sites are shown here:

- http://www.ellenmacarthurfoundation.org/case_studies
- https://docs.google.com/a/circle-economy.com/spreadsheets/d/1Ahxd5czhSQp5mwU4sy9rIXpuwPMdeMz8izarWs5eWso/edit?pli=1#gid=146394347.
- http://www.c2c-centre.com/products

12.3. Products & Services Designed For Biosphere & Technosphere Cycles

Because Biosphere and Technosphere cycles are a basis for circularity, one place to start is with products certified for levels of compatibility with those cycles.

Figure 12.1 shows an excerpt from the table in Annex B. The table contains:

- Company
- Product name
- Product type
- Product description - Note: The product description is not displayed completely, but can be viewed in the Excel file available on request by the Ministry of the Economy.
- Website
- Market presence Greater Region – Regional Office/Agent
- Distributor or sales point close to or in Greater Region
- Listed on C2CCertified.org (Nov 2014).

An Excel file with full functionality is available on request by the Ministry for the Economy.

See also map Figure 12.3 for a map of distributors offering those products in the Greater Region and Benelux. Sometimes more than one product is available at a sales point, so there are more products represented on the map than pins. See Excel file for information. The interactive image of the map is accessible at; https://mapsengine.google.com/map/viewer?mid=zpSFGzwBVyio.kq02ZxmHet-E&authuser=0&hl=nl (last accessed November 21, 2014).

The table and the map are designed to be updatable as an interactive library.

Company	Product Name	Product Type	Product description	Website	Market presence Greater Region	Distributor or sales point close to or in GR	Listed on C2CCertified.org (Nov 2014)
Accsys Technologies PLC	Accoya wood	Wood	Accoya® is a world leading high technology wood with properties that surpass the best tropical hardwood -thus reducing their depletion. Accoya® wood is manufactured via a non-toxic treatment and uses fast growing timber from sustainable sources. The wood has very high durability and dimensional stability allowing for reduced maintenance and a viable alternative to even high-energy man-made materials.	http://www.accsysplc.com	Also in Lux	Accoya through BAUMANN HolzhandelGmbH. Fruchtbahnhofstraße 3, 68159 Mannheim, Germany Tel: +49 621 3009920	
AGC Glass Europe	Stratobel and Stratophone	Glass	Stratobel is the range of AGC laminated glass. Laminated glass consists of an assembly of two or more sheets of glass and one or more PVB (polyvinyl butyral) interlayers. If the glass is broken, most of the fragments remain stuck to the interlayer. With Stratobel, it is possible to combine safety with other functions (thermal insulation, solar control, protection from UV radiation, acoustics, design) in a single glass product.	http://www.agc-glass.eu/English/Homepage/Home/page.aspx/1583	Also in Lux	AGC glass through AGC Energypane. Rue de Houtain, 32 4280 Grand-Hallet - Belgium Tel: +32 19 635060	
AGC Glass Europe	Float glass and magnetron coated glass	Glass	World demand for flat glass is around 45 million tonnes per year, of which 50% is supplied by Asia, 27% by Europe and 15% by North America. Of this total, 70% is used for construction, 20% for interior furnishing and decoration, and 10% for the automotive and transport industries. Float technology is now universally used for making flat glass. With around 13% of world production capacity	http://www.agc-glass.eu/English/Homepage/Home/page.aspx/1583	Also in Lux	AGC glass through AGC Energypane. Rue de Houtain, 32 4280 Grand-Hallet - Belgium Tel: +32 19 635060	
AGC Glass Europe	Lacobel, Lacobel T, Matelux, Matelac and Mirox	Architectural glass	Lacobel An extensive range of painted glass featuring 25 trendy colours. Lacobel has a high quality paint layer on the back of the glass. This protects it form any damage and keeps the colour and glossy appearance of the glass in brilliant shape. Lacobel glass can only be used for interior applications, such as furnishings, wall cladding, cupboards or	http://www.agc-glass.eu/English/Homepage/Home/page.aspx/1583	Also in Lux	AGC glass through AGC Energypane. Rue de Houtain, 32 4280 Grand-Hallet - Belgium Tel: +32 19 635060	
Ahrend	A2020 desk chairs, A230 desk chairs	Office furniture	Ahrend 2020 The Ahrend 2020 was designed by British designer Paul Brooks and has a dignified look. Its transparent backrest and sleek design make this chair a recognisable Ahrend product that looks good in all environments. The chair fully fits in with the Ahrend tradition: sustainable design, 'less is more', functional and aesthetic.	http://www.ahrend.com/en/Products/Seating/	Also in Lux	Ahrend. Romboutsstraat 9 1932 Sint Stevens Woluwe Belgium. Tel: +32 (0)27 16 22 00	
Ahrend	A500 table series	Office furniture	Ahrend 500 is an innovative range of conference tables, flexible in all areas and easy to adapt. Whether you are looking for permanent conference situations at boardroom level or flexible, mobile solutions in training rooms, Ahrend 500 has the solution. Main features:	http://www.ahrend.com/en/	Also in Lux	Ahrend. Romboutsstraat 9 1932 Sint Stevens Woluwe Belgium. Tel: +32 (0)27 16 22 00	
Ardagh	Ardagh Paint can and 400 g Infant Formula can	Can	Paint can The strength and rigidity of metal makes it the material of choice for paints and coatings which require safety and robustness in handling, filling, distribution and use in the home. The "Three Fingers" and "Waisted" cans are examples of how functional shapes can also be used to create differentiation and shelf impact. Special textures and finishes such as Ultra Matt™ are also being developed to	http://www.ardaghgroup.com/	Also in Lux	Ardagh. Bahnhofstrasse 16/17 56575 Weißenthurm Germany Tel: +49 2637 6010	

Figure 12.1: Screenshot of database of products designed for Biosphere and Technosphere cycles. Source EPEA

Outstanding examples of circularity systems connected to products

A few outstanding systems examples are not on the enclosed map fig 1.2 because the product distributors are located outside the boundaries, but nonetheless the products are available to be shipped to Luxembourg, and as well include *systems approaches* at the back end and/or front end.

- *Gugler printing products from Austria*. One of the only printing systems whose inks, paper and additives together are certified for circularity, where they are safely compostable, recyclable without generating toxic sludge, or combustible without creating toxic emissions. One of the leading examples of a systems approach to circularity, starting with the process itself.
- *KEFibertec Cradlevent®* from Wunsdorf, Germany. KE Fibertec Cradlevent® systems approach healthy ventilation with a washable removable, disassemblable textiles vent made from certified materials and designed for draft-less ventilation. While most vents in buildings are hard to access so get dirty after a few years and pollute buildings as well as requiring more energy to operate, the Cradlevent® solves those challenges. It also opens the potential for takeback services for ventilation systems. It is available in Luxembourg (Fig. 12.2).

Figure 12.2: KE Fibertec Cradlevent®. Source KEFibertec.

- *Steinbeis paper in Gluecksstadt, Germany.* Systems approach to recycled paper. Steinbeis is perhaps the highest quality recycled white office paper in Europe. Its super-white quality is indistinguishable from other non-recycled office papers. The patented circularity-certified process preserves the quality of paper fibres. Steinbeis paper is used by Luxembourg government agencies. Steinbeis with partners organised a complete customer/supplier closed loop for reducing costs and improving quality, which is described in Annex B.

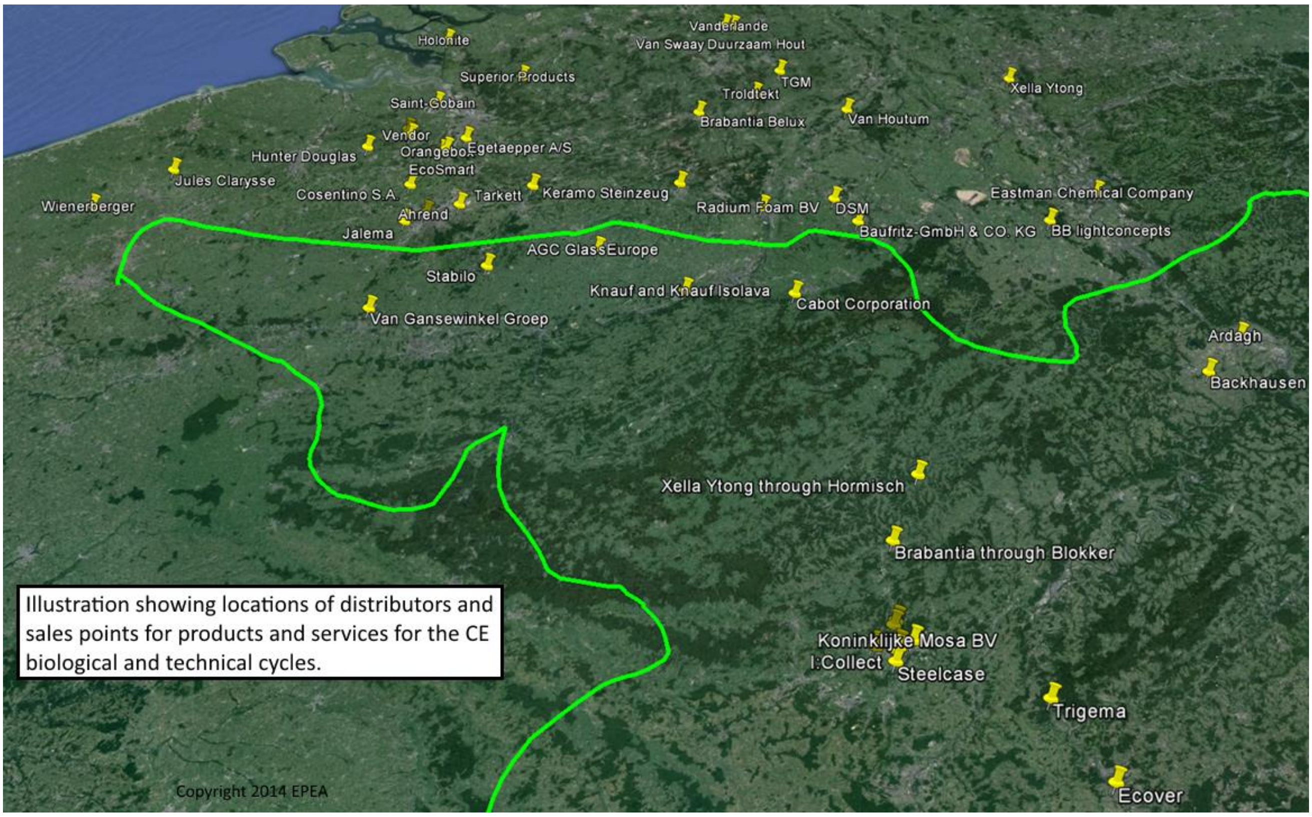


Figure 12.3: Graphical representation of distribution & sales points of circularity products in Luxembourg Greater Region & Benelux. The interactive image of the map is accessible at; https://www.google.com/maps/d/viewer?mid=zpSFGzwBVyio.kq02ZxmHet-E Source EPEA

12.4. Examples Of Circularity Systems & Services Functioning & Under Development

Systems for manufacturing, using, and recovering circular materials

Products are Systems. Products designed or certified for the circularity Biosphere and Technosphere cycles usually undergo an analysis of their supply chains and the materials they are comprised of. Those products are effectively systems because their supply and use chains are defined, which involves a systems approach. One product for example might have 100 suppliers who together constitute a community.

In total, more than a thousand of those communities exist around circular-certified products. However, additional to those products are purpose-designed systems & services for handling groups of products or streams of materials. The following figure 12.4 shows a snapshot of a table with examples of circularity value stream systems presently functioning, which are designed to achieve circularity although still imperfect see Annex B. An Excel file with full functionality is available on request by the Ministry for the Economy.

As well, Annex K includes systems under development. As with other described systems, these are not all circular systems, but most of them are on the way to circularity and each contains different elements of circularity.

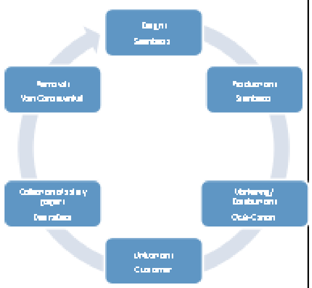
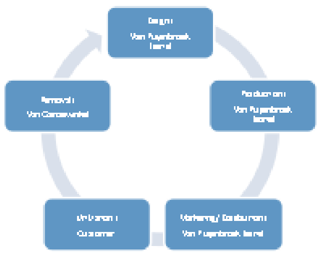
Community	Company to contact	Description of programme	Which part are recycled, upcycled and returns in the bioshpere?	Quality Improvement	Programme partners	Financial advantages to customers & producers	Website link
White paper recycling	Steinbeiss	The company Steinbeiss is working with different partners is order to create a closed-loop system. The design and production steps are made by Steinbeiss. The marketing and distribution steps are partly done in cooperation with Océ (Canon Group). The use phase is done by the customer. DestraData is collecting safety paper from the customer and sending it with the help from Van Gansewinkel to Steinbeiss. 	The safety paper is upcycled to paper again in a technical cycle.	Substance optimization Closing the loop for safety paper	Van Gansewinkel + DestraData and EcoSmart (Paper collection, recycling, logistic) Océ - Canon (Marketing and Distribution)	No disposal costs for the producer. Less primary raw materials costs	http://www.stp.de/en/returnity-cycle/cradle-to-cradler/ http://www.vangansewinkel.com/sitecore/content/Merksites/officepaper/Home.aspx
Rework workwear textiles	Van Puijenbroek Textiel (VPTex)	The company Van Puijenbroek Textiel is working with different partners is order to create a closed-loop system. Van Puijenbroek Textiel is in charge of the design, production and marketing/distribution steps. After the use phase by the customer the company Van Gansewinkel organise the take back logistic. 	All the components are designed for upcycling. No waste is generated. Old and worn REWORK workwear can be used to spin new yarn or to make compost in the biological cycle	Design for disassembly Improved quality of the materials for recycling, through EPEA assessments	Berendsen Lavans Van Gansewinkel	Less primary raw materials costs for the producer Take back and washing is included in the service contract for the customer	http://www.c2ccertified.org/products/scorecard/rework_-_workwear_by_van_puijenbroek_textiel

Figure 12.4: Screenshot of table listing circular systems and those on the way to circularity See Annex B for table. Source EPEA

For examples of other circularity enabling mechanisms relevant and organised by sector for Luxembourg please refer to Sectorial Snapshots.

In Luxembourg a broader list with potential links to circularity is the Greenworks business awards. These activities are not necessarily circular, but merit further investigation and cataloguing; http://gala.greenworks.lu/awards/candidates/

12.4.1. Examples of the service concept with leasing

The service concept for circularity, also referred to as a leasing concept, is described in many publications since the 1990s. The service concept often transforms materials, components and products into services which lease or rent the materials instead of selling them. The following table prepared by EPEA describes the main features as well as examples working today.

Table 12.1: Circularity service concept

CIRCULARITY SERVICE CONCEPT	
THE CIRCULARITY SERVICE CONCEPT DEFINED	The service concept transforms materials and products into services adaptable to customer requirements. Leasing, renting and sharing are used in the marketplace for everything from vehicles to appliances. However circularity service leasing of high-quality, safe and healthy products for materials banking and re-use is relatively new. It was published by Braungart et al. in 1992 and by the late-1990s the first leasing was started for chemicals by Dow Chemicals, known as Safechem. Today companies with many C2C-optimised products lease their products to customers. The service concept includes short-term renting, long-term leasing, and lease-to own. The broader C2C Service Concept includes ownership take-back incentives like Returnity certificates which provide a discount on new purchases if the customer sends the product back to the manufacturer. Those diverse methods are connected by a framework for designing and taking back high quality materials in products for re-use or recycling. In C2C leasing as with other types of leasing there are usually two or three players; • The manufacturer or supplier • The end customer • Sometimes a third-party leasing agent
RELEVANCE FOR LUXEMBOURG	Luxembourg's financial community has much to gain from leasing concepts and some alternative investment funds are using it. See example under financial procurement later in the chapter. As well, throughout the chapter Sectorial Snapshots, examples are provided of systems already working in Luxembourg for leasing e.g. vehicles & steel piles. Leasing is an important stepping stone to accelerating the use of circular products in Luxembourg.
EXAMPLE OF SAVINGS	C2C Expolab in Venlo The Netherlands calculates it saved 31% over capital costs for a five year period leasing C2C-certified office furniture. Companies like BB-Lightconcepts offer guarantees on energy savings with light leasing. For example BB-Lightconcepts guarantees a certain percentage of the lease cost will be paid back in energy savings over a five-year period. UNIDO published case studies on savings from chemicals leasing.

CIRCULARITY SERVICE CONCEPT	

ADVANTAGES & CHALLENGES	Considerations for crafting new agreements to balance the pros & cons of leasing include;
	• **KPIs.** Among the main Key Performance Indicators identified by leasing participants are;
	  ○ Top management support
	  ○ Knowledge sharing for technology & finance modifications
	• Establish long-term relationships
	  ○ Transform contractual agreements from sales to lease.
	  ○ Facilitate working capital requirements
	• **Capital vs. Operating**. Calculating leasing advantages and disadvantages is a careful balance between (a) capital and operating budgets for the customer, (b) working capital for the lease provider.
	• **Depreciation.** For customers, movables like furniture are often not an investment but rather are a depreciating cost, so it makes sense to compare capital depreciation pros& cons against the lease cost.
	• **Administration.** Multiple products are sometimes offered in packages for cost-effective ordering.
	• **Disposal.** Well-structured lease allows for repair as well as takeback at the end of the lease period.
	• **Maintenance.** If the manufacturer is involved in the lease, maintenance quality control is sometimes more effective, for example inspection of floor surface cleaning.
	• **Component Harvesting.** Leasing provides new potential for harvesting components from e.g. furniture which are often good for future uses. Balanced against that are changes to models which make the components obsolete, which cuts component re-use by up to 50%. In those cases design for recycling is paramount.
	• **Redesign.** For the lessor, the priorities for design are different. For example In a chair some parts wear out quicker and have to be replaced, and sometimes this is planned obsolescence. However for the lessor this type of planned obsolescence is expensive. A new link between lessor and manufacturer is practical.
	• **Supporting policies.** Governments and companies have environmental policies to support high quality recycling. The service concept actively supports those policies. Sometimes there are tax advantages to using C2C certified products, as in The Netherlands.
	Advantages
	• Saves capital expenditures
	• Saves operating energy costs e.g. in the case of lighting and ventilation
	• Promotes high quality healthy materials, redesign, and re-valorisation
	• Eliminates disposal costs for customers
	• Permissible under EU tendering procedures
	Challenges
	• Operating budgets have to be adjusted for the shift from capital to expense budgets. However it is possible to capitalize leases so the shift is sometimes not necessary.
	• It might be perceived that the customer loses the advantage of resale revenues, but resale has its own costs including administration, carrying inventory, and not being able to resell everything.

<table>
<tr><th colspan="2">CIRCULARITY SERVICE CONCEPT</th></tr>
<tr><td>DIFFERENCES FROM RECYCLING</td><td>
<table>
<tr><th>Conventional Recycling</th><th>Leasing</th></tr>
<tr><td>The user is responsible for recycling or disposal of the post-use product</td><td>The producer is responsible for the post-use product</td></tr>
<tr><td>No positive incentive to recycle</td><td>Financial gain through optimized recycling</td></tr>
<tr><td>Recycling only possible at a lower quality than virgin material (due to contamination, degradation of materials etc.)</td><td>Products optimized for re-use at the same high quality as virgin material (via choice of materials and ‘design for disassembly‘)</td></tr>
<tr><td>Responsibility for providing recycling facilities is left to public services</td><td>Industries provide infrastructure for re-using their own technical nutrients</td></tr>
<tr><td>Slows the loss of resources</td><td>Resources no longer need to be lost at all</td></tr>
<tr><td>Slows pollution</td><td>Pollution can become an obsolete concept</td></tr>
</table>
</td></tr>
<tr><td>TYPES OF PRODUCTS

BEING LEASED

For more information see database on systems Fig. 12.4</td><td>

Furniture, carpets, & interior products sometimes bundled with services for e.g. paper towels.
Lighting bundled with energy management.
Appliances like washing machines.
Systems to generate renewable energy.
Workwear.
Waste bins.
Chemicals and metals.
For chemicals the United Nations Industry Organisation has an international leasing programme across diverse industries and published a case studies book.

</td></tr>
</table>

CIRCULARITY SERVICE CONCEPT			
	Customers	**Manufacturers**	**Third party providers**
EXAMPLE OF COMPANIES INVOLVED IN C2C-INSPIRED LEASING OF BUILDING INTERIORS (Note; Excludes Chemicals leasing which is occurring globally. See accompanying box for example.)	• Park 2020 • C2C Expolab • BMW • Rau Architects • National Union of Students U.K. • Dozens of companies lease C2C-certified waste bins in The Netherlands • Hundreds of companies use power purchase agreements.	• BB-Lightconcepts Lighting • Philips Lighting • Steelcase • Ecosmart • Herman Miller Furniture • Desso Carpets • ColbrookBossonSaunders • Gessner Climatex Fabrics • Bosch Siemens appliances	• De Lage Landen (Rabobank Subsidiary) • Gamma (U.K) • HME (Netherlands) • Turntoo (Netherlands) • Ikano (Scandinavia)

Chemicals leasing

Leasing turns the traditional practice of minimizing emissions on its head, and encourages customers instead to maximise the amount of chemical returned to the lessor. As a result, the incentive is to design high-quality chemicals, which are re-usable, instead of chemicals which only have less bad emissions. Companies experimenting with chemicals leasing are discovering new advantages and challenges, which are described in a UNIDO study. See http://www.chemicalleasing.com/. Following is a synopsis of experiences described by DHVHaskoning, an engineering company based in The Netherlands;

After 3 – 5 years experience, companies learned that leasing as a financial model has knock-on management and regulatory effects; For example, if materials are leased and ownership does not change hands, and depending on national regulations, the chemicals and their by-products once used are usually not classified as waste, so are not subject to waste regulations. For Luxembourg the advantage is clear; companies to not have to be licensed as waste handlers, which is otherwise an expensive and time-consuming process. However, they are subject to the new European registry of chemicals REACH, so the management parameters change. The good news is that licensing requirements are less stringent if you do not have to be classified as a waste handler. The challenge is that in order to maintain ownership, you have to comply with REACH also for your by-products.

Other management and accounting changes occur also; companies have an incentive to improve the quality of by-product streams from their processes in order to take back those by-products and re-valorise them. Engineering companies like DHVRoyalHaskoning, using training provided by EPEA, developed leasing systems for chemicals companies offering takeback services to customers. The systems are used extensively. http://www.royalhaskoningdhv.com/en-gb/news-room/papers-and-articles/20130331-chapter-implementing-service-based-chemical-supply/648

(Source DHVHaskoning presentation at C2CBIZZ Nov 19/14)

12.4.2. Procurement

Procurement is used increasingly as a tool for accelerating circularity, but it also has challenges. See Chapter 9.1 Strengths and Weaknesses by Topic.

A few examples;

- Green Deal Procurement

  Working with Circle Economy and MVO, more than 30 organizations have entered at Green Deal for Circular Procurement; http://retro.mvonederland.nl/wegwijzer-circulair-inkopen

  The Charter for the Green deal is found here;

  https://docs.google.com/a/circle-economy.com/file/d/0B1EpTFJpl7-HWUx6N1dDcVBMbGVSbHBBQkZzQV8tdEYzNmJR/edit?pli=1

  Since 2010 EPEA co-operated with Netherlands and other agencies to develop procurement criteria and approaches. Those draft criteria are being explored further with diverse organisations. For example;

- Recommended on the MVO website as part of the earlier referenced Green Deal are Cradle to Cradle purchasing process & criteria (in Netherlands C2Cinkopen) developed with a Dutch government ministry and EPEA. The tool describes a process for developing circular purchasing criteria. Source http://www.pianoo.nl/sites/default/files/documents/documents/stappenplanc2cinkopen.pdf (Dutch language).

- The city of Venlo in the Netherlands developed an extensive supplier consultation process for its €50 million City Hall which was designed according to Cradle to Cradle principles. See section on Sectorial Snapshots under Construction.
- The C2C Expolab developed purchasing criteria for its interior furnishings.
- The municipality of Ronneby developed a procurement specification for tendering demolition, which resulted in immediate re-use of materials and savings for the municipality.
- The municipality also developed a procurement pamphlet for its 50 hectare planned development site Kilen site definition, which resulted in a systems approach to defining the site according to C2C principles and methods.

Taxation. As described in the enclosed Annex B, tax breaks are available for circular designed products. (see http://www.rvo.nl/subsidies-regelingen/mia-en-vamil?gclid=CJbz0v3z5cECFQrLtAodtEQAXw)

As well, incentives are being provided through so-called *positive lists*. However these lists have diverse definitions and require careful examination as they are sometimes not developed with circularity in mind.. As an example of positive lists with potential to be upgraded to circularity see http://www.rvo.nl/subsidies-regelingen/positieve-lijsten-miavamil.

Procurement for financing

Akuo renewable energy & storage (France)

Using materials for energy storage is one of the fastest growing areas for circularity in renewables. One example involving a Luxembourg-based subsidiary of a French financing group;

Luxembourg-based Akuo Investment SCA SICAV SIF II Fund invested EUR 3 million euros in a 9 MWp solar photovoltaic (PV) farm with a 9 MWh storage system. The project is located in northwestern part of La Reunion, Commune de Port and was developed by Akuo Energy's local subsidiary Austral Energy.

Bardzour is one of the projects attributed to Akuo Energy during the 2012 call for tender launched by the French energy regulation commission (Commission de Regulation de l'Energie) and it profits from a 20-year power purchase agreement (PPA) with EDF SEI. Moreover, the project is one of the largest PV with storage installations in France, equipped with BenQ 327 Watts panels using SunPower cells, while the storage system employs SAFT Li-on batteries. The ground-mounted solar panels will be integrated with joint agricultural activities so the solar farm will also be used for organic vegetable farming. (Source http://akuoinvestment.com/akuo-investment-sca-sicav-sif-ii-announces-its-first-investment-after-its-first-closing-in-september-2013/)

13. THE GREATER REGION & BENELUX

The Greater Region is covered throughout the present study, so the following section is only to consolidate and highlight some aspects.

The Greater Region is about 20 times the population of Luxembourg so deserves a study on its own for circularity potential. In that context the present study focused on a few co-operation areas already functioning and with circularity potential, notably; supplier communities, R&D, and retailing.

Takeaways

- The majority of Luxembourg's products are exported to countries represented in the Greater Region, which opens the potential for reverse logistics. For example speciality glass, steel and aluminium products already fall in that range. A clear opportunity is optimising customer/supplier communities for scrap and cullet in the steel, aluminium and speciality glass industries to improve competitiveness. To support optimising those, co-management of secondary raw materials with the Greater Region is a potential win.
- R&D & innovation co-operation is very good with the Greater Region, which also opens the door to leverage financial industry funding. Among the main mechanisms for co-operation are; IntermatGR, The Greater Region Universities group, and the newer Greater Region EcoInnovation group. As with Luxembourg nationally, statistics relating to circularity are lacking for the Greater Region. The Greater Region EcoInnovation Group Umweltcluster Grossregion is a good vehicle to assemble those and is already working on it.
- Potential co-operation with Wallonie on diverse innovations due to the earlier support of the Belgium EU Presidency for circularity.
- Potential co-operation with Saarland and Rhineland-Palatinate on new materials, topsoil restoration, and off-grid energy solutions..
- Greater Region commuters often drive cars leased in Luxembourg. There is a potential to close the customer loop with Luxembourg automotive parts suppliers but it requires investigation to determine if repair and remanufacturing are feasible.
- A more immediate win to scale up is shoppers from the Greater Region who buy "Grown in Luxembourg" food products when they come to shop. Looking in the other direction, diverse products certified for circular cycles

are sold in the Greater Region so might speed the task of integrating those products into the Luxembourg economy.

Example; The Potential for completing commercial and materials loops

There are very few examples where the complete cycle of raw resource extraction, manufacturing, wholesaling, retailing, use, disposal and raw materials recovery as well as the financing of those activities occur inside Luxembourg. However *the picture changes substantially when the Greater Region is considered*. For steel, aluminium, specialty glass and some plastics considerable sourcing from and delivery to the Greater Region occurs. As well retailers like Cactus, Pall Center and Oikopolis sell to Greater Region residents and purchase locally produced products from the GR. The message here is clear; *start commercial circularity co-operation with the Greater Region through Luxembourg-based companies, which already have materials flow exchanges there.*

Examples for R&D

IntermatGR is an important EU Interreg project on materials in the Greater Region, and one of the planned outcomes is a research map of the Greater Region which depicts existing know-how and technology. Of high potential for circularity. http://intermat-gr.eu/en/project/

UniGR Confederation. The aims of the University of the Greater Region - UniGR confederation, are adaptable to circularity co-operation especially in the critical area of interdisciplinary study;

Expand the courses and teaching available at the partner universities by:

New study programmes with double or joint degrees. Cross-border cooperation including the coordination of courses and regulations for recognition issues. Cross-border courses in the form of bloc seminars.

Strengthen cross-border research and doctorate training by:

Networking researchers. Reserving large research devices on a mutual basis. Close cooperation in the area of doctorate training (soft skills, "cotutelles de thèse", i.e. a thesis supervised in two countries, etc.)

Examples of potential for co-operation with Wallonie on R&D

- Reverse metallurgy.
- Textiles collection and reprocessing as part of Wallonie's participation in the Ellen MacArthur Foundation Regions project.
- Wood for sustainable construction.
- Innovation through organisations like Greenwin http://www.greenwin.be/en which Luxembourg materials experts e.g. from Dupont, participate in (Source Dupont Interview).
- For transformative technologies, Wallonie participates in the SCOT project (Smart CO_2 Transformation), a collaborative European project (supported by the Seventh Framework programme) in the area of Carbon Dioxide Utilisation (CDU). The main objective of the project is to define a Strategic European Research and Innovation Agenda for Europe in the field of CO_2 reuse http://scotproject.org/scot-project.
- Statistics. Wallonie was the only region able to provide certain materials flow statistics to the study in the available timeframe.

Examples of co-operation on circularity in Saarland & Rhineland Palatinate

In Saarland the Leibniz Institute for New Materials works on biobased materials and bringing new materials to markets http://www.inm-gmbh.de/en/.

In Rhineland Palatinate, Palaterra developed a new type of topsoil manufacturing for carbon management in agricultural soils, a ptential boost to restore Luxembourg's depleted soils http://palaterra.eu/

Moorbach energy landscape; a large-scale experiment in going off the grid with renewables. http://www.energielandschaft.de/

Governance in the Greater Region in relation to the power of commuting

The governance structure of the Greater Region is complex because it is subject to national, state, and municipal governments as well as intergovernmental structures. For the latter see extracted table Figure 13.1 showing various Greater Region governance structures, excluding national and local governments (Source; Grenzüberschreitende polyzentrische Metropolregionen 2010). According to some speakers at the 2014 Greater Region Business Days, intergovernmental structures lag the reality of 200,000 commuters who are driving integration faster than government institutions.

The commuter-driven phenomenon is instructive for the CE. For example retailers are already exploiting the competitive advantage of selling locally produced Luxembourg products to commuters. The trend speaks strongly to the opportunity for the Luxembourg government to empower entrepreneurs through for example a national quality label campaign for local products.

Luxembourg	QuattroPole	Consultative Institution	Working groups	-	2000	1971 (Regional Commission Saar-Lor-Lux-Trier)
	LELA +	Charter	Working groups	-	2007	
	Euregio SarLorLux +	Association	Working groups	36700	1988	
	Greater Region	Charter (Creation of EGCT under discussion)	Working groups	65401	1995 (1st Summit of the Greater Region)	

Figure 13.1: Examples of Greater Region intergovernmental bodies. Source Grenzüberschreitende polyzentrische Metropolregionen

Benelux strategy. The Valley at Schiphol Trade Park as a model for Luxembourg to track.

A new Public Private Partnership circular economy hub underway in The Netherlands might be a model for the Ministry of the Economy to track, especially regarding tax free trade zone potential and R&D incentives. Initiated by Delta Developments who developed the C2C-inspired Park 2020 in the Netherlands, and supported by the Netherlands government as well as non-profit organisations like The Ellen MacArthur Foundation as well as the Schiphol Airport Development Corporation (SADC), *The Valley at Schiphol Trade Park* plans to take circularity to a new level by creating 'materials farms', knowledge hubs and scientific networks, with a range of circular economy businesses and services (see Figure 13.2). The land is already committed and the hub will be the largest circularity development to date, encompassing an area larger than one square kilometer next to one of Europe's busiest airports. The Park is being co-developed with a wide range of local and international stakeholders who are described in the figures on the following page.

The development already gathered one of the largest international multi-stakeholder circularity platforms in The Netherlands, with the support of the Ellen MacArthur Foundation, The World Economic Forum, and a range of universities, as well as commitment of a large piece of real estate in one of the highest valued areas of Europe. The area is also adjacent to a planned recreational park, which will transform the whole area into a holistic work, live, enjoy experience based on circularity. Together those components make it the most economically significant multi-stakeholder platform for the circular economy in the Benelux.

As a starting project, the group did an inventory of the diverse residue flows around Amsterdam to identify local opportunities for upcycling it to resources and matching it with potential re-users. These fractions will be used as a basis for materials communities.

For more information contact http://www.schipholtradepark.com/contact-en/

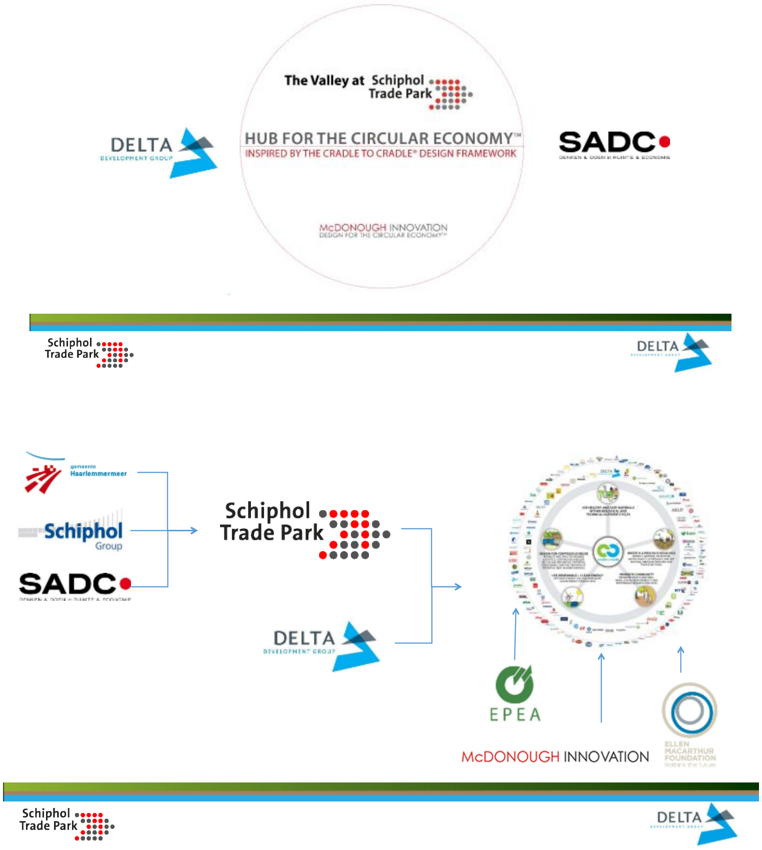


Figure 13.2: The valley at Schiphol Trade Park. Source Delta Development.

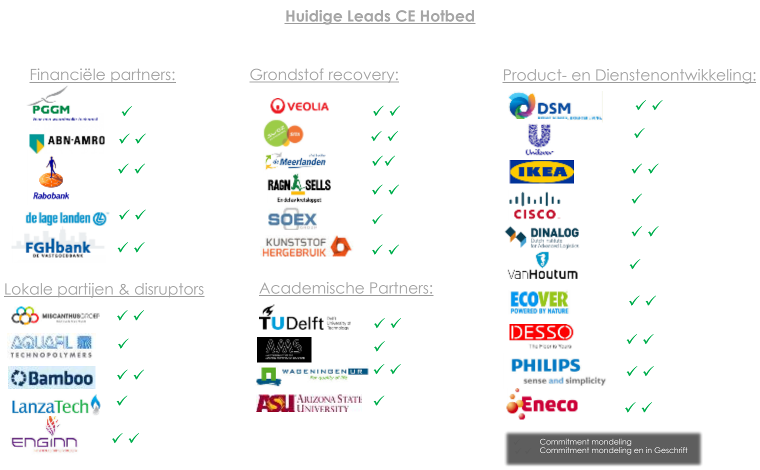


Figure 13.3: Stakeholders in circular economy hub at Schiphol Airport. Source Delta Development.

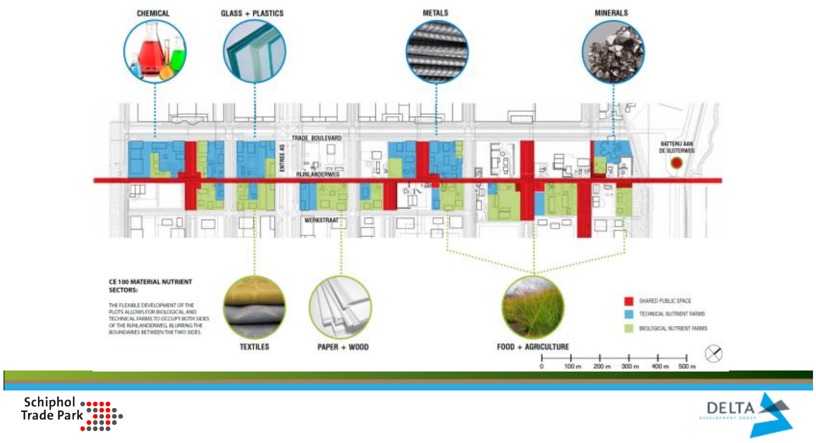


Figure 13.4: Illustration of diverse 'materials farms' where producers and users of materials co-operate for materials that are defined, healthy, and recyclable at the same level of quality. Source Delta Development.

Figure 13.5: Map showing Schiphol Trade Park "STP" location next to Schiphol Trade Park and Park 2020 near Schiphol Airport. Source Delta Development

EU Presidencies alignment

Coordinate with The Netherlands on its EU Presidency following Luxembourg. There was considerable attention in the study Steering Committee to the potential of co-operating with organisations like Circle Economy to align with The Netherlands on CE aspects of its EU Presidency, and it is planned to have a meeting in Paris to explore that and other topics. The present study encourages the co-operation of the two Presidencies.

Parallel initiatives in The Netherlands

As described earlier The Netherlands is already a circularity hotspot due partially to the introduction of Cradle to Cradle since 2006. Following on this, Circle Economy and other organisations developed initiatives ranging from procurement to materials flow tracking, and these are described in Annex K. As well Circle economy is separately providing information to the Ministry on those initiatives.

In total, The Netherlands has special significance for Luxembourg as a 'co-opetition' partner, so the Ministry of the Economy might want to appoint on individual to be responsible for tracking and where appropriate participating the diverse initiatives described here.

SECTION III - ROADMAPS

14. POTENTIAL CIRCULARITY ROADMAPS FOR LUXEMBOURG

14.1. Roadmaps Framework

Normally, EPEA only co-develops roadmaps after a goal-setting process with stakeholders. However, as a first step and in order to fulfil the study terms of reference, potential starter roadmaps were developed here as examples.

The following diagram Figure 14.2 describes the overall framework for establishing circularity Roadmaps for Luxembourg. For methodology used to identify potential Roadmap priorities see Annex M.

The Roadmap Framework consists of;

- Mission and strategic policies to support the Mission.
- Objectives to fulfil the Mission. Objectives are qualitative. (see Table 14.1 summarising objectives).
- Big Wins to fulfil Objectives.
- Goals and Milestones for moving towards each Objective. Goals and Milestones are quantifiable, to measurably achieve by specific dates. These might also be used as Key Performance Indicators (KPIs).
- Quick wins & Mid-term wins connected to selected Objectives. These were requested in the Terms of Reference.

Objectives

Every Objective has its own table containing;

- Goals & Milestones, and which party might be responsible for implementing.
- Relevant sectors involved.
- Potential for improving competitiveness & savings and reducing environmental impacts.
- Justifications & Background. Highlighted from other sections of the study.

Illustrated Roadmaps. Attached to every table is an individualised Roadmap showing progress towards circularity. The Roadmap describes where each Goal and Milestone fits into Traditional, Transitional and Transformational activities. The illustration does not contain every element described in the present study.

Instead it is intended as a starting point for Stakeholders to determine their own priorities.

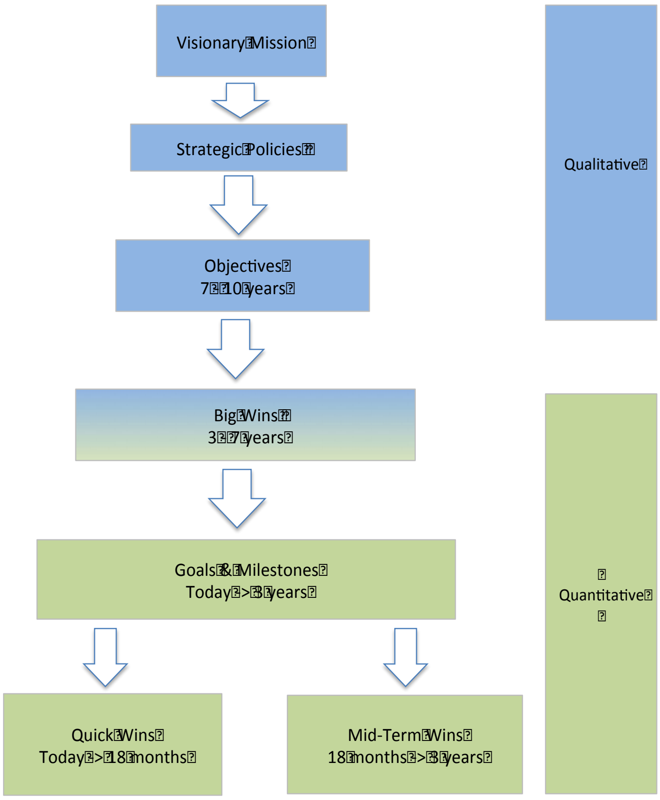


Figure 14.1: Roadmaps framework diagram. Source EPEA

In the context of the Framework described in Fig. 14.1, the following sections describe the potential Mission, Objectives, Big Wins, Quick Wins, Goals and Milestones.

It is emphasised that in order to reach final roadmaps, a goal-setting process is undertaken with stakeholders for each of the described Objectives.

14.2. Potential Visionary Mission For Luxembourg

Luxembourg aspires to be **A Knowledge Capital and Testing Ground for the Circular Economy,** to generate positive impacts, diversify its economy further, and improve the quality of life for citizens, partners and visitors.

Luxembourg will achieve the Mission by creating **Circular Economy Services** to improve productivity and resource quality across diverse sectors, for example, construction, education, finance, ICT, logistics, manufacturing, retailing, training, and R&D.

Luxembourg will fulfill the Mission through measurable objectives, goals and quick wins to accelerate employment, improve competitiveness and increase value creation.

Who does it?

Political and Executive support is a cornerstone for success. At a political and executive level the Mission might be coordinated by a **circularity leadership group,** evolving from or recruited by the initial working group being put into place to initiate circularity in Luxembourg.. The structure of a circularity leadership group is particular to the political and cultural context of Luxembourg, and will arise from the experience of the working group.

To reflect Luxembourg's diversity, the Objectives, Goals and Milestones will be implemented by diverse stakeholder platforms, as described in the accompanying tables.

14.3. Circular Economy Objectives For Luxembourg.

Potential primary objectives and big wins are shown in the accompanying table 14.1. The table is divided into Circularity Enablers and Economic Sectors.

Table 14.1: Objectives, big wins & quick wins

Overall Objectives supported by strategic thrusts 7 – 10 Years	Potential Big Wins on the road to Objectives 3 - 7 years	Potential Low-Cost Quick Wins & Mid-Term Wins 1 – 3 years
CIRCULARITY ENABLERS		
National Objective Implement a *National Circularity Roadmap for Resource Quality & Productivity*	*Implement enabling mechanisms which empower diverse stakeholders to implement the circular economy by raising competitiveness, accelerating job creation, saving costs and improving environmental impacts.*	Establish a *National Circularity Initiative for Resource Quality & Productivity* (NCC) Announce *Circularity Training Initiative* for the EU Presidency. Announce *National Quality Brand for Circularity* to improve sales and support existing Luxembourg quality labels.
Education & Training Luxembourg with the Greater Region will be Europe's leading education & training hub for creating new jobs and improving competitiveness using circularity skills and technologies.	*Luxembourg creates thousands of new jobs for youth through remanufacturing, repairing, disassembly, deconstruction & logistics.*	*Circularity Training Initiative* for hands-on training of unemployed youth for circularity skills.
Marketing & Messaging National quality co-brand for circularity-inspired products & services by leveraging existing Luxembourg labels to increase sales & competitiveness of products.	*Luxembourg increases sales of local agricultural products and manufactured goods by integrating a national quality brand with circularity.*	*National Quality Brand for Circularity* to complement existing Luxembourg labeling, piloted with local grocery retailers & growers, supported by a government 'buy local' campaign.
Economic Indicators Luxembourg is recognized as an authority for quality assurance and measurement of present and potential value of circular materials.	*Luxembourg creates a new industry for circular economy quality assurance and measurement by pioneering a New Balance Sheet for Circularity*	Announce plan to establish a *New Balance Sheet for Circularity* To start, announce Pilot for Measuring Positive Impacts by adapting LCA Announce a *National Materials Banking Valorization Inventory* for materials in Luxembourg's infrastructures.
Regulation Luxembourg be a leading partner with the EU to establish regulation and incentives for safely and equitably implementing circularity, with a focus on supporting R&D incentives and removing licensing barriers.	*Luxembourg is a consulting services hub for advising governments & companies on circularity legislation, regulation, & incentives.*	Optimize & embed already-developed *CE positive criteria* into new legislation, regulation and investment guidelines. To conform with new EU regulations announce a CO_2 *Phase-In programme for replacing Hydrochlorofluorocarbons HFCs* with economical & energy-saving closed loop CO_2 systems.

Overall Objectives supported by strategic thrusts 7 – 10 Years	Potential Big Wins on the road to Objectives 3 - 7 years	Potential Low-Cost Quick Wins & Mid-Term Wins 1 – 3 years
	ECONOMIC SECTORS	
Manufacturing Luxembourg with the Greater Region will be a European R&D frontrunner for recovering & using secondary raw materials for primary manufacturing to support its existing industries. Luxembourg will be the technology frontrunner in ICT, robotics and additive manufacturing for near-shoring circularity.	*Luxembourg & Greater Region achieve substantive resource security and improve margins by 10% with smart specialization in secondary raw materials.* *Luxembourg integrates high-technologies to be a significant participant in the repatriation of millions of near-shoring jobs to Europe, i.e. bringing jobs back to where the markets are.*	Accelerate *Circular Supplier Communities* for improving secondary raw materials productivity & quality. Upcycle scrap & cullet trading into a *Materials Banking* service to improve margins for Luxembourg's manufacturers. Initiate *Positively Defined Materials* with manufacturers, anchored by years of successful R&D at Tarkett in Luxembourg.
Construction National materials management for circularity in construction & building management fully operational. The plan to be developed in the near-term.	*Luxembourg and the Greater Region save hundreds of millions in costs annually and increase the real value of the new & renovated building stock amounting to billions of Euros in gains, by converting demolition liabilities into bankable materials assets.*	Announce *National Materials Management Plan* for construction headlined by *Upcycling Construction Residues* to reduce excavation and construction waste 30% by re-using it. Pilot a *Circularity Light-house* in Luxembourg with 100% defined materials to improve residual value.
Investment, Banking, Insurance Luxembourg will be the leading financial center for circularity investment & banking, including new mechanisms for integrating Greater Region R&D with industry and finance, & best practices	*Luxembourg becomes the Trillion-Euro circularity banking hub for revenue-generating banking services, investment, materials leasing, and insurance.*	Quality-Assured *Circular Matchmaking* with Greater Region R&D innovators. Pilot *Secondary Raw Materials Valorization Service* with municipal governments and builders, vetted by the financial community.
Logistics Luxembourg will be a European reverse logistics hub, leveraging its existing assets to provide new services.	*Increase the share of logistics revenues for reverse network activities and re-distribution in the Greater Region.*	*Circular Logistics Service* with La Poste Investigate feasibility of *Circular Vehicle Repairing & Leasing.*
R&D Luxembourg with the Greater Region and supported by the investment industry will be an R&D frontrunner for introducing positively defined chemicals, composites, nanomaterials and biomaterials to existing and new industries.	*Luxembourg and the Greater Region lead near-shoring of industry with 3D and automated circular manufacturing to repatriate millions of jobs .* *Luxembourg is the IP capital for licensing circular materials, generating billions of Euros in licensing fees.*	Pilot 3DRD; *3D & Robotic De-construction Initiative* based on existing R&D. Announce The New BBC. Biobased Biocompatible Composites

Potential secondary objectives

Table 14.2 shows the potential secondary circular economy objectives for Luxembourg. The classification of these activities as secondary is provisional and might be changed after stakeholder consultation by the Ministry of the Economy.

Table 14.2: Secondary objectives to fulfil the mission

Category	Objective
ENABLING MECHANISMS	
ICT & advanced technology systems	Luxembourg will be the technology frontrunner in ICT, robotics and additive manufacturing for circularity.
ECONOMIC SECTORS	
Agriculture	Establish a national circular agriculture programme focused on improving local marketability of Luxembourg agricultural products and restoring soil quality with advanced methods**.**
Automotive	Investigate the feasibility of circular supplier communities through pilot projects based on increasing secondary raw materials use, remanufacturing, tracking systems for returnable packaging.
Water	Luxembourg will be a circularity leader in value-added water recycling to meet and exceed its EU water quality goals.

14.4. Goals & Milestones To Achieve The Objectives

Objective. Establish a national circularity initiative for resource quality & productivity

Table 14.3: Objective. Establish a national circularity initiative

Category	Objective. *Establish & Implement a National Circularity Initiative for Resource Quality & Productivity*
Goals & Milestones	Goals Examples. See Roadmap illustration for further examples. • In early 2015 establish a National Circularity Initiative for Resource Quality & Productivity (NCI) and a working group to start first steps. • By mid 2015, after consultations with stakeholders the working group identifies quick wins based on the present study and begin to implement. • By end 2016 based on experience with quick wins announce a National Circularity Plan. *Milestones.* • CE Celebration Workshop, to celebrate and accelerate what Luxembourg already does well. Diverse businesses including steel, aluminum, glass, equipment rentals, automotive robotics, and retailing are already doing circularity but not calling it by that name. The purpose of the workshop is to celebrate those achievements and see how to scale them up and transfer them to other businesses. To be done in parallel with or as part of other CE event being planned for the circular economy in 2015. A high priority for motivation and replication. *Ambition level* Support tradition, transition and transformation. *Quick win potential* See 'Establish a National Circularity Initiative' in potential quick wins.
Leading Stakeholders and Sectors Involved	Every sector. See section *Potential Quick Wins* for more information. See further objectives & goals described in this chapter.
Potential Gains in	See section *Potential Quick Wins* for more information.

Category	Objective. *Establish & Implement a National Circularity Initiative for Resource Quality & Productivity*
Competitiveness, Savings, Job Creation & Preservation, Environmental Impacts	The objectives and goals described throughout this chapter form potential elements of the plan.
Justification/ Background information	The justification and background for the Circularity Framework and the NCI are described throughout the present study.

Figure 14.3 shows the Roadmap connected to the table.

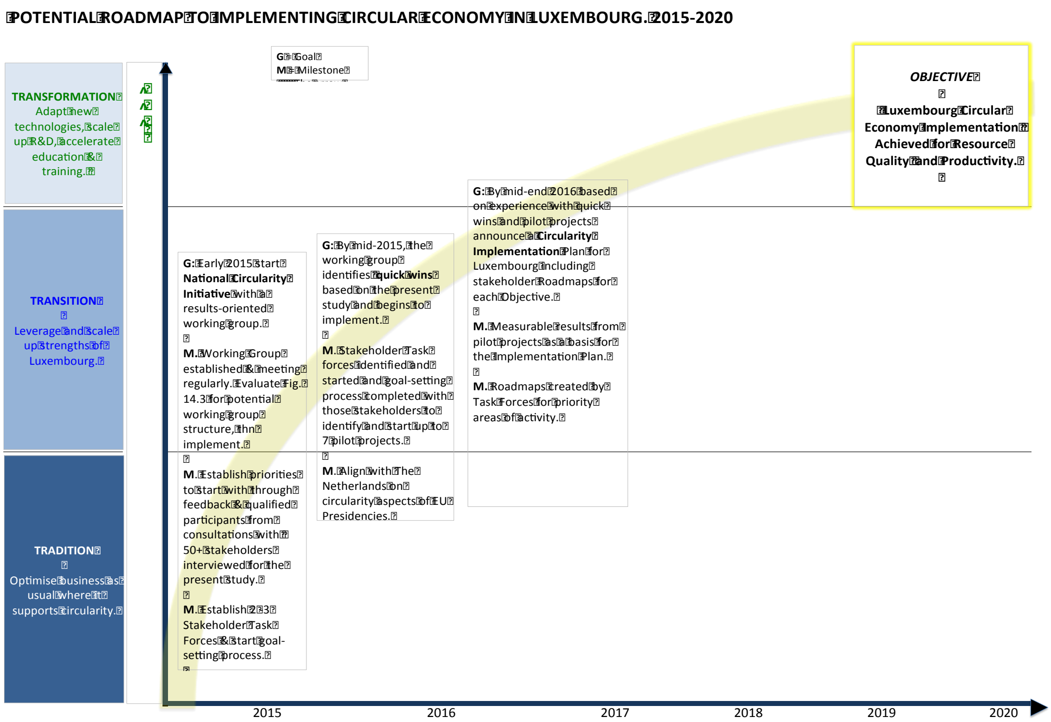


Figure 14.2: Potential Roadmap to Implementing Circularity. Source EPEA

14.5. Potential Quick Wins

Potential quick wins are designed to kick-start objectives and goals.

The quick wins shown here resulted from a prioritisation exercise with the Study Steering Committee as described in the methodology. For methodology on selecting potential quick wins see Annex M. However, priorities will change depending on stakeholder perception.

The following quick wins are feasible to start immediately;

1. Start a National Circularity Initiative for Resource Quality & Productivity, with practical stakeholder activities.
2. A retailer and wholesaler circularity co-brand for agricultural products as a visible sign of action for the NCI as well as a blueprint for supporting and extending existing Luxembourg labels to circularity.
3. A Circularity Training Space to accelerate training for circularity skills.
4. Start reducing excavation and construction waste by re-using it
5. Start a Life Cycle Assessment Task Force to measure positive impacts.
6. Establish a reverse logistics pilot with La Poste
7. Establish a new quality label for secondary raw materials

14.5.1. Quick Win #1. Start a National Circularity Initiative with practical stakeholder activities

Connected to Objective;

Establish a National Circularity Initiative for Resource Quality & Productivity with practical stakeholder activities.

Why?

- Accelerate where Luxembourg is already doing the right thing the right way, which is considerable.
- *Materials Security*. America, Europe, China, Germany each have national agencies for strategic resources security. Luxembourg's leading established and newer industries already rely on strategic materials for their existence. It makes sense for Luxembourg to safeguard those.
- *Quality Assurance.* The study found that interest about CE is high and know-how about supporting technologies and services is high, but awareness of what circularity involves as a holistic approach is low. In that context, there is a risk that uncoordinated information might lead to conflicting understandings of the CE and misallocated investment.
    - Activities Integration. In Luxembourg, no fewer than 20 activities relevant to the CE are going on in parallel to the present study. See Table 2.1.
    - In early 2014 the *High Commission for Industry* as well as the *National plan for smart, sustainable and inclusive growth Luxembourg 2020* made recommendations for improving Luxembourg's competitiveness. The present study is closely related to those recommendations.
    - There is agreement across leading CE studies that systems integration is essential for scaling up CE activities. For example, the World Economic Forum recently created a meta-council to coordinate work on circularity (source WEF news release).
- S*hort-term potential to establish a frontrunner position*. Luxembourg has a short-term but also short-lived opportunity to seize the initiative as first mover in some CE categories, thereby raising its international profile; a main recommendation of the Haut Comité pour L'Industrie.

What? Potential functions

- Establish the National Circularity Initiative for Resource Quality and Productivity (abbr NCI).

- *Terms of Reference.* The NCI is an initiating, communications & coordination mechanism. The following functions were identified which might be performed by stakeholder task forces and coordinated by a working group;
  - *Secondary raw materials.* A range of activities is identified in the study for upcycling and accelerating the use of secondary raw materials;
    - Competency programme for industrial secondary raw materials.
    - Valorisation and tracking mechanisms for use by municipalities.
    - New standard for secondary raw materials.
  - *National quality co-brand for circularity* to improve competitiveness in the agricultural products, automotive and other industries.
  - *New Balance Sheet* for the financial industry, which gives investors and bankers tools to accurately estimate and account for circularity.
  - *Networking* among diverse parallel activities described in Table 2.1.
  - *Quality Assurance.* Oversee a consistent message on what is the circular economy.
- *Participants*. Composition. The NCI is intended as an activist and catalyst for circularity instead of a committee catch-all for every ministry and industry association. An initial working group might consist of representatives from the Steering Committee which supervised the present study; Ministry for the Economy, MDDI, CRP Henri Tudor, Ecoinnovation Cluster. As well, working group task forces might be drawn for example from personnel who work on; Steel renting at ArcelorMittal, scrap and cullet conversion at Guardian and Eurofoil, Materials R&D and manufacturing at Tarkett, possibly reverse logistics at Amazon and Kuehne & Nagel.
- *Political, Business & Inspirational Leadership.* The initiative will benefit from high level political and business support. However structuring the support without creating bureaucracy is a challenge, which was examined at some length by the study Steering Committee. Initially it was thought a National Council might be set up, but after some evaluation it seems there might be too many national councils. As well, the aim is to recruit new individuals instead of having the same Councils members at the same tables. *Due to those considerations, the present study suggests the Ministry for the Economy evaluate how to best establish a leadership group, but while it is working on that, start the practical activities with a CE working group;*
- *Management*. It makes sense for cost savings to base management of the NCI working group in one of the existing Innovation clusters in the Ministry of the Economy; probably the Ecoinnovation Cluster who are leading the circularity initiative.

- Gradual integration of circularity with other Clusters might provide a powerful focus for the innovation clusters, some of which are still looking to find a unifying theme for their activities. Environment is also a driving force for circularity and it is clear MDDI will be closely involved.

How and who? Quick win steps

- The act of creation is a quick win on its own to signify intentions.
  - Announce the intention to establish an Initiative and promote it broadly.
  - Actively involve local media especially those with international connections. For example, RTL has connections across Europe. The media are large consumers of paper and electronic equipment so have their own role to play. Challenge them to come up with their own circularity roadmap.
  - *Coordination*. As its first practical step the Ecoinnovation Cluster might start assembling information on and coordinating the many initiatives parallel to the present study as described in Table 2.1 in the Context chapter. Those activities represent a substantial existing commitment of resources, which, if coordinated, have the potential to accelerate circular innovation in Luxembourg.
- Announce the initiative as part of Luxembourg's EU Presidency, then leave it to the Ecoinnovation Cluster working group to do the implementation. Based on the present political scene with circularity, it is probable that once the announcement is made it might generate a high level of support, which leverages related activities of the Presidency.
  - Coordinate with The Netherlands on its Presidency following Luxembourg. There was considerable attention in the study Steering Committee to the potential of co-operating with organisations like Circle Economy to align with The Netherlands on CE aspects of its EU Presidency, which follows Luxembourg, and it is planned to have a meeting in Paris to explore that and other topics. The present study encourages the co-operation of the two Presidencies. As well, the present study recommends that the Ministry of the Economy and Innovation Clusters connect directly with the multi-stakeholder circular economy hub being developed around the Schiphol Airport complex by a range of business, academic and governmental organisations and described in the chapter Roadmaps.
- *CE Celebration Workshops*. Organise stakeholder workshops to celebrate and accelerate where Luxembourg is already doing the right thing the right way. Diverse businesses including automotive robotics, flooring, steel, aluminum, glass, equipment rentals, and retailing are already doing circularity but not calling it by that name. The purpose of the workshops is to celebrate those achievements and explore how to scale them up and

transfer them to other businesses. The workshops might also provide tools to local managers to convince their 'absent decision-makers' that something significant is happening in Luxembourg. Might be done in parallel with or as part of other CE event being planned for the circular economy in 2015.

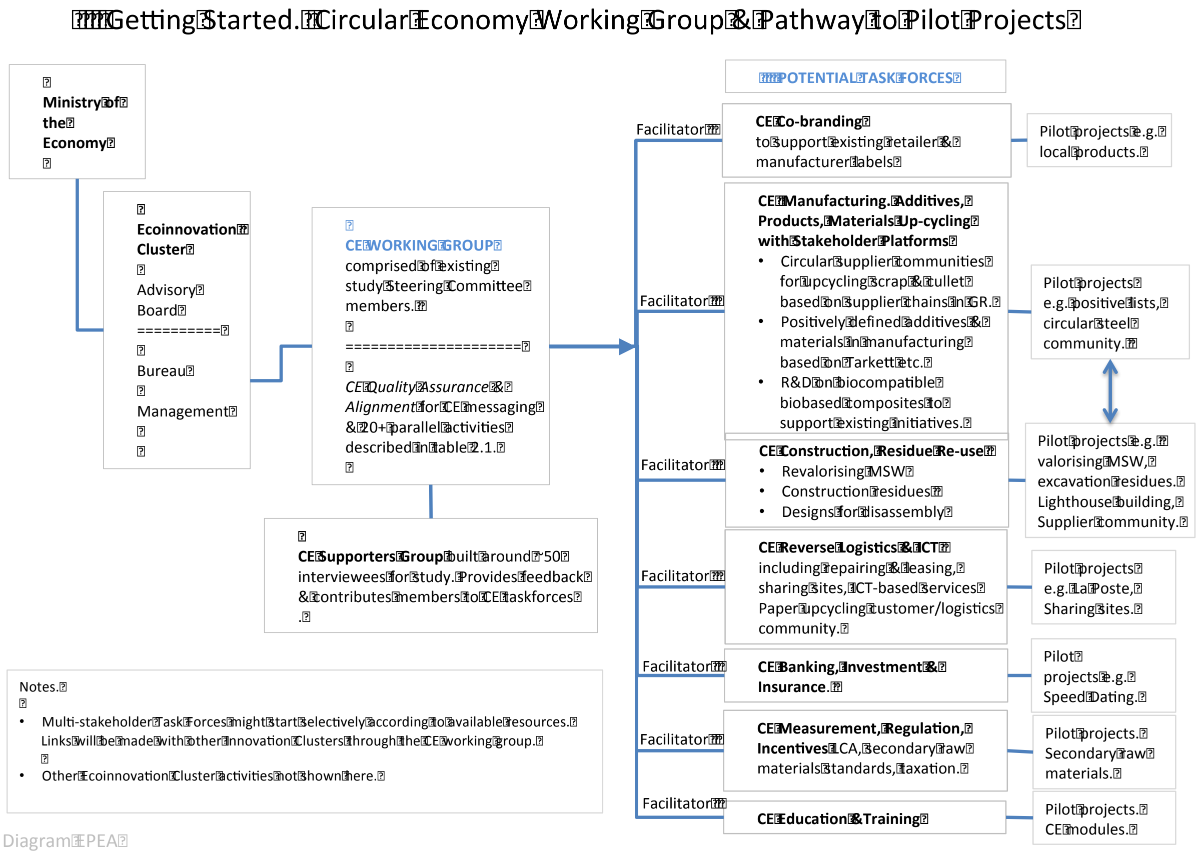


Figure 14.3: Organogram for Circular Economy working group. (Lines indicate communication rather than authority). Diagram EPEA

Potential CE Initiating Actions to Align with Existing Activities

December 2014 - March 2015
Working group created from the present study steering committee to;

- Analyse the study in-depth & get feedback from steering committee members.
- Organise consultation with 45+ study interviewees to get feedback and recruit implementers & initiators to be on stakeholder task forces.
- Do stakeholder goal-setting & find capable coordinators for quick-win pilot projects.
- Identify CE leadership group candidates to catalyze government & business.
- Start organising a practical stakeholder workshop to celebrate & accelerate where Luxembourg is already doing the right thing the right way.
- Identify upcoming events & what to announce where & when e.g.
  Participate in and integrate February finance symposium results.
- Generate a compelling narrative based on stakeholder selection of priorities.

Figure 14.4: Potential CE initiating actions to align with existing actibities.

14.5.2. Quick Win #2. A 'Grown in Luxembourg' quality co-brand as pilot for national circularity co-brand

Connected to Objective;

National quality co-brand for circularity-inspired products by leveraging existing Luxembourg labels.

Why?

- At the December 12, 2014 Cluster Forum, the majority of Cluster managers or presidents emphasized the importance of branding.
- In its draft report (p. 64-65), the Luxembourg High Commission for Industry recommends actions to improve the perception of Luxembourg industry by launching a promotional campaign. The recommendation fits well with the following quick win as well as other quick wins for establishing a circularity quality label for Luxembourg.
- Luxembourg agricultural producers, manufacturers and retailers face a challenge; while the country produces high quality goods the reputation is overshadowed by Luxembourg's reputation as a financial centre. As a result, Luxembourg businesses have difficulty compensating for high labour and other costs with a quality label, which lets them justify a marginally higher selling price, or encourage consumers to buy locally production.

What?

- Luxembourg businesses already have some of their own quality labels and there are also various 'green labels'. However presently there is no 'circularity' marketing co-label anywhere on the European scene although the situation will not persist for long as more countries join the CE.
- Companies like The Pall Center, Cactus and Oikopolis each have versions of 'buy local' branding, and report it improves sales with local as well as visiting shoppers from the Greater Region. In this way the co-label also might let Luxembourg leverage its relationship with the Greater Region, which is one of the terms of reference of the study.

How?

- It might be possible for Luxembourg businesses to align those labels into a national quality label based on circularity. For food retailers the 'circularity' aspect might be a quick win because products grown locally, sold locally and consumed locally are usually more circular than products imported from long distances. It might be possible to establish a circularity label with relatively low barrier to entry e.g. without an extensive certification process.

- **Quick win steps.** Convene a retailer-led workshop of agricultural producers and food retailers who express motivation to co-develop such a label, describe the parameters and set a roadmap for investigation and implementation.

14.5.3. Quick Win #3. Circularity Training Space (CTS) to accelerate competencies

> Connected to Objective;
>
> Luxembourg with the Greater Region will be Europe's leading education & training hub for creating new jobs and improving competitiveness using circularity skills and technologies.

Why?

- The High Commission on Industry recommends developing new and existing technological competencies for high added value.
- Metiers make up by far the largest employment segment in Luxembourg, and the question is; are they ready for circularity? The following factors make a compelling case for upgrading existing competencies & facilities or creating new facilities and competencies through hands-on training centers for circularity;
- A broadly acknowledged barrier to circularity is a deficit of skillsets relating to designs for rapid assembly and disassembly, materials integration, improved repair, leveraging existing remanufacturing capacities, and reverse logistics.
- A few European showrooms feature products designed for circularity (Source C2C Expolab & Cefur Showroom), but there is no space in those showrooms to demonstrate what the products are designed for; disassembly and re-assembly.
- The study received feedback (Source interview with Jeannot Schroeder) that to be successful, hands-on training has to use a mix of off-site training with in-house experience tailored to individual companies, instead of only requiring trainees to attend outside courses. The careful mix is central to success for circularity.

- Job creation and skill availability go hand-in-hand. If Luxembourg wants to attract jobs especially for the trades and lower skilled workers, then the skills have to be there for the jobs to be filled. Experience in Luxembourg shows clearly that training of immigrant workers leads to new jobs (Source interview with Tom Wirion).
- Studies show that knowledge retention improves by a factor of 2 or 3 with hands-on training compared to classroom lectures. See Figure 14.5. Yet in Europe there are still only a few hands-on circularity-training centers to take advantage of hundreds of innovative products already in the marketplace, and those are mostly for students.

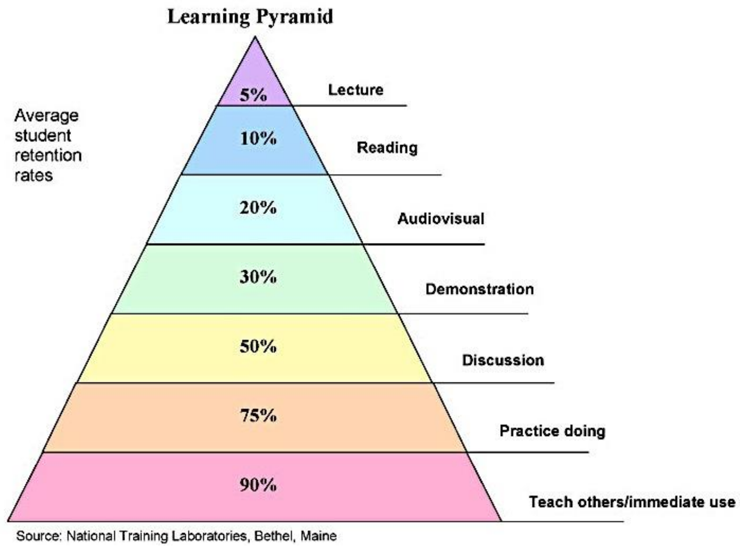


Figure 14.5: Learning retention rates from different teaching modalities. Source Natl. Training Laboratories

What?

- Institutions like The University of Luxembourg but also technical training institutes might jump to the front of circularity training by establishing a hands-on Training Space where trainees can physically assemble and disassemble Circular-Inspired products and materials, and see how quality leads to savings and profitable innovations.

How?

- The Center might partner with Circularity Showrooms in e.g. Sweden and The Netherlands, also in partnership with materials platforms like Materials Connexxion who have an online segment and showroom sections dedicated to circular materials.
- The components of a Training Space already exist, they only have to be integrated in one place. It is a potential quick win for Luxembourg and might also be integrated with a product test-marketing platform described later in the study.
- A range of companies and institutes in Luxembourg already have training facilities for the Metiers as well as for high-tech experts. Among them are the LuxFutureLab, the Learning Factory Capability Center, as well as international programmes like BEST and LILA. The CRPs each have variations on technical training facilities, and new ones are underway.
- **Quick win steps.** Convene a workshop of representatives of existing training facilities in Luxembourg to describe the Circularity Training Space concept.

14.5.4. Quick win #4. Start reducing excavation and construction waste by re-using it

Connected to Objective;

National materials management plan for circularity in construction & building management.

Why?

Excavation and construction waste are the largest waste fractions generated in Luxembourg and excavation waste is a political headache due to lack of space, and NIMBY movement among municipalities opposed to truck traffic, and landslides creates by poor management practices as well as unstable soils.

The question is; are there innovative solutions, which might transform excavation waste from a cost into an added value? Lessons can be taken from e.g. The Netherlands where waste dumps are transformed into recreational facilities. Those facilities are more problematic than excavation waste because waste dumps have higher levels of contaminants and off-gassing.

What?

The study received anecdotal reports that excavation waste is already being used for some landscaping and there is a potential for those activities to be greatly expanded. For example, does it makes sense to raise the level of large areas of vacant land by 1 – 2 meters after removing the fertile topsoil for re-use, making those areas available for use, instead of piling up waste in areas which become unusable? The approach of extensive shallow terraforming might solve unstable soils in Luxembourg, but might contravene local regulations.

Another potential is to investigate the feasibility of using excavation waste to build new vertical recreation facilities like e.g. motocross facilities. Presently there is a problem across Europe where motocross incursion into natural areas causes noise pollution. A dedicated facility build with excavation waste might solve the problem.

The other potential quick win for construction waste is to identify 2 – 3 pilot projects for piloting best practices on designs for disassembly and assembly as well as on-site packaging and waste sorting and procurement methods. For example the City of Ronneby Sweden pioneered a high level procurement criteria for disassembling old buildings, which resulted in added revenues to the municipality resulted from a high rate of materials re-use.

How and who?

- Excavation waste is subject to local and national regulations. In order to identify innovative uses, a first step is to investigate if there are regulatory barriers to those uses. For example, it is reported by MDDI that an earlier proposal for a website on excavation residue re-use did not yet get off the ground due to concerns over trans-border regulations on waste trade.
- Inventory the existing and potential uses to see if those might be expanded.
- Establish an electronic Excavation Resources Marketplace in the same model as e.g. FLOOW2 where those who generate the waste and those who might use it have a real-time mechanism for matching each other's requirements. The cost of setting up such a marketplace is minimal.

14.5.5. Quick Win #5. Start an LCA task force for circularity

Connected to Objective;

Luxembourg is recognised as an authority for quality assurance and measurement of present and potential value of circular materials.

Why?

- LCA is broadly used but requires 'upcycling' to be more practical for circularity. Companies interviewed for the study expressed readiness to participate in a workshop to explore the applicability of LCA for Circularity, especially how to quantify positive impacts and multiple re-use of materials.

- Adapting LCA is central to the CE because measurement of positive and negative impacts is a tool for determining which direction companies and governments take for new development.

What?

- Identify the leading LCA circularity challenges through a Task Force of participating companies and academic institutions to solve them.
- Establish Luxembourg & the Greater Region as leaders in the LCA circularity field.
- Among the main questions are;
  - Re-defining the scoping phase of LCA to include the two circularity cycles.
  - Defining "objective" measurement parameters e.g. 'recycled content' vs. 'defined content'.
  - Measuring positive impacts.

How and who?

- Establish an LCA Task Force for Circularity. Luxembourg research institutions and company R&D centres are leaders in Life Cycle Assessment so might also be leaders in adapting LCA for circularity.
- *Quick win steps*; Establish an LCA Task Force for Circularity with CRPs, Goodyear, Tarkett, ArcelorMittal and other Greater Region players.

14.5.6. Quick Win #6. Reverse logistics with La Poste

Connected to Objective;

Luxembourg will be a European reverse logistics hub, leveraging its existing assets to provide new services

Why?

- Luxembourg city logistics companies like La Poste have significant spare capacity on return trips.
- Waste collectors cannot cost-effectively service more remote areas but La Poste already does.

What?

The reverse logistics and other circularity potential at La Poste includes;

- *Internal Services*: Establishing CE-business models for their own material intensive businesses (e.g. performance based contracts for vehicle fleet, procurement of CE-content rich services, products, improving durability re-use of equipment (e.g. pallets).
- *External Services:* Enabling CE-business model shift as core player with dominating physical transportation network, superior intelligence on business community and material flows, trust-based relationships and complete capability base to offer outsourced reverse services.

For example;

- Pick-up and delivery of new and used paper from banks and government institutions,
- Setting-up re-commerce platform for SMEs to increase re-distribution of pre-owned products, components.
- Leveraging active tracking devices to boost productivity and utility of shared products.

Immediate opportunities;

- Paper collection and re-distribution.

  They serve large senders twice a day. Morning delivery and afternoon pick-up. Therefore they have an empty trip every day to/from the large paper users and could imagine to use current fleet at incremental costs to provide the physical transport and handling required for this system to work.

- Potential for an e-re-commerce platform

  Currently no e-commerce platform active in Luxembourg to their knowledge, which is noteworthy because the largest e-commerce business Amazon, has high-profile headquarters in Luxembourg.

  SME platform could provide opportunity for others to establish re-distribution services powered by La Poste (IT-backbone, physical transportation network, fulfillment)

- Potential for company-specific pilots to show feasibility.
- Establishing closed loop operations with big brand customers to showcase ability to collect, valorize and re-distribute.
- Stop leakage of high valued WEE-waste in cooperation with Ecotrel
- Avoid leakage by orchestrating pick-up at consumers homes.
- Collaboration with e.g. Ecotrel on re-distribution of products

- Improving the percentage of waste fractions collected where existing waste management providers see it as too expensive due to low density. La Poste goes to those locations as part of its regular deliveries.

How and who?

- La Poste is already developing a pilot project. The logistics cluster might support and track its progress.

14.5.7. Quick Win #7. A new quality label for secondary raw materials starting with separation

Connected to Objective;

Upcycle scrap & cullet trading into a *Materials Banking* service.

Why?

- In order for the financial industry to make reliable investments in secondary raw materials, it requires comparable standards on content.
- European standards for secondary raw materials range from well-established with e.g. glass to chaotic with polymers. As well secondary raw materials usually come in batches rather than streams. To establish quality assurance standards consistent batch testing methods are required.
- The low-hanging fruit to improve quality is separation, which is cost-effective and according to anecdotal reports improves the capacity of waste handlers to service economic downturns, as well as improving margins for producers.

What?

- Standardize batch testing regimes for diverse secondary raw materials streams.
- Inventory the range of quality assurance regimes and best practices for each type of secondary raw materials including scrap metal, industrial glass, polymers, paper.
- Develop pilot programmes with municipalities and other agencies who presently lack real-time methods for valorizing waste streams.
- Involve the investment community in the standards so it understands and support them.

How?

- For primary industrial streams like steel, aluminium and specialty glass, study and optimise the grading and separation of scrap as well as matching scrap quality with intended output quality.
- For example, ArcelorMittal uses a steel pile take-back, renting and resale business to generate millions of euros and is the largest model of circularity for a company in Luxembourg. According to ArcelorMittal a marginal improvement in matching scrap grades with intended grade of recycled steel might lead to up to a 5% improvement in net revenues, which in a low-margin industry is the difference between profit and loss.
  - Evaluate the potential to establish a supplier community among scrap dealers who supply the steel industry, to improve matching of scrap quality with intended use of the steel.
  - Study how the model might be applied to other companies' metals and products, and how the financial community might leverage it. Luxembourg Materials Cluster with EcoInnovation Cluster and investment funds representatives.
  - Calculate how the programme might be adapted for steel & other metal banking over extended periods. Involve the Luxembourg financial community with 10-20 year investment horizons.
  - Explore benefits of optimising the protective coatings on steel piles for compatibility with the Biosphere or Technosphere. *Primary responsible* ArcelorMittal with a qualified independent scientific institute.
- SDK and other recyclers are working on systems for improving separation and recycling of traditional waste streams.
- One group has already put in place a valorization protocol with municipalities in The Netherlands, which is useable as a platform for quality assurance of secondary raw materials. The opportunity is for Luxembourg to be the first outside Netherlands to take advantage of this new mechanism. The company FBBasic with partner Kunststof Hergebruik developed a tool and entered into agreements with municipalities to implement it. The tool represents a potential for Luxemburg to leap over other countries to a frontrunner position and avoid the trial-and-error being experienced by other less experienced organizations. FBBasic and its partners are run by experts with more than 20 years experience in the waste management and other industries.
- A few European paper recycling companies have high quality input and output protocols which might be adopted for Luxembourg. Ecoparc Windhof and CRP Henri Tudor have already studied those.

- Various patented technologies for cleaning used plastics and recycling them to food grade quality might be licensed in Luxembourg.
- The potential is to establish 2 - 3 projects to pilot improved methods.

14.6. Potential Mid-Term Circularity Wins

Table 14.4: Potential mid-term circularity wins & related actions - who does what

SECTORIAL & CROSS-SECTORIAL FOCUS	ACTIONS & ORGANISATIONS
	PRODUCTS & SERVICES
Steel Banking Cross-sectorial links to infrastructure projects, financial industry modelling.	**Why, What, How** ArcelorMittal uses a steel pile take-back, renting and resale business to generate millions of euros and is probably the largest scale model of circularity for a company in Luxembourg. • Calculate how the programme might be adapted for steel & other metal banking over extended periods. Involve the Luxembourg financial community with 10-20 year investment horizons. • Study if LCA accurately reflects the benefits of steel leasing. Tudor and ArcelorMittal, possibly with other companies who face similar challenges with LCA. Explore information sharing with ArcelorMittal to solve potential confidentiality barriers.
Materials for Circularity Cross-sectorial links to materials quality improvement	**Why** Tarkett in Luxembourg as well as its new subsidiary Desso are leading the circular materials innovation wave for flooring materials. The flooring industry is competing heavily for circularity claims, and companies like Shaw and Interface are leading examples. **What** Celebrate, Accelerate & Scale up positively defined materials and additives for flooring and transfer the know-how to other industrial sectors to speed scale-up. **How** Education & training. Tarkett launched a European initiative developed at its Luxembourg R&D facility for designing billions of euros worth of materials for circularity, including additives, adhesives, parquet, linoleum & PVC. Organise cross-sectorial workshops to explore; • How Tarkett re-designed materials and ingredients might be used across other industries. • Potential for extending the Tarkett materials development methods. • Potential for national takeback scheme in Luxembourg for flooring as a model for Europe. [*Transparency statement:* EPEA is working with Tarkett & Desso.]

SECTORIAL & CROSS-SECTORIAL FOCUS	ACTIONS & ORGANISATIONS
Circular Automotive Leasing *(requires further interviews to validate)* Cross sectorial links to equipment leasing.	**Why, What, How** At least 2 types of automotive leasing occur or are financed in Luxembourg, and Luxembourg has a high rate of automotive leasing compared to other countries due to its services sector, covering up to €1.5 billion in vehicle assets plus a substantial connected maintenance business. As well Luxembourg city is investing in a new vehicle sharing mechanism. However it is still an open question if those models extend to take-back and recycling of vehicles or parts. An institution like one of the CRPs or the University of Luxembourg might analyse how those leasing models could be extended to circularity for materials, and especially how the automotive cluster in Luxembourg might participate to establish reverse logistics for parts. A special focus might be remanufactured components used extensively already in heavy vehicles and machinery and support circularity. Another potential focus is extending leasing to electric vehicles to solve some of Luxembourg's negative CO_2 balance due to tank tourism.
Recycle Phosphate Refer to agriculture section under Sectorial Snapshots	**Why, What, How** European agriculture depends on imported phosphate fertiliser from outside Europe. Those imports are billions of euros annually and are a food security risk because only a few countries produce phosphate and some like China put export controls on phosphate fertiliser, which led the EU to designate phosphate as a *strategic material* in 2014. At the same time Luxembourg is fertilising waterways downstream with phosphate in its wastewater. As well, some phosphate fertilisers used on farms leach quickly into waterways. Luxembourg is under pressure from the EU to improve water quality overall. Because of this actions in the water field are being favourably received. The good news is there are technologies in the marketplace for extracting valuable phosphate from wastewater, using it as a high quality fertiliser, and saving energy for wastewater processing. Do a feasibility analysis of the cost/benefit of adapting those systems for wastewater systems in Luxembourg. It is possible some is being done already. In that case investigate scaling up across Luxembourg. Luxembourg is focusing on increasing trade & services with BRIC and other economies outside Europe. For example in July EPEA & CRP Tudor met with the heads of Tunisia's phosphate industry; they are trying to fix their mining & processing environmental problems. Lux has a historic aid relationship with Tunisia, which broke a few years ago but is being re-started.

SECTORIAL & CROSS-SECTORIAL FOCUS	ACTIONS & ORGANISATIONS
	RESEARCH & DEVELOPMENT
Improve Energy Storage with Materials	**Why, What, How** The Ministry of the Economy aims to improve energy efficiency in buildings by improving the efficiency and safety of insulation. New phase change and other energy storage materials are entering the marketplace, sometimes developed by Luxembourg based R&D facilities. The potential is to pilot those materials especially for retrofitting existing buildings. There is already a programme underway to do this, but the added feature of designing insulators for circularity might be considered.
Robotics for Disassembly	**Why, What, How** Disassembly costs are a main challenge for improving the residual value of materials. Disassembly by robots working with humans is becoming feasible due to a new generation of robots, which interact safely with humans in the workplace and are taught by humans how to disassemble complex products. Applied research on human-robot interaction is being done by Luxembourg researchers and might be accelerated with government support.
Improve Agricultural Soils	**Why, What, How** As described under quick wins, a new topsoil amendment technology locks carbon into the soil and improves soil quality. It is available for purchasing and possibly licensing in Luxembourg to upgrade the quality of Luxembourg's soils. As well biological residues from other processes in Luxembourg are considered contaminated for direct use in compost, but these might be remediated by the new technology, thereby converting unusable waste into a resource. A research project might be started to investigate the feasibility of converting contaminated residues to value-added soil amendment materials.

SECTORIAL & CROSS-SECTORIAL FOCUS	ACTIONS & ORGANISATIONS
Improve Agricultural Competitiveness with Greenhouses **See sectorial snapshots under agriculture for further information.**	**Why, What, How** Luxembourg faces cost competition from the Greater Region for agricultural products which traditional efficiencies are unlikely to solve in the near-term. The potential quick win of working with retailers to pioneer quality labels with local products is described in chapter 14.5.2. However, there is a mid-term potential to scale up ecological production by re-visiting the opportunities of greenhouse horticulture. The Netherlands, Belgium and China are turning high land and operating costs into advantages by using the efficiency of greenhouses, which are also excellent tools for nutrient recycling. It is perceived that greenhouses were tried in Luxembourg but did not work. However the reasons for failure seem to be external to the greenhouses themselves and might be resolvable. • The Agriculture. Ministry might re-evaluate greenhouse potential for particular agricultural sectors.
GOVERNMENT INCENTIVES & ENABLING MECHANISMS	
Education for Circularity at University of Luxembourg Refer to Education section	**Why** University of Luxembourg is new and still has great flexibility in developing its curricula, but the opportunity will not last long. **What** Introduce circularity into diverse curricula to integrate it across the academic spectrum. **How** University of Luxembourg is at a special stage of flexibility in its development where new courses might be developed to support circularity, providing a competitive advantage for Luxembourg and establishing it as an educational frontrunner for circularity. • Convene a circularity working group of the leadership and student body of University of Luxembourg with the EcoInnovation Cluster, Materials Cluster, steel industry, biomaterials researchers. As a low-cost and educational exercise ask students to perform a Circularity Potential overview of courses offered by U. of Luxembourg and report back to the working group.

SECTORIAL & CROSS-SECTORIAL FOCUS	ACTIONS & ORGANISATIONS
Procurement & Purchasing for Circularity **Reference Procurement section of finance in sectorial snapshots**	**Why** Procurement is a potentially powerful circularity accelerator but has barriers. **What** Inventory and disseminate best practices instead of starting from nothing. **How** Procurement seems a natural way to encourage circularity, but in practice a range of barriers stands in the way especially for public procurement. Central purchasing, anti-competition rules, and business-as-usual each present significant barriers. The government will overcome those barriers more quickly by providing information to procurement authorities on circularity practices already in the marketplace as described in chapter 12, and by holding workshops focused on circular procurement. Especially pre-conceptions about anti-competition rules are possible to overcome in existing regulatory frameworks. Public and private stakeholders are to be included because procurement departments in large companies have similar challenges as governments.

14.7. Let The Imagination Run Free With Lighthouses.

Throughout the present study diverse suggestions are made for actions and initiatives to accelerate and scale up circularity. Although some of those are included in the preceding quick wins and mid-term wins, others are spread throughout the text in other chapters. The segmenting is deliberate to be sectorial-specific, and to avoid over-prescribing. Ultimately stakeholders are the ones who determine what they see as feasible.

In that context, the following summary Table 14.5 is randomly ordered to provide a fresh perspective, and is provided for convenience only. It is not intended to describe priorities or preferences. Those are still to be determined by stakeholders.

Table 14.5: Potential lighthouse projects to accelerate circularity competitiveness, employment & savings

- Training. Organise a *How does it come apart?* workshop for trade association trainers.
- Education. Initiate a *Circularity Potential* review by University of Luxembourg students of academic courses with potential to integrate circularity.
- Construction & Education. Based on experience with e.g. Ecoparc Windhof and the Backsippan kindergarten in Ronneby Sweden, build a *Circularity Kindergarten* focusing on healthy light, air, surfaces materials, and nutrition
- Finance. Workshop for investors *The profitable road from power purchase agreements to materials leasing.*
- Industrial policy. Organise a workshop with authors of the National plan for smart, sustainable and inclusive growth Luxembourg 2020 and the Haut Comité pour L'industrie to explore where their recommendations support or might be aligned with circularity.
- Excavation waste. Organise a *Landslide of ideas* workshop with MDDI and local startup design firms on concepts for transforming excavation dumps into profitable recreation or landscaped sites.

- Planning & Construction. Organise a workshop *How to use circularity to improve the value of your next building project* for organisations planning new buildings in Luxembourg.
- Manufacturing. Start a *Steel Banking* pilot with the financial sector and ArcelorMittal to investigate the feasibility of extending steel pile renting into steel beam and other leasing for structures.
- Manufacturing. Start a *Supplier Community Forum* with the metals, specialty glass and plastics manufacturers and scrap dealers in the Greater Region; '*the 5% solution*' to use circularity to improve margins by 5%; the difference between profit and loss. Connect the community to a training programme for competencies for optimising re-use of secondary raw materials.
- Manufacturing & plastics. Introduce Tontarelli to food grade recyclers in the U.K. and U.S. to support the company to certify its food grade plastics.
- Manufacturing & Materials. Organize a *Materials that do good things* festival to celebrate and spread materials improvement achievements. Involve circular innovators e.g. Tarkett, Desso, KEFibertec, Vanderlande Industries.
- Celebrate Materials Science. Develop a *Luxembourg Initiative for Positive Lists* to support the EU in accelerating its move to healthy additives.. Start with a *Positively Defined Additives'*workshop for materials scientists in the Greater Region.
- Logistics. Start a *National Paper Upcycling* campaign to save businesses 5% on paper purchases and quadruple the amount of high quality recycled paper sold in Luxembourg.
- Recycling. Organise a workshop for municipalities, SDK and others on 'real-time valuing of secondary raw materials'.
- Healthcare. Introduce local hospitals and elderly care facilities to Enspire who saved 30+% for a hospital in Denmark on food costs and waste as well as improving nutrition.
- Healthcare. Investigate how Pharmafilter saves costs and prevents infection for hospitals and municipalities.

- Retailing. Pilot a *Circularity co-brand* with Pall Center, Cactus and Oikopolis to increase sales of local products by 5% in 2015. Announce a competition for kids designing the label logo.
- Nutrition & Food. Start a *Have Fun and Eat Well Saving the Food* campaign along the same lines for cafeterias.
- Agriculture. Organise a *How to manufacture healthy soil* workshop for the agriculture industry in Luxembourg.
- Economic Indicators. Organise a workshop with Statec and the investment community; *Who needs statistics for circularity?*

Add your own suggestions here!

14.8. How Much Does it Cost?

The present study was asked to provide an overview of how much circularity might cost for Luxembourg.

Throughout the study, diverse examples are provided of industries whose revenues already rely on circular-oriented activities as well as potential gains from cost savings. The study also provides estimates of potential savings and job creation from adopting circularity. For example;

The prize

The potential big win for Luxembourg is gaining a share of the €8 – 9 trillion in new value generation described in the KPMG report, *A new vision of value,* excerpted in Figure 1.1. In order to gain the prize, some investments are required.

For those, the present study focuses on potential quick wins, which might be achieved at low cost as part of existing programmes. The short-term opportunity is to consolidate and accelerate existing circular-oriented activities.

Education, training & R&D

There are some pivotal areas for Luxembourg to make investments to establish its frontrunner position. Education, Training & R&D are the priorities, and this is not surprising because many other studies in Luxembourg referenced in the Context chapter reached similar conclusions. For priorities like Education and Training, the study foresees investments to re-orient existing activities to circular-oriented skill sets.

One priority is to establish a hands-on training function where trainees are able to learn how things come apart instead of just how they are put together. Many examples exist already in the Benelux, and many capacities exist at Luxembourg based facilities like Tarkett, Tontarelli, ArcelorMittal modular construction partners, Floow2, etc.

In that context, it is more a question of replicating, adapting and implementing than making enormous new investments.

Costs… or investments & savings?

Circularity is based on value propositions; it is more investment with returns, than sustainability costs without returns.

The potential quick wins described in the present study were selected for the following economic criteria;

- Diversified to further support Luxembourg's economic diversification. The investments and benefits are shared across sectors.
- Build on existing infrastructure or activities to be cost-effective.
- Low cost or savings-oriented to start.

For example;

- The *National Circularity Initiative* might accelerate economic activities by aligning them more effectively.
- Circular paper communities generate savings for customers.
- A *National Co-brand for Circularity* provides an added value proposition to support existing labels to improve competitiveness of local products.
- A *Secondary Raw Materials Valorisation Pla*n supports municipalities to meet national and European recycling targets and to know the value of what they have.
- *Reverse logistics with La Poste* is designed to make more efficient use of existing assets.

Costs of not doing it

However, when considering those investments the question is; what are the costs of not doing it?

For Luxembourg to maintain and diversify its manufacturing base, circularity seems a necessity rather than a luxury;

- Luxembourg's leading primary industries rely on high-quality secondary raw materials for survival and competitiveness. Those industries generate billions of Euros in revenue, employ thousands of people, and diversify Luxembourg's economic base. Competition for secondary raw materials is increasing inside and outside Europe. For example, Asia is competing for the same scrap ArcelorMittal and Hydro bid for in markets.
- Luxembourg's largest trading partner Germany as well as its growing trading partner China, and America and the EU each have strategic raw materials agencies and policies which have significant impacts on Luxembourg-based industries.
- The earlier-referenced KMPG report *A New Vision of Value* makes it clear that externalities are quickly being internalised in companies. European regulations are forcing industries to improve producer responsibility,

reverse logistics and recycling quality. Luxembourg's logistics and manufacturing industries are affected by those developments. Those who hope someone else will continue picking up the environmental bill are likely to encounter cost surprises. However those who use circularity to save costs are likely to be more competitive.

- The competition is already underway. Substantial investments are already being made in circularity, but might not be officially characterized as 'circular'. Examples include CO_2 re-use and using materials for solar energy storage. Luxembourg's financial industry is beginning to participate in those activities. The ultimate prize according to estimates described in the present study is USD 8 – 10 trillion in new economic activity.

Where will Luxembourg be in the competitive environment?

The imagination and innovation of Luxembourgers will be the determining factor.

ANNEXES

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Annex B Products certified for circularity cycles & available in or near Luxembourg, Systems connected to products certified for circularity cycles
Annex C Bibliography of bibliographies
Annex D Examples of illustrations of the circular economy
Annex E Brief description of Cradle to Cradle
Annex F Circularity principles for new legislation
Annex G Barriers to circularity identified by other studies & S.W.O.T. methodology
Annex H Academic courses & initiatives in the Greater Region relevant for circularity
Annex I Results from EcoInnovation/KPMG finance workshop October 2014
Annex J Priority interviewees for the study
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