# NEXUS FUTURES Expert Working Paper 2

# 3 Scenarios for the differentiation of the Circular Economy in Luxembourg in 2045

Paul Schosseler, +IMPAKT, 16 February 2020

## Introduction

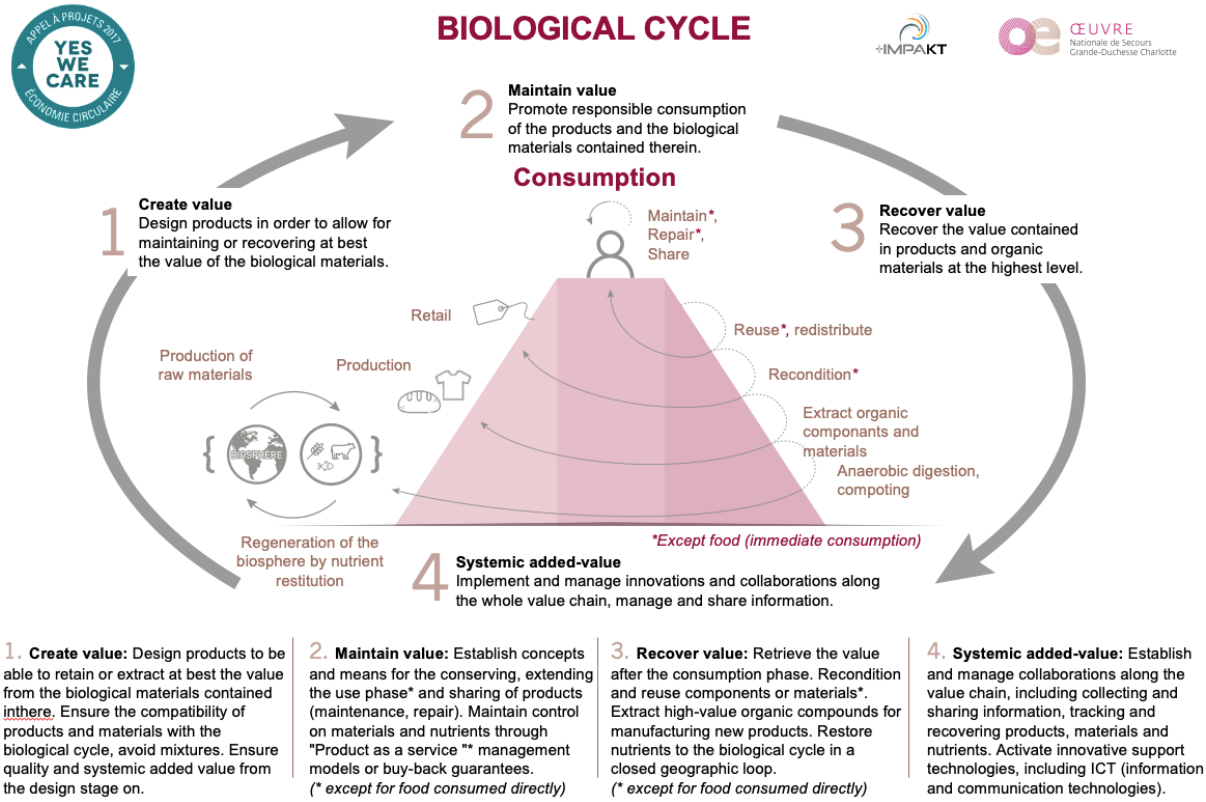
The following contribution addresses the topic of Circular Economy (CE) and more specifically how the various principles of the CE are transposed in the three scenarios. For this analysis it is important to understand that there is no single definition of CE. The principles are derived from various schools of thought), such as Cradle to Cradle, the Blue Economy, the Performance Economy or Biomimicry, with a focus on environmental and economic requirements for a more sustainable management of material and energy flows and stocks (Ellen MacArthur Foundation, 2013; Ghisellini et al., 2016; Blomsma and Brennen, 2017; Kirchherr et al., 2017, Wautelet, 2018). It is, however, increasingly recognized that socio-political implications of a CE need to be addressed as well, in order to achieve a profound transformation of today's take-make-consume-waste mentality (Murray et al., 2017; Schulz et al., 2019).

For the present purpose, we define the CE as a holistic approach towards the production and exchange of goods and services, taking into account the limited availability of (most) resources on our planet and respecting the regenerative capacities of the biosphere. Although aspects of human health are considered as well in most definitions, the CE is not the recipe for human well-being or just society. The CE should be merely considered as a powerful tool for achieving sustainable development goals in a longer term, as it embraces a systemic approach towards the management of material stocks d flows with positive environmental and social impacts, if implemented correctly. For these reasons the CE is, meanwhile, the basis for many governments around the world, including Luxembourg, as well as the European Commission for shaping economic and environmental policies and strategic roadmaps for a sustainable resource management (Hansen et al., 2014; European Commission, 2015). It is expected that the CE could provide a greater resilience facing a shortage of raw materials in key industrial sectors, contribute to the creation of local jobs for less skilled workers and reduce environmental pollution. It is, thus, also logical that the CE has been retained as one of the guiding principles for developing the NEXUS scenarios. The implementation in the different scenarios is governed, however, by the underlying socio-political value systems.

From the definition above becomes clear that the technical, managerial and financial models of the CE can basically impact all sorts of goods and services, from buildings to mobility, tools, clothing, electronics, food, leisure etc. The NEXUS project focuses on water and land in Luxembourg and we limit our analysis, therefore, to goods and services as well as activities with a strong local impact on water and land. These include land use and water services for dwelling, key economic activities such as industrial production, ICT infrastructures and services, agriculture for food and material production (e.g. crops, vegetables but also wood) and human recreation (including tourism). From the perspective of the CE, water and land are strongly interconnected through the biological cycle, where nature provides ecosystem services such as biomass production, recovery of nutrients, cleaning of water and air. Nature provides, however, also inspiration and recreation to us humans. Water is a key chemical component, as it is at the basis of all forms of life on earth, allowing for myriads of bacteria, fungi and

higher living organisms to make the soil fertile. It enables the biological cycle by serving as solute in biological systems, including the transport of nutrients through our body.

The value hill in Figure 1, a concept introduced by the Dutch think tank Circle Economy (Achterberg et al., 2016), illustrates how value should be created, maintained and recovered in the biological cycle (steps 1, 2 and 3). Products of the biological cycle are either consumed (e.g. food) or used for technical purposes, such as cotton for clothes or wood in construction. An essential condition for using biological materials for technical purposes is the (harm free) restitution of the contained nutrients to the biosphere at the end of the use cycle. The use cycle itself can, however, comprise several cascades (e.g. cellulose fibers used in recycled paper). It should also be noted that the CE relies strongly on collaborations of stakeholders along the whole value chain of a product or material in order to create systemic benefits (step 4). Information and Communication Technologies (ICT) are thus important enablers for gathering and monitoring quantitative and qualitative data on material flows and stocks. The availability of this information is crucial for managing stocks and closing loops, both in the technical and biological cycles.




1. **Create value:** Design products to be able to retain or extract at best the value from the biological materials contained inthere. Ensure the compatibility of products and materials with the biological cycle, avoid mixtures. Ensure quality and systemic added value from the design stage on.

2. **Maintain value:** Establish concepts and means for the conserving, extending the use phase* and sharing of products (maintenance, repair). Maintain control on materials and nutrients through "Product as a service "* management models or buy-back guarantees.
*(* except for food consumed directly)*

3. **Recover value:** Retrieve the value after the consumption phase. Recondition and reuse components or materials*. Extract high-value organic compounds for manufacturing new products. Restore nutrients to the biological cycle in a closed geographic loop.
*(* except for food consumed directly)*

4. **Systemic added-value:** Establish and manage collaborations along the value chain, including collecting and sharing information, tracking and recovering products, materials and nutrients. Activate innovative support technologies, including ICT (information and communication technologies).

*Figure 1: The value hill in the biological cycle, adapted from "Circular Economy" for the purpose of the "Yes We Care II" funding programme by the Oeuvre Grand-Duchesse Charlotte.*

During centuries of human development our economy was aligned with these principles. The delineation started to take place with the consequent industrial revolutions and the combined development of energy, transportation and information technologies, allowing for a decoupling of the economic development from natural boundaries (Rifkin, 2011) and resulting in massive overexploitation and destruction of natural stocks and resources. Although mankind has recognized that current economic practices might ultimately threaten all life on earth, the realignment of our societal consumption patterns with the principles of a CE has hardly started and our economy still functions in an overwhelmingly linear way. Profound disruptions or crisis as described in the three NEXUS scenarios might, therefore, be plausible triggers for society to adopt more circular economic models.

## Common drivers for change and impact on water and land

Three main drivers have been identified in the NEXUS projects to explain changes of society and economy over the next 25 years. These drivers are common to all three scenarios, with the following consequences on water and land:

- **Climate change impacts (in Luxembourg):** the natural water cycles are impacted through less regular precipitation patterns leading to a lower retention and thus decreasing stocks of water, both in the Upper Sûre river dam as well as in the groundwater reservoirs. This shortage can further be enhanced due to overall less annual precipitation, depending on the climate scenario. Higher temperatures and increased evapotranspiration due to longer vegetation periods dry out the topsoil, with negative impacts on agricultural yields and probably loss of agricultural land. In all three scenarios a more rational use of water and land is thus vital. Natural ecosystems, are, however, also affected by these changes with heavily damaged forests, loss of biodiversity and invading species from warmer regions.
- **Technological innovation:** overall the CE benefits from the fast innovation in ICT, data management, supercomputing, artificial intelligence, robotics, etc. as these technologies allow for a better monitoring, modelling, and management of material stocks and flows, boosting more efficient production and distribution patterns, including reverse logistics. The innovation favors new business models, such as “product as a service” and contributes to a better understanding of technical and biological systems in a holistic way (Bocken et al., 2016, Lewandowski, 2016, Nußholz, 2017). This applies, of course, also to the water system as well as agricultural land or forests.
- **Dwindling public finances:** This driver asks for reconsidering the distribution of (economic) value over the whole value chain. Overall the CE could help save money in public procurement through less resource and capital intense circular business models. Sharing models can benefit twofold from a reduced purchasing power of public and private consumers. First, sharing of high value goods becomes more attractive as people might favor access over ownership. Second, land is very valuable resource in Luxembourg and financial shortages might lead to denser construction forms, which also make sharing easier in terms of reduced distances between users and more acceptable, as space is missing for storing excessive personal goods.

An additional important aspect, which plays out, however, somewhat differently in the three scenarios is the coming into decision power of the generation Z. This generation is expected to be well informed about the pressure on national resources, having experienced immediately the consequences of climate change, and is very receptive to new technologies, especially to ICT. The young people have grown up in a world where access to goods and services primes over ownership, enabled by ICT, and sharing is natural to them. They are, *in fine*, the key drivers for implementing the circular economy in its various forms, however, with different purposes reflecting the overall societal values and geopolitical circumstances.

## Differentiation of the scenarios for coping with water and land

The three scenarios provide different answers in coping with societal, environmental and technological disruptions. Table 1 compares the consequences of these different answers for the biological cycle from a CE perspective and more specifically for the management of stocks and flows of water, the production of biobased materials and food and land use. An overall assessment of the scenarios with respect to CE principles is provided as well.

| | Smart Sustainability | Common good | Web of life |
|---|---|---|---|
| *Water cycle* | - ICT driven control and monitoring of stocks and flows.<br>- Water cycles are closed, using smart technologies.<br>- Negative rebound effects from economic and demographic growth on natural water bodies (pollution, overconsumption) are observed. | - Production and consumption of water is managed in a holistic way at river basin level, respecting the natural cycles.<br>- Different technical and managerial solutions are implemented, depending on the specificity of the region (also for energy), e.g. black water collection is combined with energy production (biogas) in denser populated areas. | - Natural water bodies have been restored and are strongly protected. Abstraction is limited to a strict minimum.<br>- Water and related nutrient flows and stocks are managed in a holistic way, inspired by nature.<br>- Water use for technological purposes is expensive and organised in closed loops, with a strong water-energy system integration. |
| *Land use* | - Sprawling and uncoordinated urbanisation and industrialisation, affecting the integrity of ecosystems.<br>- Strong decline of forests and other natural areas, increasing pressure on natural water cycle.<br>- Continued decline in biodiversity and quality of ecosystem services. | - As for the water cycle, spatial planning is organised at regional level, and regional urban centres have emerged.<br>- Local nature and ecosystem services are highly valued and protected, e.g. for groundwater protection.<br>- Land use for food production has a high priority, soil-water-plant interactions are monitored and managed. | - Stringent spatial planning has restored large areas of pristine nature and led to a highly densified urban corridor.<br>- Land belongs mainly to the central State and land use is strictly regulated and controlled. |
| *Food & Bio-based materials (Agriculture)* | - Precision farming, indoor farming, smart hydro- and aquaponic systems compensate for some loss of agricultural land.<br>- Wood production is very low due to damaged forests, fibre production as well due to the loss of agricultural land.<br>- Luxembourg depends strongly on imports for nature-based resources. | - Food production is organised at a regional level and sensitive to the limited irrigation capacity.<br>- Some high-tech farming is deployed, depending on the region (e.g. poor soils in the North need fertilisers).<br>- Some production of natural non-food materials but competition with food production. | - Food production for local needs relies on permaculture and urban gardening, based on natural principles and healthy soils.<br>- Diets are mainly vegetarian or vegan, insect and algae farming provide for proteins.<br>- Wood and natural fibre production is low, due to the preservation of natural habitats. |
| *Overall CE evaluation* | - The biological cycle is not valued, technology is supposed to solve environmental problems and substitute ecosystem services for food and material production.<br>- Technological CE models prevail ("product as a service", performance economy).<br>- Anthropocentric understanding: Nature is at the service of mankind. | - The biological cycle is valued, and loops are intended to be closed at regional level, including nutrient cycles.<br>- The importance of water for the biological cycle is recognised.<br>- From a CE perspective, sharing and learning from nature are the dominant features (e.g. C2C, blue economy).<br>- Patho/biocentric understanding: Nature has" rights". | - Natural values are strongly recognised and the interference with the natural cycle minimised.<br>- In this sense the biological cycle (for provision of food and materials) is also strictly controlled, with a strong focus on water, soil and nutrients.<br>- Learning from nature drives the CE (e.g. C2C, biomimicry).<br>- Holistic understanding: Human being is part of nature. |

*Table 1: Comparison of stock and flow management in the biological cycle for the three scenarios.*

Table 2 illustrates the consequences for other key economic sectors and some key impacts for society as a whole, with a focus on the production and exchange of goods and related services.

| | Smart Sustainability | Common good | Web of life |
|---|---|---|---|
| *Industry* | - Industry 4.0, large corporations, smart technologies and production processes (involving AI, 3D printing, etc.), strong digital economy with data centres etc.<br>- Industries are integrated in worldwide economy, depend on imported raw materials, in addition to efficiently recycled secondary raw materials. | - Production of more simple goods is organised locally in cooperatives, with the support of innovative technologies, such as AI, robots or 3D printing.<br>- Larger industries are accepted only if there is a small impact on available resources (e.g. water, land use). | - Production is organised along the central corridor, with minimal ecological impacts, but limited resource availability.<br>- Hi-tech goods are mainly imported, otherwise economic focus on repair, maintenance and refurbishing. |
| *Construction* | - The construction sector is thriving, thanks to continued growth, focus on smart homes and residential areas.<br>- Mostly technical construction materials (concrete, steel, glass). | - Construction activity relies on local companies, with the risk of inefficient, regional monopoles and poor qualifications.<br>- Some use of local construction materials, leading to regional architectural styles. | - Natural construction materials are rare, the sector focusses on the recovery of materials from demolition, but risk of historical contamination.<br>- New buildings are designed in a circular way, allowing for adaptation and non-destructive deconstruction. |
| *Logistics* | - Worldwide logistics, reverse logistics, highly automated delivery and recovery chains.<br>- Luxembourg has specific know-how on managing complex circular designs. | - Regional logistics prime over international logistics.<br>- Access locally mainly to goods of lower quality or thus very expensive (imports). | - Local to regional logistics, organised along the corridor.<br>- Overall much less international exchange, due to high fuel prices. |
| *Service industry (focus on finance and insurances)* | - Luxembourg has maintained a leading position in service industry, with a shift from financial services to IT and data driven regulatory, auditing and monitoring services of resource stocks and flows (including finances). | - The finance industry is green, promoting responsible investments and exporting new business models with sustainable bonds.<br>- Local cryptocurrencies allow for valuing local services and goods, exchanged trough cooperatives. | - The finance industry is strongly regulated and oriented towards creating and preserving natural capital.<br>- The economic power of IT companies providing data services is confined by public authorities. |
| *Tourism* | - Nature highlights and attractions have been eroded, tourism is mostly limited to business trips and historical sightseeing, including a refined gastronomy for an upper class. | - Tourism is differentiated geographically and plays and important economic role, especially in rural areas with a focus on well-being and recreation in a natural heritage. | - Luxembourg is a laboratory for subsistence farming and permaculture with international visibility and attractivity.<br>- Responsible ecotourism provides an offer for a healthy and meaningful lifestyle in a pristine environment. |
| *Overall resource use* | - Smart design, but nevertheless important rebound effects worldwide.<br>- Highly efficient and automated processes for recovering components and materials, cheap energy allows for controlling entropy. | - Development limited by availability of resources.<br>- Repair and refurbishment of goods, local jobs prolong use cycles. | - Technological resources are made available through intense urban mining, e.g. in the construction sector. |
| *Society* | - Identity is linked to the Greater Region, Europe or World, but social injustice within and between regions is important.<br>- Sharing of good and services through electronic platforms, but highly individual and anonymous.<br>- Overall, the economy governs daily life. | - Identity is strongly linked to regions; diversity is favoured and respected.<br>- Spatial and cross-sectoral collaboration between regions is considered as useful but hampered by regional competition.<br>- Smartly designed goods with low material intensity are valued and shared. | - Contingency of infrastructure allows for sharing equipment and an efficient public transport.<br>- Key social and economic interactions are controlled by the central state.<br>- A universal basic income increases the availability of labour for the tenure of land and nature. |

| | Smart Sustainability | Common good | Web of life |
|---|---|---|---|
| | | - People put well-being, social resilience and leisure over economic and material wealth, but overall national social safety nets are weaker. | |

*Table 2: Key impacts from the implementation of CE principles for the three scenarios.*

## Conclusions

In all three scenarios the management of stocks and flows will be organized in the future according to key principles of the CE, although the implementation plays out differently, based on prevailing societal values and diverging economic frameworks. The assumption that the CE can provide solutions to cope with key drivers for socio-economic change, namely the consequences of climate change and the resulting scarcity of the natural resources water, agricultural soil and forests, is plausible in all three scenarios. The challenges ahead for getting the CE to work are important and touch a broad range of topics:

- Intergenerational conflicts and social unrest will most probably arise as the patterns for resource and land use are shifting, especially in the second and third scenarios. Innovative regulation and taxation schemes will be important to frame these disruptive changes and the younger generations need to be prepared for creating, transposing and operating these schemes. Schools need to deliver the necessary knowledge and skills, for tackling the future in an optimistic way.
- ICT is a key driver in all scenarios, especially for the implementation of the CE, and important questions linked to the management and ownership of personal and professional data need to be solved. Digital literacy and awareness have to be promoted at all levels so that society as a whole can benefit from the technological advances.
- The implementation of CE principles asks for a holistic and multi-criteria policy and decision making, both at public (state, commune) and private (company, association) level. Participatory processes and stakeholder involvement can provide valuable answers to complex problems. Finding consensus on potential solutions is time consuming but facilitates at a later stage the implementation of the solutions. Co-creation processes and other methodological approaches are not easily adopted in a linear economy and have to be learned, trained and judiciously deployed.
- As much as the adoption of CE principles in daily life depends on the appropriate societal values, the transposition in industry and the broader economy asks for a favorable entrepreneurial spirit and mindset. Companies will be important drivers for positive change, if the socio-economic and regulatory framework allows for innovative business models. The financial sector will be a key player in providing incentives and support for these business models, at regional, national and international level. Especially for the second and third scenarios it is not clear, however, in how far the local economy can connect to international markets, especially for the provision of high-tech products and non-local resources, including food and biobased materials.

## References


Achterberg, E., Hinfelaar, J., Bocken, N. (2016) The Value Hill Business Model Tool: identifying gaps and opportunities in a circular network. Working paper. https://docplayer.net/86718304-The-value-hill-business-model-tool-identifying-gaps-and-opportunities-in-a-circular-network.html (accessed 15.02.2020).

Blomsma, F., Brennan, G. (2017) The emergence of circular economy: a new framing around prolonging resource productivity. J. Ind. Ecol. 21: 603-614. https://doi.org/10.1111/jiec.12603

Bocken, N. M. P., de Pauw I., Bakker C., van der Grinten B. (2016) Product design and business model strategies for a circular economy. Journal Ind. and Prod. Eng. 33(5): 308–320. https://doi.org/10.1080/21681015.2016.1172124

Ellen Macarthur Foundation, 2013. The Circular Model - Brief History and School of Thought. Available: https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought (accessed 15.02.2020).

European Commission (2015) Closing the loop - An EU action plan for the Circular Economy. COM(2015) 614 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Ghisellini, P., Cialani, C., Ulgiati, S. (2016) A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod 114: 11-29. https://doi.org/10.1016/j.jclepro.2015.09.007

Hansen, K., Mulhall, D., Zils, M. (2014) Luxembourg as a knowledge capital and testing ground for the circular economy: National Roadmap for Positive Impacts. Tradition, Transition, Transformation, EPEA Internationale Umweltforschung GmbH. Available at https://www.luxinnovation.lu/news/luxembourg-knowledge-capital-testing-ground-circular-economy (accessed 15.02.2020).

Kirchherr, J., Reike, D., Hekkert, M. (2017) Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conserv. Recycl. 127: 221-232. https://doi.org/10.1016/j.resconrec.2017.09.005

Lewandowski, M. (2016) Designing the Business Models for Circular Economy—Towards the Conceptual Framework. Sustainability 8, 43. https://doi.org/10.3390/su8010043

Murray, A., Skene, K. and Haynes, K. (2017) The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context, Journal of Business Ethics, vol. 140(3) : 369–380. https://doi.org/10.1007/s10551-015-2693-2.

Nußholz, J.L.K. (2017) Circular Business Models: Defining a Concept and Framing an Emerging Research Field. Sustainability 9(10), 1810. https://doi.org/10.3390/su9101810

Rifkin, J. (2011) The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World. Palgrave MacMillan, NY. ISBN: 978-0-230-11521-7.

Schulz, C., Hjaltadóttir, R.E., Hild, P. (2019) Practising circles: Studying institutional change and circular economy practices. J. Clean. Prod 237, Article 117749. https://doi.org/10.1016/j.jclepro.2019.117749

Wautelet, T. (2018) The Concept of Circular Economy: its Origins and its Evolution. Working Paper. http://dx.doi.org/10.13140/RG.2.2.17021.87523