Some thinking around a close-loop approach for material use and management.

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The limits of linear consumption

A characteristic of the industrial economy has often been a linear model of resource consumption that followed a "take-make-dispose" pattern. Companies extracted material, applied energy and labour to make a product, and sold it to a consumer who discarded it when it no longer served its purpose.

In 1972 Club of Rome published the report Limits to Growth, which for the first time predicted that economic growth could not continue indefinitely because of the limited availability of natural resources. Over the last 30 years, global extraction of raw materials has increased by 80%. The change caused to ecosystems has already hit unsustainable levels. One day might come when specific resources either become unaffordable, unavailable or where the environmental burden associated with extracting them becomes unacceptable. Where easily accessible resources have already been exploited, opening up new sources of supply often involves more energy intensive mining and refining, with higher greenhouse gas emissions and increased demands on water supplies and other natural systems. Using future projections of consumption, the need to reduce material use is increasing.

The concept of Circular Economy

The circular economy is a generic term for an industrial economy that, by design or intention, is restorative and eliminates waste. Material flows are of two types; biological nutrients, designed to re-enter the biosphere safely, and technical nutrients (non-biological materials), which are designed to circulate at high quality, with their economic value preserved or enhanced. (Wikipedia).

For technical cycles the circular economy draws a sharp distinction between the consumption and use of materials. Consumption suggests destruction or exhaustion whereas the technical material can be seen as something to use over extended periods of time. This has direct implications for the development of efficient and effective take-back systems and the proliferation of product- and business-model design practices. Circular economy may require a model in which manufacturers or retailers increasingly have the ownership of their products and, where possible, act as service providers—selling the use of products, not their one-way consumption. The large number of ‘users’ calls for a new contract between businesses and their customers based on the performance of the product. Durable products can be leased, rented, or shared wherever possible. If they are sold, there must be incentives or agreements
in place to ensure the return and thereafter the reuse of the product or its components and materials at the end of its period of primary use. The circular economy seeks to provide a model to decouple economic progress from resource constraints in a way that inspires innovation throughout the whole value chain, rather than relying only on the waste recycling end of the market.

Large shares of municipal solid waste end up in dumps or sub-standard landfills. If not conducted properly, dumping or landfilling creates both short- and long-term risks for human health and the environment in the form of harmful leachate, dust, odour, local traffic burden, and powerful greenhouse gas emissions. Any biodegradable material generates landfill gas when it decays under anaerobic conditions. Landfill gas consists of around 50% methane, which is a greenhouse gas over twenty times more powerful than CO2. Even sanitary landfills can cause problems as they require substantial space close to centres of consumption and are usually difficult to locate due to community concerns.

One of the characteristics of the circular economy is its ability to restore the land, promote soil fertility, and thus increase agricultural productivity which is now growing more slowly than before and with a declining nutritional value of food. Alternative sources of nutrients (sewage, animal waste, and food waste) may be sufficient to cover the entire need for fertiliser in today’s production systems and break the dependence on foreign minerals.

**The levels of circularity**

There are four clear-cut sources of value creation that offer opportunities in comparison with linear product design and materials usage: they are described collectively as the power of circles:

- The ‘power of the inner circle’ refers to minimising comparative material usage vis-à-vis the linear production system. The tighter the circle, i.e., the less a product has to be changed in reuse, refurbishment and remanufacturing and the faster it returns to use, the higher the potential savings on the shares of material, labour, energy, and capital embedded in the product and on the associated externalities such as greenhouse gas (GHG) emissions, water, and toxicity.
- The ‘power of circling longer’ refers to maximising the number of consecutive cycles (reuse, remanufacturing, or recycling) and/or the time in each cycle.
- The ‘power of cascaded use’ refers to diversifying reuse across the value chain. An example is when cotton clothing is reused first as second-hand apparel, then crosses to the furniture industry as fibre-fill in upholstery, and the fibre-fill is later reused in stone wool insulation for construction, before the cotton fibres are safely returned to the biosphere.
- The ‘power of pure cycles’, means that uncontaminated material streams increase collection and redistribution efficiency while maintaining quality, particularly of technical materials, which then extends product longevity and thus increases material productivity.

**Barriers to the circular economy**
Today's recycling processes typically reduce material to its lowest 'nutrient' level. In a circular economy reverse activities may extend across an array of circles for repair and refurbishment of products and remanufacturing of technical components. Biological nutrients can be returned back to biosphere via composting and anaerobic digestion.

Some of the main barriers for companies to accelerating circular economy approaches may be:

**Valuation of externalities** Prices must reflect real costs. Progress towards a circular economy would be significantly accelerated if cradle to cradle externalities were fully incorporated into the value of goods and services, which in broad terms means moving to valuation methods that properly take into account the economic value of environmental damages avoided or caused.

**Cultural and consumer acceptance** There has been a societal shift towards access rather than ownership, but consumer acceptance still needs to grow significantly. In addition, there must be a realignment of cultural values and incentives – particularly in the sales functions of businesses.

**Procurement** Equipment that has been designed to meet circular economy criteria might require a greater capital outlay than the linear equivalent, resulting in the decision being taken to purchase the latter. A positive Net Present Value might only be apparent when considered over two or three lifecycles, rather than one, so procurement rules may need to be adapted and purchasing managers incentivised differently.

**Infrastructure** Large companies and their main suppliers might be big enough to adopt the principles of a circular economy, but the majority of companies must rely on external providers to create closed loops.

**Regulation** Regulation or restriction of choices may be used as a means of providing environmental externality so that circular economy based approaches can compete on a more even footing.

**Resource data** Improvements in tracking, and making visible, material flows so that opportunities can be more readily identified.

**Metrics and measurement** As part of the transition to a circular economy, metrics could focus on the post-consumer recycled content of products, embodied carbon and durability.

**Taxation** Consumers normally do not pay a premium for sustainable products. Stimulation may be needed, and varying VAT or product taxes could be a way to ensure that a circular economy product is not penalised by the tax system.

**How can companies/manufacturers work towards a circular economy?**

The companies must think in ‘systems’, that is they must develop the ability to understand how parts influence one another within a whole, and the relationship of the whole to the parts. The key principles are to design for the whole system – optimise not maximise. Rather than
focusing on how to get the maximum efficiency from one element of a system, one should try to redesign the whole system to make it more effective, and look for multiple benefits and collaborate across disciplines. Approximately 80% of a product’s environmental impact is ‘locked in’ at the design stage, so understanding production cycles and reconfiguring them for maximum effectiveness is essential. The idea must be to design out waste, based on a differentiation between consumable and durable components of a product.

Studies have indicated that essential building blocks of a circular economy are:

**Skills in circular product design and production.** Design for disassembly is a strategy that considers the need to disassemble products for repair, refurbishment or recycling. The questions to be asked are: Will a product need to be repaired? Which parts will need replacement? Who will repair it? How can the experience be simple and intuitive? Can the product be reclaimed, refurbished, and resold? How to facilitate the disassembly into easily recyclable components if the product must be discarded?

The principles of segregating biological from technical nutrients and phasing out toxic materials must be a priority. Products can be modularised so problem elements can easily be isolated and replaced. Manufacturers can determine what long-lived materials should be used to form the core of a modularised product—i.e., the skeleton that lives on while modules and customisable add-ons are replaced.

**New business models.** Changing from ownership to usage- and performance-based payment models (e.g., leasing, hiring) and expanding the product definition to embed it in related services (e.g., power tools combined with building kits and training) are elements of such business models.

When consumers buy products it’s likely that they will be destroyed, abandoned or lost, or too expensive to recover, once the user has finished with them. When there is a relationship between the user and the materials storehouse this can be avoided because it may mean that the manufacturers or retailers never let go of the products. Firms may come to recognise this as a source of their prosperity.

“Today’s goods are tomorrow’s resources at yesterday’s prices.” - Walter Stahel

**Skills in building reverse cycles and cascades.** Collection systems must be user-friendly, they must be located in areas accessible to customers and end-of-life specialists, and they must be capable of maintaining the quality of the materials reclaimed.

**Enabling factors to improve cross-cycle and cross-sector performance.** Joint product development and infrastructure management can be facilitated by transparency along the value chain, available ‘match-maker’ mechanisms, establishment of industry standards (e.g., product labelling), and the alignment of incentives among business partners.

**How can governments/authorities encourage circular economy?**
The circular economy may be encouraged by a number of measures:

**Provide a suitable international set of environmental rules.** Product labelling is important to ensure proper treatment in the reverse loops regarding non-toxicity, purity, or handling issues. Another tool is to phase out (toxic) chemicals that—if blended into waste—significantly hinder recycling or reuse of a much larger set of products and materials.

**Rethinking incentives.** Taxation today largely relies on labour income. Resource and labour market economists have long argued that labour as a ‘renewable factor input’ is currently penalised over material and non-renewable inputs in most developed economies. They promote a shift of the tax burden away from labour/income and towards non-renewable resources.

*Shifting taxation away from labour to boost employment and economic growth is already emphasised in the Annual Growth Survey for 2011 and in the European Council Conclusions from March 2011. "Green tax reforms", which consist of increasing the share of environmental taxes, while reducing others, have a role to play in this context. Environmental taxation can also align the efforts for fiscal consolidation with facilitating the restructuring towards a resource efficient economy.* COM (2011)571 final.

**Aligning incentives between customers and manufacturers** regarding contract financing and duration may be essential to make alternative ownership models work.

Authorities may **initiate concerted efforts among different companies** in the value loops that are large enough to overcome diseconomies of scale. One example of this is in phosphorus markets, where a few governments have started actively trying to help businesses extract value from sewage sludge.

Creation of an **infrastructure to support the efficient collection** of products after use (reverse cycles) can be heavily influenced by government policy (such as landfill tax), producer responsibility, new business models and take-back schemes. Skills in remanufacturing and ‘re-logistics’ (return or reverse transport and handling), storage, and information transfer capacities may need strengthening, to keep materials and components identifiable as they cycle through different uses and applications.

Developing biogas from food and other sources, is an alternative to natural gas for heating purposes. Many biogas providers are sub-scale, so tapping into this source at scale may require changes at the system level, for example by adjusting quality control rules or commercial rules which are designed and better suited for the large players.

**The benefits of the circular economy.**

The circular economy may give tangible benefits to companies, users and consumers, and for the society.

**The benefits for companies** can be cost reduction and less exposure to price volatility, reduced supply risk and dependency on resource markets, reduced warranty costs through "building to last", improved customer interaction and loyalty through new business models,
less product complexity by providing stable products kernels with other part of the product as add-ons.

**Benefits for users/consumers** may be reduced cost of obsolescence with "built-to-last" or reusable products and reduction of environmental costs. Moreover with new business models users may not have the difficulties of getting rid of cumbersome consumer goods like washing machines.

**Benefits for the society** may be relieved environmental burdens by reducing the need for landfill and decreasing the public costs of waste treatment. Municipalities that can generate revenues from their waste collection systems will have reduced budget pressure. If food waste were diverted from landfill and the energy from food waste-derived biogas was used as a replacement for natural gas, the impact on GHG emissions could be substantial. Bio waste can also restore the land, promote soil fertility, and increase agricultural productivity. Sectoral shifts can allow employment creation in new downstream businesses. While some of the jobs created by the circular economy are highly skilled, such as in technology development and research, a large share of the job creation is also for unskilled labour, addressing a major problem of developed countries, where such positions are becoming increasingly scarce. New entry-level semi-skilled jobs may replace the factory jobs that the linear economy has out-sourced to the developing world.

The subject of moving towards a close-loop approach is reflected in the EU document *Towards the EU's 7th Environment Action Programme*, which states the following in the under the title **Substantially reduce natural resource use**:  

- *Strengthened links between natural resources, products and waste policies, to drive more focus on avoiding impacts at the source, rather than continuing to deal with problems at end-of-pipe.*
- *Waste-related targets should be included, focusing on waste prevention, reuse, material recycling and phasing out of waste deposits to landfill [and seas] (without driving waste to incineration).*
- *Development of land-use policy, to better address increasing pressure on land-use, via more structured identification of linkages, better sustainability policies, and concerted effort in linking to sustainable consumption and production.*

Also China has made the circular economy the center of its economic policy. (China's National Development and Reform Commission (NDRC). 2006)

**Conclusions:**

The linear ‘take-make-dispose’ model relies on large quantities of easily accessible resources and energy. Working towards efficiency alone (a reduction of resources and fossil energy consumed per unit of manufacturing output) will not change the finite nature of the stocks, but may delay the inevitable. A change of the entire operating system will be required.

Resource prices are increasing, and so are the implicit or explicit costs of disposal. Progress in technologies and material science is yielding longer-lasting and more reusable designs. The information technology allows that material can be traced through the supply chain, products and material fractions identified, and the product status and costs during use period can be tracked. There are social networks now that can mobilise millions of users around a new idea
instantaneously—from motivating consumer awareness to facilitating concrete actions. Consumers and corporations have grown more accustomed to commercial practices based on performance instead of ownership. All this indicates that the time can be right to embrace the circular design philosophy.

_In a world with growing pressures on resources and the environment, the EU has no choice but to go for the transition to a resource-efficient and ultimately regenerative circular economy. Our future jobs and competitiveness, as a major importer of resources, are dependent on our ability to get more added value, and achieve overall decoupling, through a systemic change in the use and recovery of resources in the economy. According to the OECD, this could lead to steady economic growth with business opportunities across the whole economy._ (MANIFESTO FOR A RESOURCE-EFFICIENT EUROPE, Brussels, 17 December 2012).

References:

**Ellen McArthur Foundation:**
- Towards the Circular Economy, 2012
- Towards the Circular Economy 2, 2013

**Aldersgate Group:**
- Resilience in the Round, Seizing the growth opportunities of a circular economy. 2012

**BIS / Defra**
- Resource Security Action Plan: Making the most of valuable materials 2012