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Circular Economy

Improving the Management of Natural Resources




Preamble

Global consumption of natural resources, and with it the scarcity of natural resources and the total amount of waste due to consumption, have increased significantly throughout recent decades. This raises the question of how we can deal with resources in a more sustainable way. Not only are resource consumption and waste disposal connected with severe environmental impacts, but resource scarcity also limits the growth of the economy in its present form. A very important aspect is the reduction of resource use through clever design and intelligent choice of materials and processes in order to increase overall resource productivity (fewer kilograms per service unit).

The sustainable handling of natural resources is not simply a question of technology, ecology and waste management but also includes economic, social, political, cultural and ethical aspects. The optimization of entire processes and systems rather than single components becomes increasingly important. This "systems thinking" is at the core of the concept of circular economy, which aims to organize material and product flows in cycles in such a way that no resources are spoiled and the volume of waste is strongly reduced. The corresponding transformation of the systems from a linear to a circular design calls for the close collaboration of scientists, governments, economists and other stakeholders in society. In fact the achievement of a circular economy is seen as essential for shaping a sustainable society.

Dr Xaver Edelmann
President World Resources Forum

Purpose of this brochure
This brochure gives an insight into the current implementation of Circular Economy at national level by presenting three country case studies and their different approaches to achieving the same goal of a more sustainable planet.

China, besides being a huge economy, has the political power for a top-down approach to shape a completely restructured industrial and social system. Germany on the other hand is subject to external constraints in the form of EU directives along with national, regional and local demands. Finally Switzerland adopts a step-by-step approach based on finding solutions through the involvement of all stakeholders.

In the section Analysis and Comparison, the three countries are investigated according to a number of indicators and consideration is given to the kind of indicators that could serve for a meaningful annual audit of countries' Circular Economy performance.

In the concluding section we give recommendations for possible future actions to take relevant steps towards the vision of a Circular Economy.

What is Circular Economy?

The concept "Circular Economy" (CE) describes an industrial economy in which material flows keep circulating at a high rate (in terms of quality, property, function, range of use) without the materials entering the biosphere, unless they are biological nutrients (based on Ellen MacArthur Foundation 2013 study, see also Figure 1). Hence CE is understood as a system which is restorative by design. The idea itself arose through insights gained from living systems, and is hardly new. Its application as an economic model was presented in 1966 by Kenneth E. Boulding (Boulding 1966). In 1969, the related terms of biomimetics/biomimicry were introduced by Otto Schmitt to describe the more technical approach of imitating models, systems and elements of nature specifically for the purpose of synthesizing sustainable products through artificial mechanisms which mimic natural ones (Schmitt 1969). This is also related to the concept of sustainable design, which aims to establish products and processes in such a way as to deliberately decrease their environmental impact and ensure the regeneration of resources.

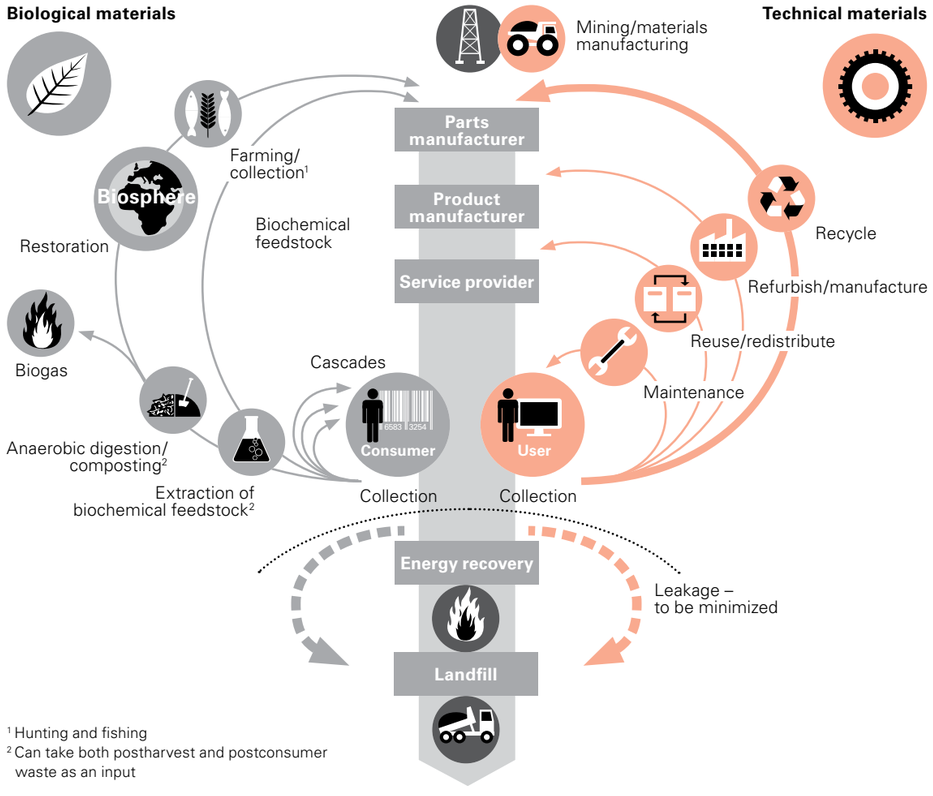

Figure 1: The Circular Economy
Source: Ellen MacArthur Foundation circular economy team drawing from Braungart & McDonough and Cradle to Cradle (C2C)

The concept of CE has not been implemented immediately, nor is it the only sustainability concept in circulation (see Figure 2). In the 1970s and 1980s, economic and population growth led to increased amounts of waste. Due to the lack of space for waste disposal and growing awareness of the environmental impact of disposed waste, ideas for recycling entered the political agenda in many countries. Scientists, politicians and industrials came together to tackle the problem of waste management and developed waste policy guidelines such as the Swiss Federal Waste Guideline of 1986 on how to treat waste and who is responsible for what ("polluter pays" principle).

The increasing scarcity of raw materials aroused economic interest in waste as a material resource, and countries began to invest in the re-use and recycling of waste. This development is also addressed in the research field of "Industrial Ecology" which has emerged since 1989 (IS4IE 2013). Sustainability and CE have become a major consideration in international policy, and have been discussed at great length at important international policy conferences of the United Nations (1992 and 2002 World Summits on Sustainable Development) and in relevant OECD and European Commission conferences, reports and guidelines.

From the 1990s onwards, the perception gradually shifted away from single products and processes towards a more integrated, holistic systems thinking approach. This meant the optimization of a system rather than its components, and led for example to the conception of "Integrated Product Policy" (IPP). These ideas entered a number of national initiatives worldwide, from a negotiation-based sustainability strategy in Switzerland (2002) to the ratification of an entire CE law in China (2006). Related concepts were also discussed increasingly in the UN, and the United Nations Environment Program (UNEP) in particular became very active with international initiatives such as the Ten Year Framework on Sustainable Consumption and Production, the Life Cycle Initiative and the International Resource Panel.

Today CE is generally considered to be the basic requirement for achieving a sustainable economy and a future-compliant society. More recently, the concept has begun to encompass social aspects under the term "Green Economy", and it is understood (see UNEP 2011) that to achieve sustainable development the ecological, economic and social aspects must all be taken into account.

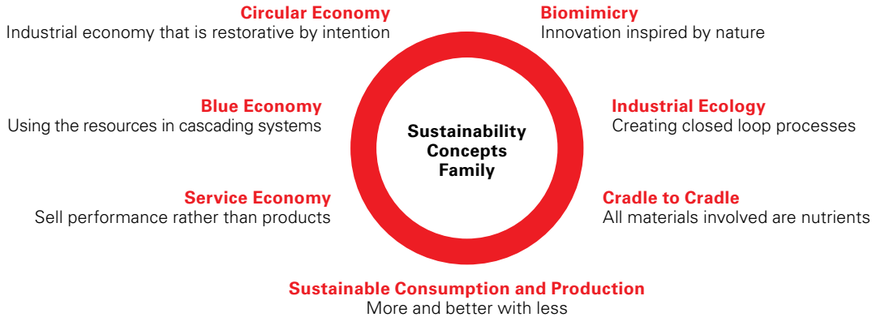

Figure 2: CE within the framework of other sustainability concepts
Source: WRF, information based partly on Wikipedia

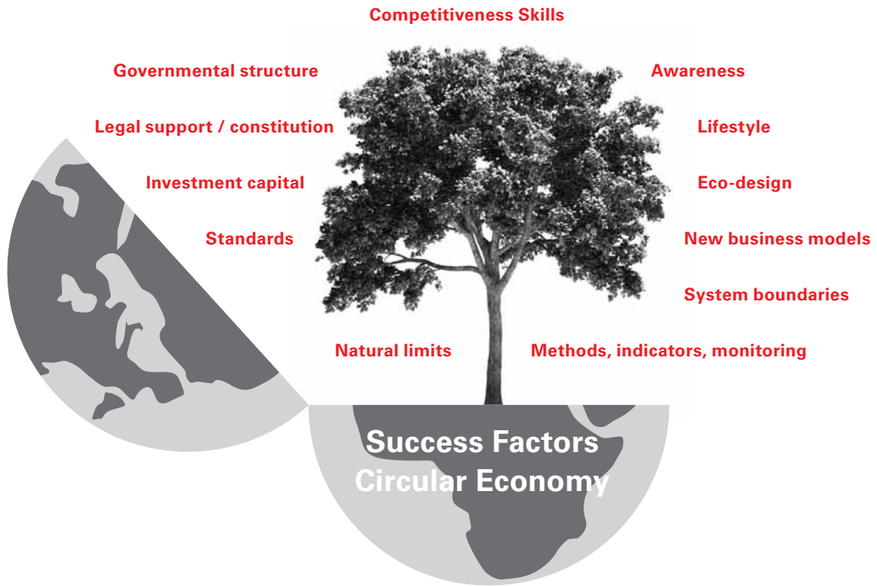

Figure 3: Relevant success factors for a Circular Economy
Sources: WRF, based on information from Indigo Development 2009 and Ellen MacArthur Foundation 2013

The implementation of a sound CE concept depends on a number of success factors which are presented in Figure 3. All of these have a bearing; however, the really essential requirements are a non-restrictive governmental structure, new business models, specially educated experts (skills), a set of comparable indicators, a reliable monitoring system and international standards.

Both the World Resources Forum (WRF) and the Swiss Academy of Engineering Sciences (SATW) have been monitoring progress in the analysis and implementation of the CE concept for many years. The two organisations delivered a joint briefing on resource efficiency to Swiss parliamentarians in 2012 (SATW/WRF 2012) and published a brochure on natural resource indicators under the umbrella of the Swiss Academies of Arts and Sciences (a+) (a+/Empa 2012).

The following sections present three country case studies and their approach to implementing CE at different levels. China was chosen as the world's largest economy, facing serious problems in its efforts to reduce its increasing environmental impacts; Germany was selected as the driving force behind resource efficiency in Europe, while Switzerland as a small economic power and a non-EU member state is striving to achieve a balance between international and national interests.

China: Township Building

The Circular Economy (CE) development strategy was formally accepted by the central government of China in 2002 and has been implemented and further developed in a number of pilot areas in China. Rather than being regarded as an incrementally improving environment management policy, the concept of CE has been introduced as a new development model to help China leapfrog to a more sustainable economic structure (Zhu, 2008; Geng and Doberstein, 2008). The main focus of CE policy in China, embedded in the original development strategy of 2002, has gradually shifted from narrow waste recycling to broader efficiency-oriented control at every stage of production, distribution and consumption in order to close loops in material flows. Besides resource and waste problems, the improved strategy also encompasses energy efficiency and conservation, land management and soil protection and integrated water resource management as key issues (Su et al. 2013). The recent announcement of the "Circular Economy Development Strategies and Near Term Action Plan" goes further in that it defines goals for each industrial sector in detail as well as 3R measures (Recover, Reuse, and Recycle) for the various segments.

In the last decade, the Chinese government was promoting new strategies and innovations for improving technologies, in other words concentrating on single components rather than entire processes or systems. However, scholars and experts argued that restricting efforts to the micro level would not be sufficient for successful implementation of CE policy. They proposed to extend efforts to the meso and macro level (Yuan et al., 2006; Zhu and Huang, 2005). Inspired by Zhu and Huang's work, Su et al. (2013) further categorized China's CE practices into four main areas (see Table 1): production, consumption, waste management and other support. Practices at micro level are still more dynamic than those at meso and macro levels due to the complexity of the latter tasks.

	Micro (single object)	Meso (symbiosis association)	Macro (city, province, state)
Production area	Cleaner production; Eco-design	Eco-industrial park; Eco-agricultural system	Regional eco-industrial network
Consumption area	Green purchase and consumption	Environmentally friendly park	Renting service
Waste management area	Product recycle system	Waste trade market; Venous industrial park*	Urban symbiosis
Other support	Policies and laws; information platform; capacity-building; NGOs		

*"Venous industries" refers to industries that turn solid industrial waste into reusable resources, which will then be re-used in production (China Daily, 2007)

Table 1: Structure of the CE practices in China

According to Jaikun Song (2012), one of the national resource strategists from the Chinese Academy of Sciences, there are two main problems caused by the economic development in China. First of all, China has focused too exclusively on industrial and infrastructural development during the rapid economic development of the last twenty years. This has resulted in wasted energy and the inappropriate allocation of resources. Secondly, in the past decade the Chinese government has tried to shift the economic focus from labour and commodity-intensive industries to high-technology industries. This has led to heavy industrial development, strong urbanization and hence, severe rural depopulation, accompanied by a shift away from traditional, typically more eco-friendly agricultural practices to industrialized but unsustainable methods.

At the 2012 World Resources Forum held in Beijing, Song presented the novel concept of 'township building', which in conjunction with all the initiatives described above could make a major contribution towards the realization of CE in China. The concept itself differs from the conventional idea of urbanization and is aimed at encouraging rural populations to remain in and develop rural areas, while avoiding waste and the misallocation of resources. Song pointed out that the core philosophy of township building is to stimulate interactions between different governmental authorities such as agriculture, resources and industry. In order to achieve this, 'township building' must optimize the effectiveness and efficiency of the spatial structure of the targeted region by considering three 'spatial factors':

1. How different resources such as material, energy and human resources can flow more efficiently within the region;
2. How space, land and environmental resources can be used collectively and more effectively within the region;
3. How different structures within the region such as industrial, labour, ecological and environmental structures can be changed rapidly to suit the purposes of development.

At the same time he stated that by grouping together 7 to 10 villages with different eco-production or waste management systems, their expertise can be combined to build small towns next to existing large cities. If village managers understand one another's needs and cooperate, resources and waste can be handled more efficiently and effectively. Ultimately these once-separate villages can be managed as an integrated system and a value-creating chain.

Indeed some of the latest practices at meso and macro level such as the building of a waste trade market (see Table 1) can be used to support the development of townships.

On the other hand, township building itself can be seen as a concept designed to foster better meso and macro implementation of CE. This is one of the main development strategies proposed by the Chinese Academy of Sciences.

The Chinese central government seems to be supportive and resolved to promote 'township building', as affirmed by Premier Li Keqiang: "We will aim at expanding our domestic demand and stimulating our potential in township building" (Keqiang, L. 2012).

In China, efforts at all three levels (companies, industrial parks, regions/townships/urban systems) include the development of resource recovery, cleaner production methods and public facilities to support the realization of the CE concept (Indigo Development 2009).

Germany: Decoupling Waste from Economic Growth

Before the first waste law in 1972, every village and town in Germany had its own waste dump amounting to a total of around 50,000 in the whole country. This number was drastically reduced to less than 2000 in the 1980s and 1990s. Today there are only 160 remaining disposal sites for municipal waste. Instead many waste incineration plants have been built.

During the 1980s there was a growing awareness that resources should re-enter the economic cycle through separate collection, sorting and re-use. The Circular Economy and Waste Law based on the political credo of waste hierarchy through "Avoidance, Reduction, Disposal", was implemented in the 1990s. This placed product responsibility at the core of Germany's waste policy. There was a paradigm shift from the waste management policy approach towards the CE model (Karavezyris 2010). This meant that producers and sellers were now obliged to design their products to meet the following criteria:

1. Minimization of the amount of waste arising from production and use;
2. Possibility of maximum high-quality waste recovery and
3. Feasibility of environment-friendly disposal of unusable waste.

This responsibility is not simply a duty; it also has potential benefits. More than 250,000 employees, including engineers, administrative assistants and professionals apprenticed to specialized education programs have been working in Germany's circular and waste economy industry since 2010. The yearly business volume exceeded 50 billion EUR in 2010, showing that waste has become an important economic driver. Germany leads the international market in goods for waste management with a share of around 25 percent (Karavezyris 2010).

In Germany, the total weight of waste put into recycling is 239 million tons (2010). This corresponds to more than 3 tons of recycled waste per citizen. The majority of this, 173 million tons, comes from the construction industry, which has a recycling efficiency of 89 percent. More than 60 percent of municipal and production waste is now recycled. Compared to 1990, up to eight times more fossil fuels have been saved through increased thermal (incineration) and material recycling. This corresponds to the annual energy resource consumption of a city with more than 400,000 inhabitants. Moreover, from 1996 to 2011 the total volume of waste decreased by 11 percent, while the economy grew by around 25 percent (Stat BA 2013; see also Figure 4). Germany had thus succeeded in decoupling waste volume from economic growth. However, these statistics only describe the situation within Germany's borders, which does not actually accord with the CE concept's overall goal of accounting for the whole life cycle of products and services. As a considerable amount of waste from German goods is generated outside Germany, there is still a need for further reductions in the volume of waste and better use of the energy and resource potential hidden in waste, as proposed by EU directives and strategies such as the EU Commission's "Thematic strategy for prevention and recycling of waste" (COM 2005).

On the basis of this strategy the European waste guideline was revised in 2008 to initiate actions to protect the environment and human health by avoiding or reducing the damaging effects of waste production and processing, reducing the total impact of resource consumption and using resources more efficiently.

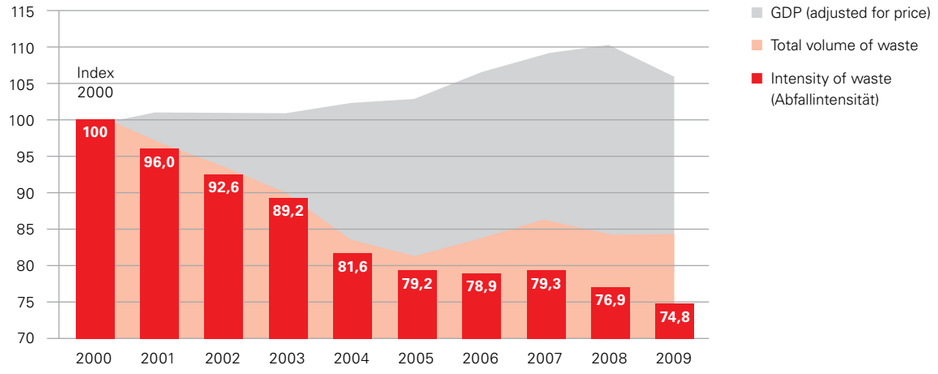

Figure 4: Decoupling of waste volume from economic growth (in percent)
Source: Stat BA 2012; Intensity of waste is the relative share of the total volume of waste compared to GDP both as indexed numbers.

Further EU provisions have been created and applied for the classification and treatment of hazardous waste, the construction and the running of disposal and incineration sites, as well as on "Avoidance and Recovery". These specific provisions include regulations for wrappings, batteries, old vehicles, electronic devices and some very problematic wastes like oil, polychlorinated biphenyl (PCB) and polychlorinated triphenyl (PCT).

In order to incorporate the new European guidelines, the German CE and waste law has been fully revised and further developed in 2012 to improve environment, climate and resource protection. For the first time, regulations exist for the end of the "waste property"; this means that waste is no longer considered as waste, but as a resource. Another new aspect was the support for waste avoidance programs additional to the product responsibility of producers and sellers. An essential part of the renewed law is the introduction of a five-step hierarchy of waste (BMU 2013). Avoidance is still considered the first choice. Next, recovery is split into three steps: preparation to re-use, recycling and (thermal) recovery. At the bottom of the hierarchy is disposal.

In the German sustainability strategy "Perspectives for Germany" from 2002, goals to reach in the medium term are defined. After a status analysis in 2010 several goals have been updated. These include:

1. By 2020, the share of renewable energy sources in the primary energy consumption shall be raised to 10 percent, and up to 30 percent regarding the gross energy consumption. The interim goals for 2010 of 4.2 percent and 12.5 percent respectively have been reached before the deadline.
2. By 2020, energy and resource productivity shall be doubled compared to 1990/1994 and hence energy consumption shall be decoupled from economic growth. A productivity increase of 47.5 percent and 37.4 percent compared to 1990/1994 respectively has been achieved in 2010.
3. By 2020, the Kyoto-Gas-Emissions shall be reduced by 40 percent compared to 1990. A reduction of 25.3 percent has been reached in 2009.
4. By 2015, the share of freight haulage by train shall be doubled compared to 1997 (thus a share of 25 percent by 2015). Considering the slow increase of this share from 17 percent in 2005 to 18 percent in 2010, it is not expected that the goal can be reached in time.

Switzerland: Incentive Schemes and Negotiation with International Focus

In Switzerland, for many years experts and the general public were more concerned about the pollution caused by disposed waste than by its environmental impact during the exploitation phase (resource depletion). Waste management was understood as an incrementally improving environment management policy. Its economic branch, waste economy, was described in the Federal Waste Guideline of 1986 (FOEN 1986). This distinguished three fields of action: Avoidance, Reduction (re-use, recycling) and environmentally responsible Disposal. The core concept of the regulations was the "polluter pays" principle, which led to the widespread separate collection of waste, especially glass, aluminium and paper (see Figure 5). Although the recycling rate has increased twelvefold since 1970, the volume of municipal waste has not decreased since 1990 (see Figure 6). This can be seen as a rebound effect of a consumer society; the total amount of waste generated is not decreasing despite the remarkable efforts in recycling, not least due to population growth.

As a consequence of the UN conference on "Environment and Development" in Rio de Janeiro in 1992 (Rio92) and in preparation for the Johannesburg conference on "Sustainable Development" in 2002 (Joh02), the Federal Council released its "Strategy Sustainable Development 2002" (StSD 2002). Based on the fully revised Swiss Federal Constitution of 1999, in which sustainable development had become a national objective, this strategy shifts the focus towards a far broader context than ecology alone. Sustainability must be perceived as a political domain covering and guaranteeing future-compliant development by addressing ecological, economic and social aspects and challenges equally. Due to the country's high import rates, around 60 percent of the environmental impacts caused by the production and processing of goods consumed in Switzerland are actually impacts on foreign countries (Jungbluth et al. 2011, FOEN 2013). Following the "polluter pays" principle, responsibility must also be assumed for these "imported" impacts (see Figure 7 for the situation in 2005).

StSD02 therefore defines fields of action and tasks which extend to the following topic areas:

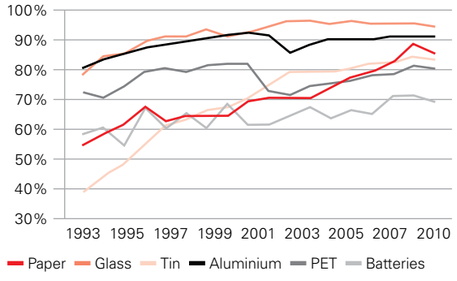

Figure 5: Separately collected municipal waste (recycling) – collection rates
Source: BFS (2012)

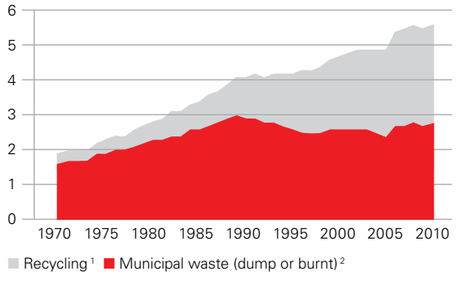

Figure 6: Municipal waste in Switzerland – in millions tons
[1] Total of compost, paper, glass, tin, aluminium, PET, textiles, batteries (since 1993), electric and electronic devices (since 2001)
[2] The figures from 2004 to 2010 include only the domestic amounts (no import).
Source: BFS (2012)

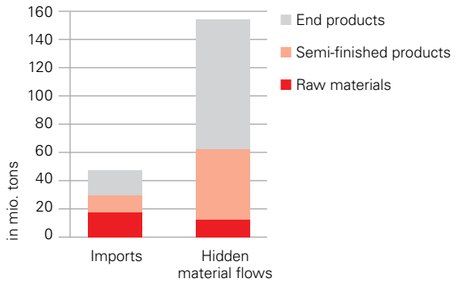

Figure 7: Imported materials and goods and their hidden material flows abroad, 2005
Source: FOEN (2013)

1. Finance and Industry (Integrated Product Policy (IPP), CO_2 taxes). Education, Research and Technology (scientific collaborations ARAMIS, education21, IDANE)
2. Health and Poverty (AMEPA)
3. Environment and Urban Development (spatial planning, regional policy, energy and climate policy, green area)
4. International efforts (development cooperation, multilateral policy on sustainability, peace building, UNEP, sustainability in WTO)
5. Mobility (public transport, clean vehicles)
6. Monitoring

Integrated Product Policy (IPP) can be seen as a direct follow-up to and expansion of the former waste policy which also extends the cost-by-cause principle to the entire lifecycle of products by considering their ecological impact. As a first step, information about the ecological impact of existing products has been gathered in an inventory database (www. ecoinvent.ch). This has provided a basis for initiating and supporting the development of eco-labels and life cycle assessment methods, for example through the application of ISO14025 and other standards. To support these initiatives and also encourage industry to take responsibility, it has been decided that public procurement should set an example and should take sustainability and IPP into account in all its activities. Due to its high share in waste production and resource imports, the construction industry has been addressed directly by the "recommendation for sustainable construction" (SIA 112/1). IPP also includes educational initiatives (IDANE, education21) to raise consumer awareness.

In 2010, the Federal Council launched the "Action plan Green Economy" (AGE; FOEN 2012) as an extension of the principles of StSD02. AGE activities are coordinated centrally by FOEN. Four key areas have been defined: Consumption and Production; Waste and Resources; Overall Instruments; Goal, Measurement, Information and Reporting.

Green economy is regarded not only as a means to ensure the availability of resources in the future, but also as an opportunity to strengthen the Swiss economy, especially in the field of clean technology (FOEN 2013). In order to enforce these activities, the Swiss Federal Council launched a new strategy for resource efficiency and renewable energies, the so-called "Masterplan Cleantech" (Masterplan Cleantech 2011). This is designed to initiate innovation processes and promote research activities by developing a new competence center and building networks.

Furthermore, the importance of Switzerland's involvement in international initiatives and in supporting other countries in the implementation of green economy is also stressed. In June 2013, the Federal Council suggested a revision of the Environment Protection Law (USG) in order to build a regulatory framework for all activities and support plans for a circular/green economy. This revision was presented as a counter-proposal to the people's initiative "Green Economy" launched by the Green party in September 2012. Decisions from the Rio+20 meeting in favour of a green economy will thus affect everyday political discussions in Switzerland.

With regard to CE concepts, experts in Switzerland suggest the following everyday principles: "Recycle to produce new goods, repair existing products as far as possible, focus on the benefit of a product rather than the product itself, and start to share products and services wherever you can – like in the old days with the collective baking ovens" (FOEN 2013).

Analysis and Comparison

Given the size of the countries and cities and their population figures (see Figure 8), political structures, resource availability, business practices, use of clean technologies etc. it is obvious that China, Germany and Switzerland face different preconditions for implementing CE concepts. Still, the overall goal of CE remains the same, namely to reduce the country's footprint and improve resource management practices in order to achieve economic stability and sustainable living-conditions in a worldwide context.
China has invested heavily in accessing the natural resources of other countries in recent years in order to secure its increasing demand for raw materials. This is also supported by national action programs inside China and through intensified international cooperation in the global resources dialogue.

Europe has good prospects of implementing CE concepts in national legislation, although the process is rather slow and complicated. The European Commission's "Roadmap to a Resource Efficient Europe" (2011) has yet to be implemented in the EU and its member states. Moreover, developments in Germany, one of the forerunners in CE implementation, have a direct impact on national decision-making processes in Asian countries.

The two sections on Germany and Switzerland clearly indicate that waste management is linked to the more general system goals of resource efficiency and climate protection in manifold ways (Karavezyris 2010). But this is only one side of the picture. CE concepts should encompass the whole life-cycle of goods and services, including eco-design and material/water/energy reduction in the production stages and a more self-sufficient lifestyle for consumers.

One important tool for implementing a sound CE at micro (companies, communities) and macro (national, global) level is the establishment of specific social, economic and environmental indicators to measure progress. The discussion about which parameters should be measured and how is ongoing. Prammer & Schrack (2012) for example suggest a so-called "Integrated Resource Efficiency Indicator Set (IRIS)" to support companies and regions in their efforts towards achieving CE goals. Material flow analysis (MFA; material inputs versus material outputs of an entire economy) is one of the tools for assessing the efforts made. However, this raises the problem of setting the correct system boundaries and providing the costs and infrastructure for consistent monitoring. Life-cycle assessment (LCA) considers the impact of the whole life-cycle of products and services, but must also overcome similar deficiencies to those of MFA (Welz et al 2013). For a set of indicators to be meaningful it must also be integrated into mainstream policy mechanisms: it should include

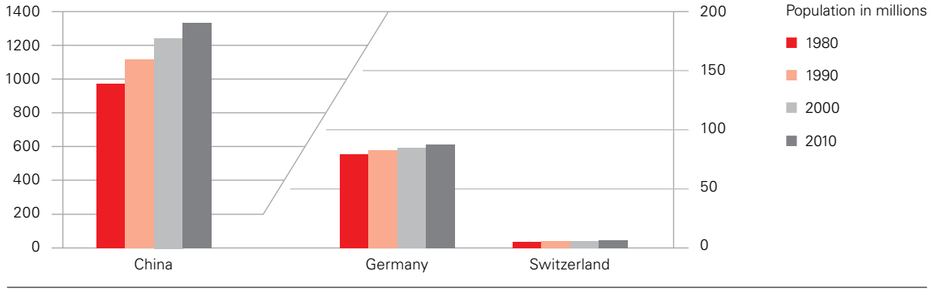

Figure 8: Population of China, Germany and Switzerland in 1980, 1990, 2000 and 2010
Source: World Bank (2013): List of countries by total population

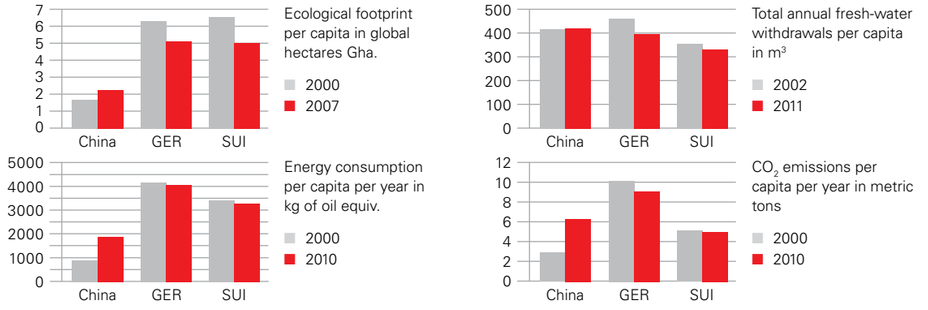

Figure 9: CE and environmental impacts in China, Germany and Switzerland, shown on 4 specific indicators, calculated per capita (for definitions see references).
Source: World Bank (2013) and Wikipedia contributors (2013a; for Ecological footprint)

social and economic indicators, should aim for an urban-industrial symbiosis, should achieve absolute mat-erial and energy reduction and should be of a prevention-oriented nature (Geng Y. et al 2012). The main difficulty usually arises with an incomplete, inconsistent data inventory broken down by economic sector in the respective countries. On the other hand, indicators do not have to be complex to reveal a trend. In Figure 9 above (see also Ellen MacArthur 2012; figure on the impact of more circular production processes), the ecological footprint, total annual fresh water withdrawals, energy consumption (kg of oil equiv.) and CO_2 emissions, each per capita, for the three country case studies for 2000 and 2010 (2007/2011) are shown as an example of this.

Despite China's efforts to implement CE, the country's huge economic growth has increased its ecological footprint, energy consumption and CO_2 emissions per capita since 2000. Only the total annual water consumption has remained approximately the same. But however high these consumption or emission levels may have risen in China recently, their per capita impact is still half or even less than half that of a German or Swiss citizen. The per capita impact for these indicators in Switzerland and Germany has been slightly reduced over the last decade, which is a good sign but far from being enough.

Discussions at the World Resources Forum Conferences between leading experts from business, politics and science indicate that all nation states will have to contribute to CE concepts, whether they be developing countries, countries in transition or developed countries. Countries with a currently low ecological footprint should aim at "leapfrogging", a development theory which may allow them to accelerate their development by skipping the inferior, less efficient, more expensive or more polluting technologies and industries and moving on directly to the more advanced ones (Wikipedia Contributors 2013b). Developed countries on the other hand should drastically reduce their consumption patterns and resource-intensive lifestyle, according to the motto "doing more with less". Strategies are needed for re-using/refurbishing the accumulated amounts of minerals and materials in produced products (concepts such as "Urban mining"; cf. Schluep et al. 2013). This would lead to new fields of activities, create jobs and reduce environmental impacts to a minimum.

One important step to achieving a sustainable resource policy is the establishment of a neutral international platform for resource governance. Common international activities will be essential to overcome global environmental problems.

The final chapter provides a number of recommendations to assist with the implementation of CE concepts at different levels.

Recommendations

As illustrated in the previous sections describing the case studies, Circular Economy (CE) has become a high-profile issue not only in Europe but also in developing countries and countries in a state of economic transition. Different countries have chosen to adopt different approaches: Germany follows a combination of a top-down and bottom-up approach, while Switzerland has chosen a more bottom-up and participative path and China has implemented the CE concepts from the top down, thereby becoming one of the first countries in the world to implement CE in its constitution. The way of approaching CE is strongly connected with the existing political and governmental systems in the individual countries. However, CE concepts in a mid-term perspective can certainly bring about positive results in environmental and economic development.

Since its first event in 2009, the World Resources Forum has increasingly focused its efforts on discussing CE concepts, and will continue the debate in upcoming conferences. Based on the results of the WRF conferences in Davos (2009, 2011, 2013) and Beijing (2012), the most important steps for realizing successful framework conditions for a worldwide CE are the following (taken from WRF Declaration 2009 and Chairman's Summaries WRF 2011, 2012, 2013):

a) Introduce effective *policy measures* to greatly enhance resource productivity and curb demand over time in the form of standards, while also taxing resources, non-renewables and pollution rather than labour with the possibility of reducing taxes elsewhere or introducing capping and trade mechanisms. (WRF 2009, 2011, 2013)

b) Focus *research and development* on the goal of increasing resource productivity. The resulting innovation will create space for economic and social development. As a side-effect, national economies and cities will become less dependent on resource imports, in particular fossil energy carriers. (WRF 2009)

c) Phase out or drastically *reduce dependencies* on fossil fuels, in particular the world's addiction to oil and coal. This is considered to be technically and economically feasible in the next few decades, with each country choosing its own path for alternative materials. (WRF 2012, 2013)

d) Reshape the *framework conditions* for the economy to account for the scarcity of natural resources. Aside from the traditional curriculum of natural resource economics (fisheries, forestry, minerals extraction), other resources, notably air, water and other "environmental resources" have become increasingly important in policy making. (WRF 2009; also Wikipedia contributors 2013c)

e) Strengthen education to *increase awareness of resource limits,* especially among economists, and foster the ability of decision makers to analyse long-term and systemic trends and to implement sustainability-driven innovation. (WRF 2009)

f) Initiate the process of *rethinking lifestyles* and help to develop consumption patterns based on sufficiency and careful use of natural resources. (WRF 2009)

g) For *developing countries,* technology transfers, access to resource-efficient technologies and financial support for making the transition are necessary, as well as effective governance, a resource-efficient infrastructure, education, and leapfrogging. Township building is one of the concepts to implement on a wider scale, to reintroduce the sustainable lifestyles of the past. (WRF 2011, 2012)

h) *Critical metals* require urgent attention due to their potential for use in essential sustainable technologies and products. The problems associated with critical (or rare earth) metals are: increasing demand, environmental pollution, disastrous working conditions in mines, and unstable prices. Countries apart from China with larger deposits of critical metals include Australia, Brazil, Canada, India, Malawi, Malaysia, Peru, Russia, South Africa, the U.S. and a few others. There is a severe threat of conflicts between countries and companies for rare earth metals. (WRF 2011)

i) Key instruments for developing resource-efficient economies include the establishment of a clear set of *indicators and goals* for the production of annual reports on resource efficiency performance, as well as practical roadmaps with straightforward plans for implementing financial and legal instruments. (WRF 2011, 2013)

j) CE approaches require not only technical but also institutional changes and *social innovation;* partnerships must be built between governments and businesses and between businesses and civil society (multi-stakeholder partnerships). SMEs have shown themselves to be open to change; capacity building programs are very important to increase knowledge and improve the capacity of entrepreneurs to achieve cleaner and more resource-efficient production. (WRF 2011, 2012)

k) Achieving a *Green Economy* should become a worldwide strategic priority; governments need to be alert to the growing spider's web of *bilateral resource agreements,* in particular those involving developing and emerging countries. Major steps forward in the efforts towards greater social, economic and environmental sustainability have been taken by international companies such as Umicore SA (Belgium), Natura Cosmeticos SA (Brazil), Statoil ASA (Norway), Neste Oil OYJ (Finland), Novo Nordisk A/S (Denmark), Storebrand ASA (Norway), Koninklijke Philips Electronics NV (Netherlands), Biogen Idec Inc. (USA), Dassault Systèmes SA (France) or Westpac Banking Corp (Australia), as stated in the 2011 Global 100 List of "The Most Sustainable Corporations in the World". (WRF 2012 and Global 100 2013)

l) Better *international resource governance* would be beneficial for all, since it would lead to stability, predictability and hence lower prices. Establishment of a neutral international platform comparable to the International Energy Agency (IEA) should also be considered for natural resources, with the involvement of developing countries from the start. (WRF 2012, 2013)

m) The provision of *incentives* for recycling practices and in particular for improving collection systems, and showcasing BAT (Best Available Technologies) are priority actions for governments and business at all levels. (WRF 2012, Reuter 2012)

n) Increasing the *sense of urgency,* improving communication between policymakers and the scientific community, and further highlighting the business case for resource efficiency. Social sciences and humanities have an important role to play. A key strategy in spreading the sense of urgency is to empower young consumers through formal (schools, programs) and informal education (family, colleagues). (WRF 2012, 2013).

References

The complete list of references is available online: www.satw.ch/circular-economy

Imprint

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Adam Wong (Student Reporter at WRF 2012 Conference in Beijing, China)

The authors thank Dr. Xaver Edelmann and Dr. Yi-Heng Cheng for their kind support.

Review: Hans Hänni, Urs von Stockar, Andreas Zuberbühler and external reviewer

Editing and coordination: Beatrice Huber

Illustration: Andy Braun

Published by

SATW

Schweizerische Akademie der Technischen Wissenschaften
Académie suisse des sciences techniques
Accademia svizzera delle scienze tecniche
Swiss Academy of Engineering Sciences