10 Circular Systems

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Market research question:

Since most firms are not involved in all phases of the life of a product themselves, the questions arise what makes a loop system successful and for which materials there were loops successful in the perspective of circularity.

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Executive summary:

Loop system evolve successfully from local or regional level to strong oligopolistic or monopolistic market strength if the partners of the loop system provide abilities and capabilities for the

1. management of diversity for the use phase (design for complexity reduction),
2. management of diversity after the use phase (for collection, refurbishment, recycling),
3. installation of mechanisms for collection and tracing of the material,
4. functionality of market, public management or mixed market allocation mechanisms.

The loop systems evolvement gets triggered by policy fit of regulation and motivation of participants in the system. Resource scarcity is another trigger, it forces policy makers into regulation.

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1. List of abbreviations:

CSC	Circular System Characteristics
DRS	Deposit Return System
EPR	Extended Producer Responsibility
LCA	Life-Cycle-Assessment
RR	Recycling Rate

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2. 10 loop systems have been identified as circular systems:

Evaluated systems have reached technical maximum for recycling and materials are successfully managed in almost closed loop:

Aluminum (Europe), 95 % RR

Asphalt (Japan), 99 % RR

Biomass (District of Nationalpark Hunsrück, Germany), 100 % RR

Container glass (Sweden), 99 % RR

Gold (Global), 99 % RR

Heavy Machineries (Joy Global Ltd./Kumatsu), 100 % RR

Ion Exchanger (Envirofalk, Veolia, BWT, Germany), 100 % RR

Paper (Germany), 79 % RR

PET Bottles (Norway), 97 % RR

Slurry/ Sludge (Braunschweig, Germany), 100 % RR

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3. Method
3. 1. Circular System Characteristics

The template for the Circular System Characteristics is a fact sheet. The schematic reduction of the loop system helps to identify market key players and market powers. By reduction of the complexity within the system as a process, three different kinds of markets can be differentiated: Polypoly, Oligopoly and Monopoly. Further, the technical reduction of material diversity (i. e. collection, sorting of material for further processing and recycling) could be identified. In another step, the mechanisms for material diversity for use were identified. Diversity growth was marked within the loop system.

As allocation mechanisms the structure of market exchange was identified, which can be market, stock market or public tender.

The availability of technology describes state of the art of technology within the system.

A probe of circular principles was taken. No system entered, which does not apply these (see 3.1.1.)

Template – searching for system characteristics

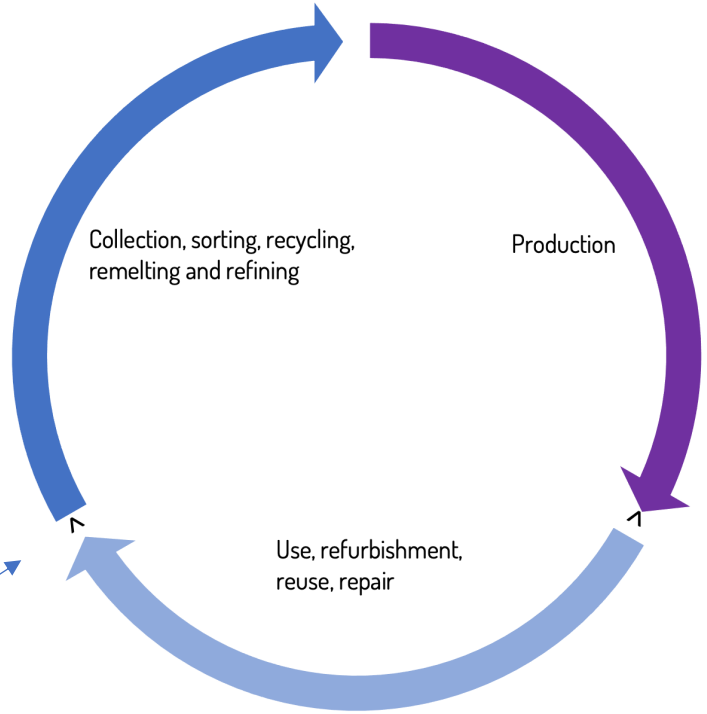
<u>System Characteristics</u>
- Description of the system

<u>Availability of Technology:</u>
- Level of technology (production/sorting/recycling)

<u>Maturity of Market</u>
- Market concentration
- Oligopol (lilac)
- Polipol (light blue)
- Monopol (dark blue)
- Stakeholders
- Allocation mechanisms

<u>Policy Intervention:</u>
- Legislative Interventions
- Action Plans
- Tender mechanisms
- Governance

Source:, For further reading – see bibliography



> Reduction of material diversity for processing
< Growth of material diversity for use

Polypoly
Monopoly
Oligopoly

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3.1.1. Probe of Circular Principles

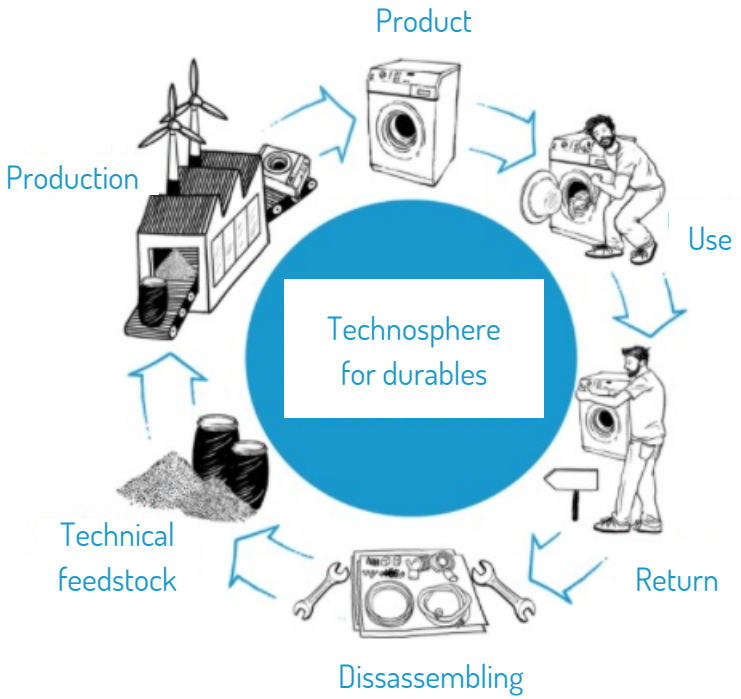
Cradle-to-Cradle Design principle:
„This design philosophy considers all material involved in industrial and commercial processes to be nutrients, of which there are two main categories: technical and biological. [...] Cradle to Cradle design perceives the safe and productive processes of nature's 'biological metabolism' as a model for developing a 'technical metabolism' flow of industrial materials. Product components can be designed for continuous recovery and reutilization as biological and technical nutrients within these metabolisms."

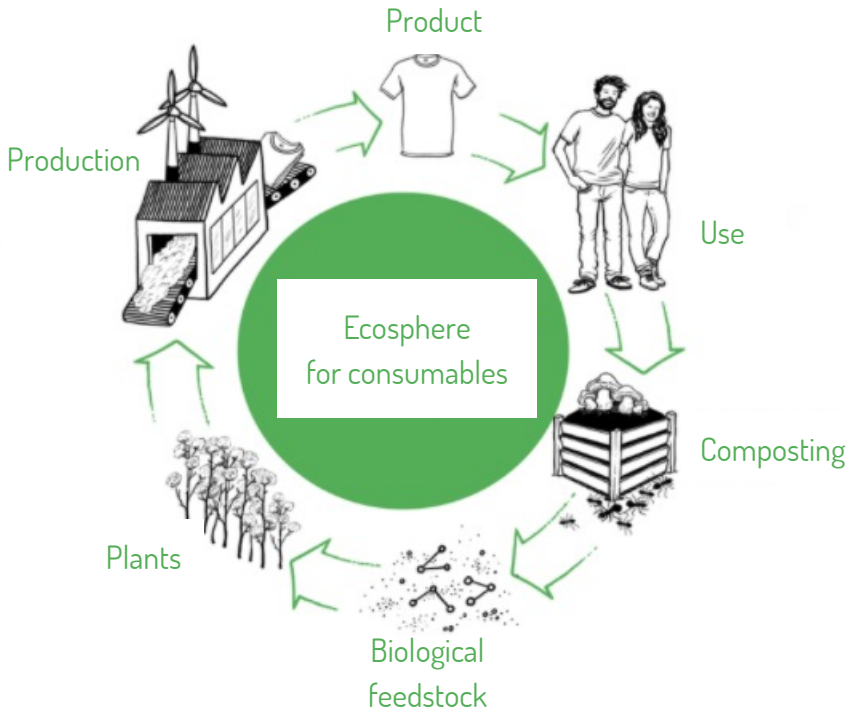
RESOLVE principle:
ReSOLVE = **Re**use, **re**furbish, **re**pair, **re**cycle, **re**new, **s**hare, **o**ptimize, close-the-**l**oop, **v**irtualize (trace), **e**xchange

Economically viable:
An analysis of the Ellen MacArthur Foundation shows that the concept of circular economy works and is economically viable and scalable for diverse products regardless of length of service life – examples:

- Substantial net material savings
- Mitigation of price volatility and supply risks
- Sectoral shift and possible employment benefits
- Reduced externalities
- Lasting benefits for a more resilient economy
- Reduced material bills and warranty risks
- Improved customer interaction and loyalty
- Less product complexity and more manageable life cycles

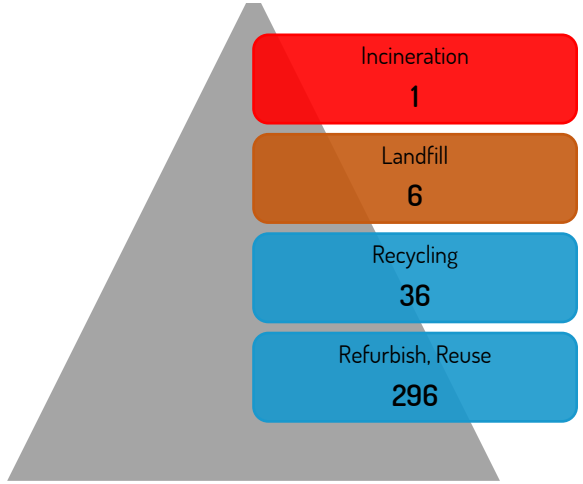
Source: Ellen MacArthur Foundation





Jobs

per 10,000 tons waste



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3. 2. SWOT

The analysis includes a general analysis by Thinking Circular® experts. Strength, weakness, opportunity and threat for the system have been identified. This SWOT template identifies the objects of discussion.

Template – searching for strengths, weaknesses, opportunities, threats

Strength

1. Loop (closed, nearly closed)
2. C2C – biological or technical cycle
3. Status of material bank
4. Status of energy- and resource
5. Market allocation
6. Other

Weakness

1. Supply side (resource scarcity vs. material bank)
2. Other

Opportunity

1. Demand side
2. Cost effectiveness
3. Growth rates
4. Innovation potential
5. Policy intervention
6. Other

Threat

1. Market concentration
2. Geopolitical resource policies
3. Other

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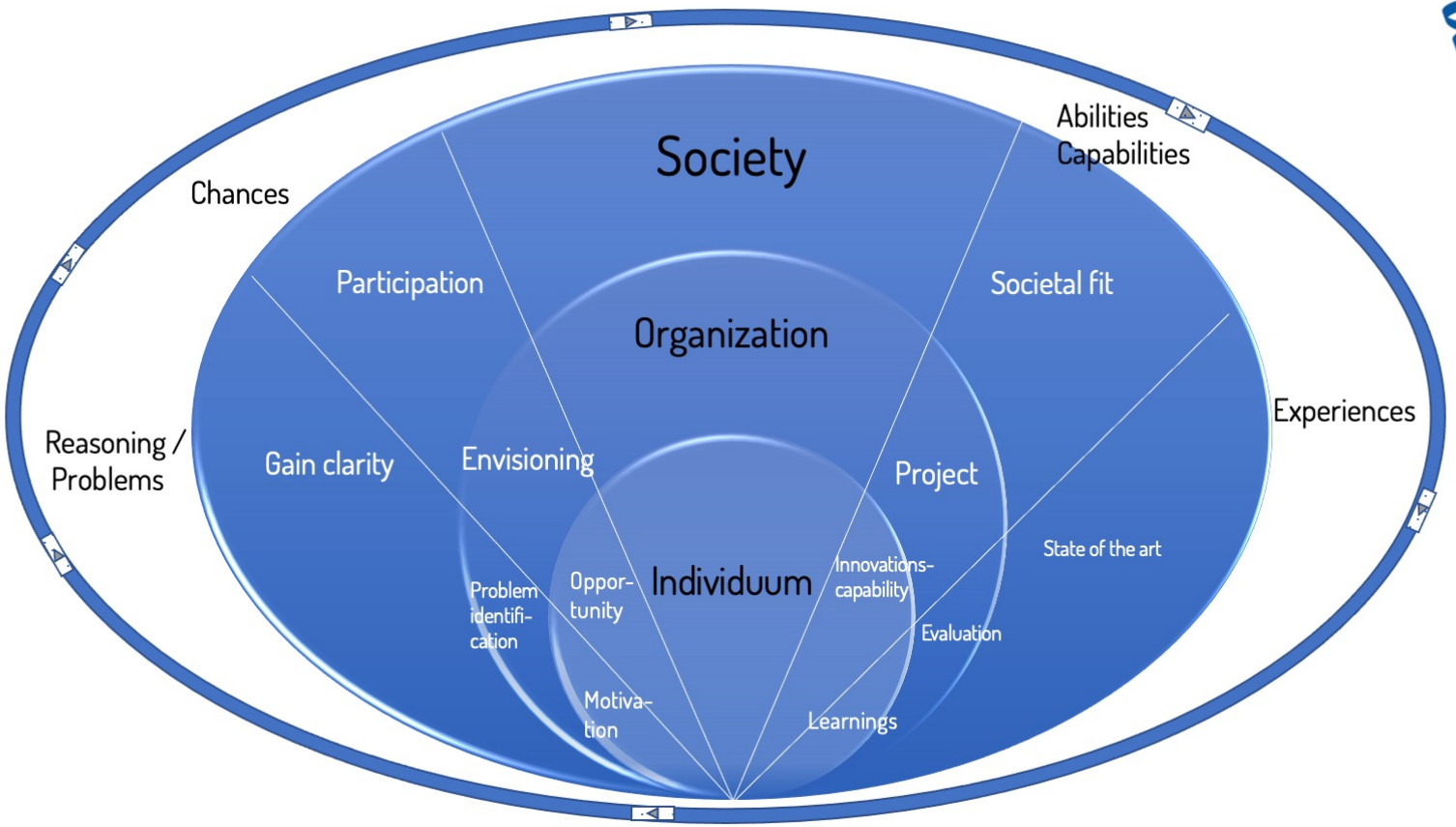
3.3. Cognition Spiral

Understanding, why technological, societal, ecological and economic development interacted has come into the focus of systems science. Economic development is understood as a symbiogenesis. This spiral offers a process for identification of patterns. It must be read clockwise from the very bottom (center) of the draft. It describes that any development starts with an individual motivation. Given an opportunity and innovation capability the individual can learn and drive his/her idea. On the next level, the individual will not drive the topic alone, but identify joint problems with others that can be solved on an organizational level. Through envisioning the solution, designing and proving in a project the group can learn and evaluate their project. Gaining clarity and offering participation to society, making the solution fit to public needs, will change state of the art in society, technology or environment. Next level evolution is solving problems on a higher level, seeking chances together, gaining through abilities, capabilities and experiences.

Sources: OECD, 2017; OECD, 2018

Template - searching for circular principles, drivers and catalysts



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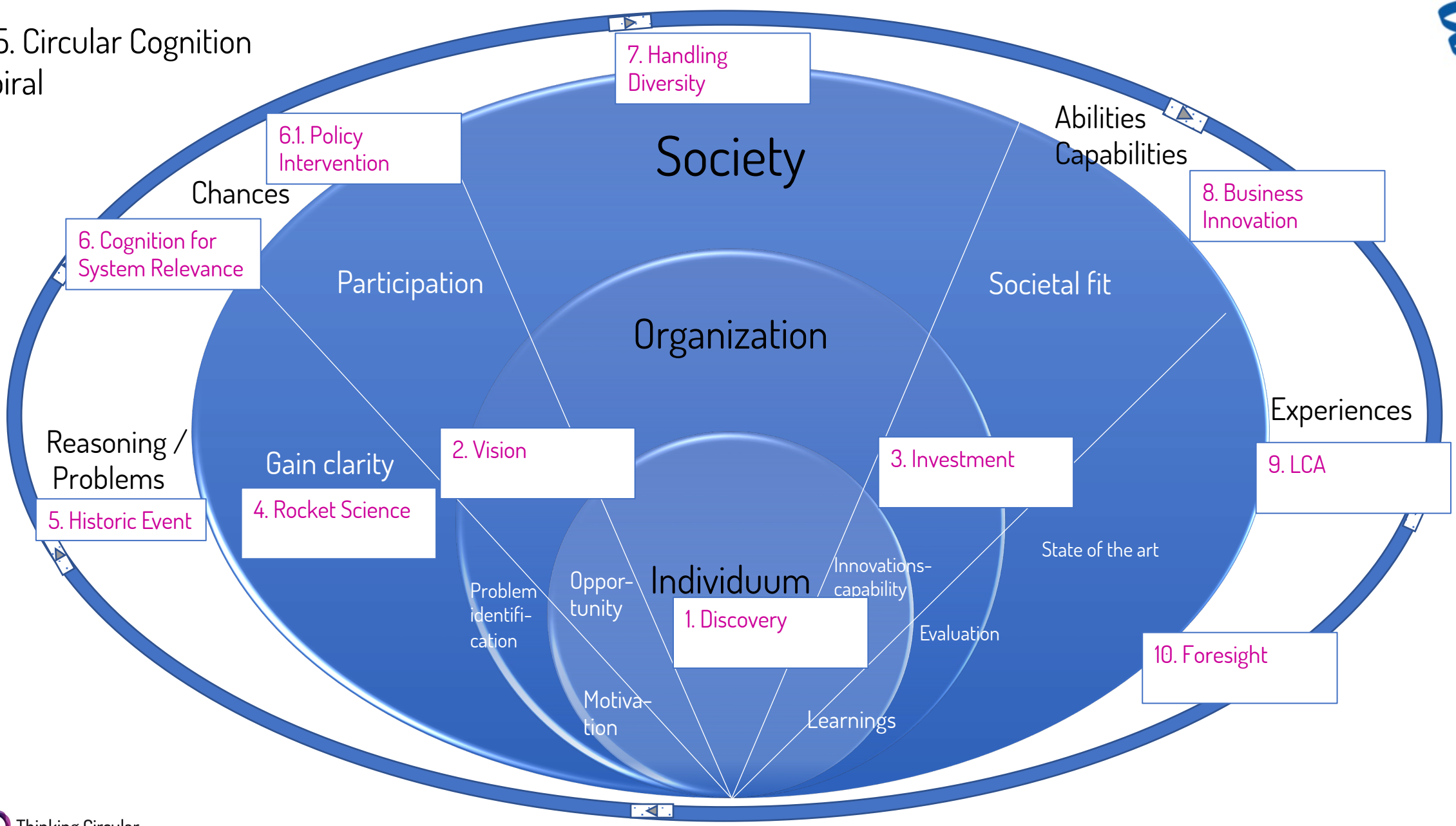
3.4. Loop patterns and innovation as organizational learning

Sources: Chen et. al., 2020; Schein, 2017

The next step in this analysis was to bring together the three theoretical aspects of 1. circular patterns that have been identified by Chen et al., 2. innovation steps that have been described in sound analysis by Schein on organizational learning and 3. imbed them within the template for the cognition spiral. This enabled Thinking Circular® to **extract innovational development patterns** as drivers and catalysts for material loops.

Loop patterns (Chen et. al., 2020)	Innovation as organizational learning (Schein, 2017)
Material **availability**	Discovery
< Technical and or social development, conserving the **complexity of use**	Vision, Mission, Strategy
Scalability	Investment
System relevance (monopoly/oligopoly)	Rocket science, causing system change
> Technical development (design for collection, separation)	Historic event, causing system change
Identification for participation, chain of custody	Cognition for system relevance rises
Installation of rules for management, according to **RESOLVE principle**	Policy intervention, regulation for or within changing systems
Scalability of value chain elements	Handling diversity
Building of material banks, **tracability**	Business innovation
Monitoring	LCA
Circular strategy	Foresight

3.5. Circular Cognition Spiral



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4. Evaluation

The evaluation as appendix based on the methodology is including the following elements for each material:

1. CSC

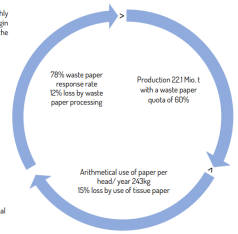
Paper, Germany - Circular System Characteristics

System characteristics:
Paper is a traditional system that has long been accepted by the population. Recycled paper is highly accepted due to its good quality and less energy consumption. Each year, 22.1 million tons of virgin paper get produced, whereof 17.4 million tons are used as recyclate. Research is done to extend the life cycle of fibers, life cycle assessment exist since 2000.

Availability/Role of recycling technology:
- Recycling rate 78% (technical cycle), technical maximum reached due to natural fiber degradation, 3-5 paper loops, renewable, C2C technology available.
- Predominant separation pulp and paper.
- Contamination through inks.

Maturity of market:
- Long established systems of waste collection, sorting, preparation.
- Stock market, stakeholder: Polypoly, private legal form.
- Competitive manufacturing markets: 91 companies, highly digitized.
- Competitive consumer markets (graphics, packaging, sanitary, specialties), not digitized.
- Competitive recycling markets: 380 for sorting, 53 for recycling, highly digitized.

Policy intervention type/regulations/directives:
- Environmental monitoring, sustainable forest and timber management.
- Collection and recycling systems regulated by law.
- MOMENTUM forest decline in 70s/80s, 1978 certified standard „Blue Angel" → transformational phase 10-15 years.



2. SWOT

SWOT Paper

Strength	Weakness
1. Closed loop 2. Technical cycle, 79% Recycling rate at maximum 3. Established systems 4. Certified standards 5. Scientific development program 6. Long history of paper sorting	1. Live cycle of fibers limited to 3-5 loops 2. High energy use 3. Overexploitation of forests 4. No recycling for hygienic papers 5. Contamination by print colors needs separate recycling technology
Opportunity	**Threat**
1. C2C technology available 2. Sustainable forest management 3. Water saving	1. Substitution by other material (i.e. plastic packaging) 2. Material mix (i.e. EPS in cardboard boxes) leads to downcycling or high sorting / recycling costs

3. Circular Cognition Spiral in pictures – 10 steps

4. Circular Cognition Spiral

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5.1 Summary: Drivers and Triggers

Drivers	Triggers
Management of diversity after use phase is under control – complexity reduction by collection, refurbishment, or recycling works.	**Scarcity** – resource scarcity forces policy makers to find solutions.
Management of diversity for use phase (minimizing material complexity) is either inherent or it is tech driven and under control.	**Regulation** – policies solve environmental / scarcity problems.
Scalability of the processes on local level: Working structures were identified on local/regional level.	
Functionality of market, public management or mixed allocation mechanism (PAS/DRS/market) is proven.	
No substitutes exist – substitutes can eliminate loop systems.	
Strong **market concentration** of players (monopolistic/oligopolistic) evolve as an **effect of system relevance** of the material characteristics.	
Mechanisms for collection and tracing are evolving (Identity preservation/ownership, banking or EPR).	
Policy fit of regulation and motivation to participate in the system (Cost reduction/gamification/ refund/speculation).	
Assurance of strategy coherence.	

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5.2. Summary Risks

All named circular risks refer to the challenge of minimizing material diversity within the product and process. Management of diversity must be at the center of the circular system.

In a nutshell: Risk minimization is a question of circular design.

	Description of risk
Aluminum	Design of compounds endanger **management of diversity for use phase** (minimizing material complexity) .
Asphalt	Layers, solvents, auxiliaries endanger **management of diversity after use phase** – recycling is becoming more difficult.
Biomass	**Scalability of the processes on local level at risk.**
Container glass	Design of compounds endanger **management of diversity for and after use phase.**
Gold	Electronic devices – the design and use of multiple materials endanger the **management of diversity after the use phase**, recycling is becoming more difficult.
Heavy Machinery	Electronic devices, plastics – the design and use of multiple materials endanger **the management of diversity for and after the use phase**.
Ion Exchanger	**Scalability of the processes on local level at risk.**
Paper	Print, furnish, auxiliaries endanger **management of diversity after use phase.**
PET	Compounds multiple layer packaging endanger **management of diversity** after use phase.
Slurry/Sludge	Inherent biological cycle – hazardous particles endanger **management of diversity** after use phase.

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Thank you for your attention

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