MOVECO

CIRCULAR ECONOMY INNOVATION TOOLS

New Material Pathways

Qualification Programme Handbook

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2. INTRODUCTION

2.1. INTRODUCTION

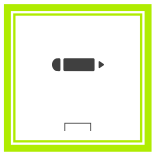
This document can either be used as background material for trainers and participants in a **workshop** or also by individual readers (**self-study** or within a self-formed study-group). For both cases, there are notes provided that guide through the material.

Indicative questions encourage you to reflect what you have just read.

In addition, throughout the text, you will find some indicative questions framed and marked by "?" that encourage to reflect what you have just read.

Cross-references to the case studies and further MOVECO materials help to deepen your knowledge about circular economy.

Moreover, there are cross- references to the case studies or other MOVECO material (such as the fact sheets) marked by "".



Practical exercises are pointed out for trainer-led workshops or self-study by individual readers or a self-formed study group

Further, the pencil sign points out practical exercises that can be done as part of a trainer-led workshop or in self-study by individual readers or a self-formed study group.

For the **practical** work, there are several **case studies** that invite discussion or reflection – paired with empty templates for worksheets that encourage looking at a self-chosen practical product example. In the end, there is a short quiz to test the knowledge gained in this section of the toolbox. You will find any specific terminology explained in the **glossary**. If you use this section as part of a workshop, there is an **evaluation form** at the very end that can be used to collect feedback at the end of the workshop.

3. CONTENT

3.1. SCHOOLS OF THOUGHTS – INDUSTRIAL ECOLOGY

Over the past one hundred and fifty years, industry has seen spectacular growth due to the systematic exploitation of the environment, which has affected, in the long run and sometimes irremediably, many natural ecosystems.

Taking into account all these developments, a number of scientists have proposed, having as a model these natural ecosystems, a series of solutions that ultimately allow for a peaceful coexistence between natural and industrial ecosystems, so that the environ-affected to a lesser extent or not at all. One of this solutions is industrial ecology.

3.2. INDUSTRIAL ECOLOY DEFINITION

The "*Industrial Ecology*" termderived from the concept of "industrial ecosystem", notion launched by Robert Frosch and Nicholas Gallopoulos in 1989 in the article titled "Strategies for Manufacturing" (Scientific American 261; September 1989, p.144–152), after, also in 1989, Robert Ayres had introduced the term of "industrial metabolism", described as being how materials and energy are used by the industry and the ways in which some of them turn into waste.[1]

"Industrial ecology is dealing with the study of energy and material which flows through industrial systems"[2]. This discipline makes a parallel between the artificial ecosystem that is the industry and the natural ecosystems, where the resulted waste from a process is used as raw material for other processes. Industrial ecology is trying to make more efficient the activities within the artificial ecosystems according to the natural model, so that they move from the linear process to a cyclical, closed process.

Man-made ecosystems are also in a state of continuous activity, in a continuous transformation. Considering the problems caused by industrial activities on theenvironment due to the useofthe planet's natural resources and waste disposal issues, industrial ecology tracks the flow of materials within these types of ecosystems.

Industrial ecology is a frontier science that brings together knowledge that highlights the relationships and links between industrial production, sustainable, clean and environmentally friendly technologies.

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[1] See Garner,A & Keoleian,G – Industrial ecology: an introduction - gttp://www.umich.edu/~nppcpub/resources/compendia/INDEpdfs/INDEintro.pdf, visited at 30.03.2018

[2]https://en.wikipedia.org/wiki/Industrial_ecology, visited at 30.03.2018

Nowadays, as a result of industrial processes and by the elimination of waste resulting from economic activities, the environment is increasingly affected.

Therefore, through innovation activities, resource efficiency, re-introduction of waste into the industrial circuit, ensuring sustainable growth, industrial ecology proposes a sustainable economic model that tends to reduce pollution. In fact, one of the basic ideas of industrial ecology is that the natural ecosystems do not produce waste. That is why industrial ecology proposes a model of development similar to the natural ecosystems, so that the industry continues to function and develop, but the development must take into account the problems of the environment.

In such a system, industry uses its own waste as a source of raw material, either for existing industries or for training industries, interacting friendly in this way with the nature.[3]

This science use a number of terms such as environmental performance, sustainable use of natural resources, risk analysis, analysis of material flows and processes, energetic efficiency, ecological design, recycling and reuse of produced waste, producers' responsibility.

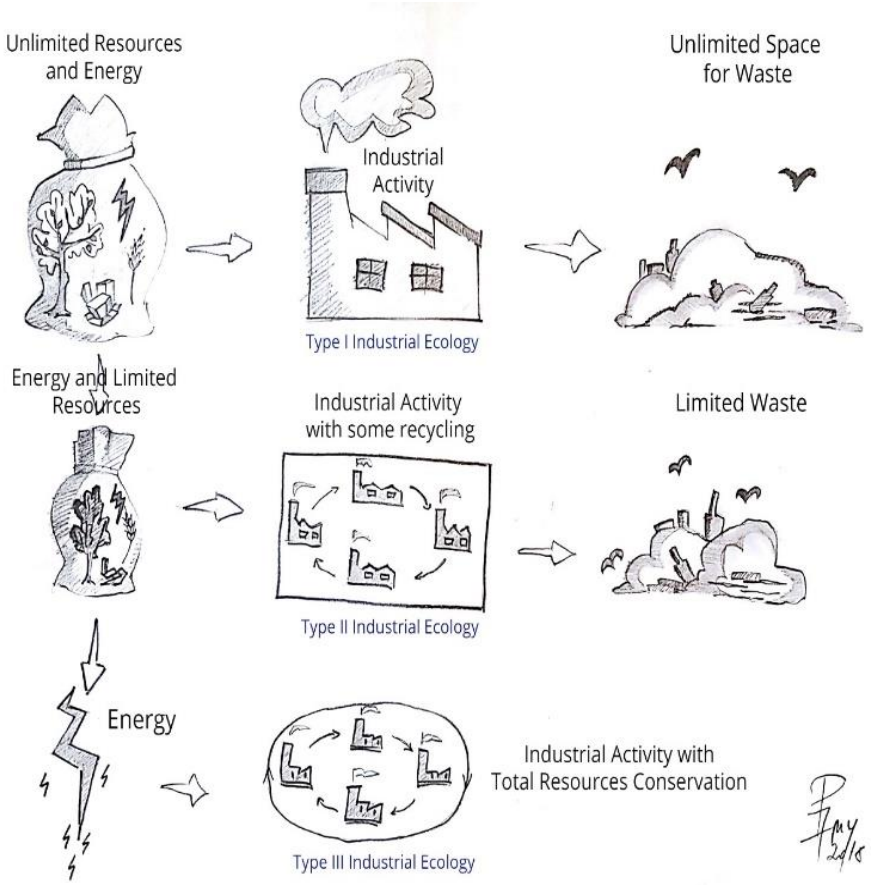

Figure 1. The three types of Industrial Ecologies[4]

[3] See The Global Development Research Center – Sustainability concepts: Industrial ecology - https://www.gdrc.org/sustdev/concepts/16-I-eco.html, visited at 30.03.2018

[4]Picture credit Chamber of Commerce and Industry Bistrita Nasaud – processed after Jonathan Krones – A Beginner's Guide to Industrial Ecology -

In a graphical representation of the previously exposed,we can divide into three categories industrial ecosystems. Thus we have in the first instance the industrial ecosystems of Type 1, characteristic of the current period, in which the resources exploited without restrictions are practically scattered and the wastes are discarded, there being enough space for the storage of this.

An evolution of these is the industrial Type 2 ecosystems. In the case of these, it has been noticed that there are a number of problems, that the environment is affected by the storage of waste and also that the resources are not unlimited. Under these conditions, there are pressures on the economic environment, including the growing costs of resources that are increasingly rare. That is why the first steps are being taken for the reuse of waste, thus defining the first loops within these artificial ecosystems.

The real solution of the environmental problems is provided by the industrial Type 3 ecosystems. In their case, the reuse of the materials and the waste is made entirely, and only insignificant quantities of raw materials and supplies are needed for their proper functioning. The energy used in the industrial processes comes entirely from renewable energy sources. The transition to this model raises a number of issues, first of all the technological nature.[5]

3.3. PRINCIPLES OF INDUSTRIAL ECOLOGY[6]

The principles of industrial ecology, which were spoken by Hardin B.C.Tibbs in 1992, are:

* Transforming current industrial ecosystems into new closed-loop ecosystems so that industrial process waste is used as a source of raw materials.

*The emergence of partnerships between various industrial branches, existing or undergoing training, for the transfer of waste so that they can be used where raw materials are needed.

* Creating a balance between demand for raw materials and supplies, imitating what is happening in natural ecosystems, thus limiting the stress of the

* Optimizing how industrial ecosystems interact with natural ecosystems by studying their behavior over time, so that the environmental impact is minimal.

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https://www.researchgate.net/profile/Jonathan_Krones/publication/265566424_A_Beginner%27s_Guide_to_Industrial_Ecology/links/5526a3150cf2f6e6516a02e5/A-Beginners-Guide-to-Industrial-Ecology.pdf, visited at 30.03.2018

[5] See Krones, J – A Beginner's Guide to Industrial Ecology - https://www.researchgate.net/profile/Jonathan_Krones/publication/265566424_A_Beginner%27s_Guide_to_Industrial_Ecology/links/5526a3150cf2f6e6516a02e5/A-Beginners-Guide-to-Industrial-Ecology.pdf, visited at 30.03.2018

[6] See The Global Development Research Center – Sustainability concepts: Industrial ecology - https://www.gdrc.org/sustdev/concepts/16-I-eco.html, visited at 30.03.2018

* Studying the mode and timing of waste dematerialization, thus ensuring the use of less virgin materials and energy. Optimizing the management and use of all types of resources, including by reuse materials or substituting one of them with more environmentally friendly materials.

* Increasing the performance of all industrial processes by achieving an ecological design of products, processes and equipment, thus ensuring that they are reintroduced into the economic circuit of materials, thus conserving resources.

* The energy used in industrial ecosystems should come in as much as possible from renewable, environmentally friendly sources, so that the impact on the environment is as small as possible. A desired goal is to integrate energy generation into industrial ecology.

* Inclusion as a basic element of industrial ecology in national, regional and international policies, as well as environmental protection. Supporting the transition to a green economy, including through the use of effective fiscal measures to encourage such a transition. Using a more comprehensive notion to highlight a nation's wealth instead of GNP.

3.4. BENEFITS OF THE INDUSTRIAL ECOLOGY

Transition to a type of economy where industrial ecosystems work similar to natural ecosystems, will bring a wealth of benefits, primarily to the environment, but not only. Of these, we will remember only a few:

- due to the use of waste as sources of raw materials for other industrial branches, the quantity of those stored in nature will decrease progressively and continuously until complete disposal, which will lead to the elimination of environmental pollution.
- by using waste, the amount of raw material required in the various industries decreases and therefore reduces environmental stress by exploiting them.
- increasing the amount of waste used in industry instead of raw material will lead to lower production costs per unit of manufactured wares.
- due to the sale of the waste that will replace the raw material, the revenues obtained in a series of industrial branches will increase.
- through the economic exchanges that will take place between the different branches of industry, the collaboration between them will be improved- in an economy that works in this way, it improves the quality of life.

3.5. CASE STUDY COLLECTION AND VALUATION OF USED BATTERIES IN THE REBAT COPSA MICA ROMANIA

Company: ROMBAT SA
Address： 4, Drumul Cetăţii st.
Bistrita, Bistriţa-Năsăud, 420129
Romania

The company Rombat SA, producer of lead acid batteries, collects the used batteries

(through the distribution stores or directly), with the purpose of their valuation in the RebatCopsa Mica working point. Over 83% of the battery weight is reused in new processes of production. Rombat distributes batteries in more than 3000 stores across Romania.

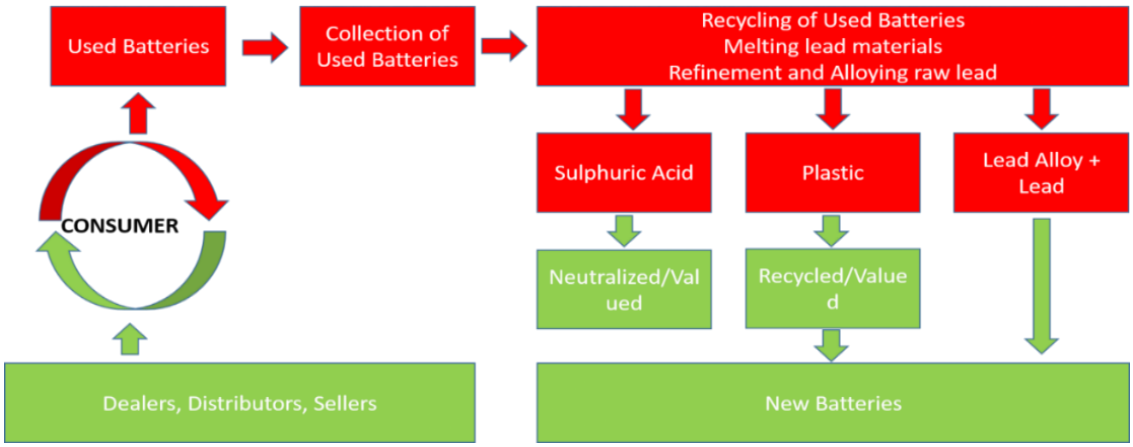
The company is progressive upgrading and retooling the technological flows in order to reduce the impact of its activities, products and services on the environment.

The activity in RebatCopsa Mica working point consists in recycling of used batteries. This provides recyclable materials, having an important contribution to the maintenance of a lower selling price for the Rombat battery.

This also contributes to less pollution of the environment (used batteries that are thrown away pollute the soil, the water and the air).

From the social point of view, it creates jobs for about 80 persons.

Foto credit: ROMBAT SA Bistrita



Picture credit : Rombat SA

CYCLE OF TREATMENT

Compliance with B.A.T. requirements for the recovery of used lead - acid battery. (Reference Document on Best Available Techniques in the non Ferrous Metals Industries).

Picture credit: ROMBAT SA

RECOVERY PROCESS

1.*Braking:*

For the recovery of lead from used lead-acid batteries, the operator applies the MX and CX (Engitec) processes, respectively the breaking and separation of batteries and components by use of patented automatic equipment.

2. Smelting:

The smelting of lead waste is done in a rotary BJ furnace with a capacity of 5 cube meters and 2 furnaces of 1.8 cube meters each. The rotary furnace is equipped with mobile burners. The control of the oxygen / gas ratio is done by control panel.

3. Refining / Alloying / Casting:

Thermal refining is a pyro metallurgical process carried out in refining pots, where the homogenization of the lead mass occurs and the removal of impurities. The process takes place by adding specific materials to this process for example S, O2, NaOH.For alloying there are use elements like: Sn, As, Ca, CaAl, Ag, etc.

Conclusion: The activity of ROMBAT SA is a good example of how an industrial ecosystem transforms, moving from an industrial ecology of type 1 to an industrial ecology of type 3. Thus, for this company, at the end of the manufacturing cycle and at the end of the battery life, the waste is taken over, processed in full, and water is recovered from the electrolyte of the batteries, which is reused in the production process. That is why the industrial ecosystem so created is much closer to an industrial type 3 than a type 2 industrial ecosystem, the waste being fully recovered and reintroduced into the production process. The only difference from an industrial 3-type ecosystem is that the energy used in this ecosystem does not come entirely from

renewable sources but also from conventional sources.

3.6. EXERCISE1

Exercise 1: Think about the industrial ecosystem in your company.

Goal: Identify industrial ecosystems and propose concrete measures using the principles of industrial ecology that transform them from Type 1 ecosystems into a Type 2 ecosystems. Think and propose other measures to turn them into Type 3 ecosystems.

3.7. EXERCISE 2

Using the Industrial ecology principles, try to redesign a known product:

1. Design phase :
    a. Define material flows:
    b. Choose a known product.
    c. Choose one or more materials from your product.
    d. Redesign the product in a way that will not affect comfort and mood.
    e. Provide constructive solutions in which a component performs several functions. Make as many functions as possible with fewer components.
    f. Use new or easily recyclable materials in the design phase to minimize the environmental impact.
    g. Redesign the product so that at the end of the lifetime of the finished product, as many components can be reused immediately or in short time.
2. Manufacturing
    a. Use energy from renewable sources in the manufacturing process.
    b. Remove harmful materials that affect the environment.
    c. If natural materials are not available, easily biodegradable materials are used in the manufacturing process.
    d. Use modular manufacturing solutions for products so that they allow proper maintenance, with damaged parts being easily changed.
    e. Preferred are technical solutions that include getting finished products with short execution times and minimum costs.
3. Use
    a. Is the product safe for the environment during its use ?
    b. Can the product be repaired, refurbished or remanufactured ?
4. End of life
    a. Can the product, at the end of its economic life, be easily decomposed into component parts ? What percentage of these are reusable immediately after dismantling? What percentage of these are easily recyclable ?

4. QUESTIONS &ANSWERS

4.1. QUIZ –QUESTIONS

This quiz can be used at the end of the workshop to check whether the key content has been understood and to sum up the most relevant take-home-messages.

1. **Industrial ecology is:**
   - ☐ a process
   - ☐ a technology
   - ☐ a frontier science
2. **Industrial ecologymakes a parallel between:**
   - ☐ different industrial processes
   - ☐ different industrial processes and different processes from the environment
   - ☐ the artificial ecosystem - industry and the natural ecosystems
3. **How many types of industrial ecology (and correspondingly how many types of industrial ecosystems) we know ?**
   - ☐ 2
   - ☐ 3
   - ☐ 4
4. **Industrial ecology proposes:**
   - ☐ the full reuse of waste and the use of energy produced entirely from renewable sources
   - ☐ partial disposal of waste and the use of energy produced by classical methods
   - ☐ total disposal of waste and the use of energy produced by classical methods
5. **Using the principles of industrial ecology we obtain:**
   - ☐ optimizing how industrial ecosystems interact with natural ecosystems
   - ☐ increasing the performance of all industrial processes
   - ☐ a balance between demand for raw materials and supplies

4.2. QUIZ – SOLUTIONS

1. Industrial ecology is:
   - ☐ a process
   - ☐ a technology
   - ↳ a frontier science
2. Industrial ecology makes a parallel between:
   - ☐ different industrial processes
   - ☐ different industrial processes and different processes from the environment
   - ↳ the artificial ecosystem - industry and the natural ecosystems
3. How many types of industrial ecology (and correspondingly how many types of industrial ecosystems) we know ?
   - ☐ 2
   - ↳ 3
   - ☐ 4
4. Industrial ecology proposes:
   - ↳ the full reuse of waste and the use of energy produced entirely from renewable sources
   - ☐ partial disposal of waste and the use of energy produced by classical methods
   - ☐ total disposal of waste and the use of energy produced by classical methods
5. Using the principles of industrial ecology we obtain:
   - ↳ optimizing how industrial ecosystems interact with natural ecosystems
   - ↳ increasing the performance of all industrial processes
   - ↳ a balance between demand for raw materials and supplies

5. GLOSSARY

- **Bio-based material:** ""Bio-"is Greek for life. Bio-based material refers to a products main constituent consisting of a substance, or substances, originally derived from living organisms. These substances may be natural or synthesized organic compounds that exist in nature. This definition could include natural materials such as leather and wood, but typically refers to modern materials. Many of the modern innovations use bio-based materials to create products that biodegrade. Some examples are: cornstarch, derived from a grain and now being used in the creation of packaging pellets; bio-plastics created with soybean oil, now being used in the creation of many modern products like tractors, water bottles, and take away cutlery." [6]**Biodegradable material**: "A material which microorganisms can break down into natural elements (i.e. water, biomass, etc.)."[7]
- **Biological metabolism** - The natural processes of ecosystems are a biological metabolism, making safe and healthy use of materials in cycles of abundance[8]
- **Biological Nutrient** - A material used by living organisms or cells to carry on life processes such as growth, cell division, synthesis of carbohydrates and other complex functions. Biological Nutrients are materials that can biodegrade safely and return to the soil to feed environmental processes[9]
- **Cascading**: see MOVECO fact sheet "Circular Economy: Terms & Definitions"
- **Compostable material**: "Materials that can be disposed with biological materials and decay into nutrient-rich material."[10]**Circular economy** - regenerative economy in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops
- **Cradle-to-Cradle®:** see MOVECO fact sheet "Supporting Tools for a Circular Economy"
- **Cradle to Grave** – "A Cradle to Grave system is a linear model for materials that begins with resource extraction, moves to product manufacturing, and, ends with a "grave" – when the product is disposed of in a landfill or incinerator"[11]
- **Decision** – "shall be binding in its entirety. A decision which specifies those to whom it is addressed shall be binding only on them"[12]
- **Directive** – "shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods"[13]

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[6]https://sustainabilitydictionary.com/2006/02/17/bio-based-material/ (26.03.2018) // "A material that is partially, or entirely made of biomass." https://www.ceguide.org/Glossary (26.03.2018)
[7]https://www.ceguide.org/Glossary (26.03.2018)
[8]Cradle to Cradle terminology – MBDC-http://www.c2cproducts.com/detail.aspx?linkid=1&sublink=26
[9]Cradle to Cradle terminology – MBDC-http://www.c2cproducts.com/detail.aspx?linkid=1&sublink=26
[10]https://www.ceguide.org/Glossary (26.03.2018)
[11]Cradle to Cradle terminology – MBDC-http://www.c2cproducts.com/detail.aspx?linkid=1&sublink=26
[12]European Network of Environmental law Organizations 2012 Implementation of the Waste Framework Directive in the EU Member States
[13]European Network of Environmental law Organisations 2012 Implementation of the Waste Framework Directive in the EU Member States

- **Down-cycle** - to recycle (something) in such a way that the resulting product is of a lower value than the original item : to create an object of lesser value from (a discarded object of higher value)[14] see: MOVECO fact sheet "Circular Economy: Terms & Definitions"
- **Eco-Effectiveness** – "The central strategy in the cradle-to-cradle development method and seeks to create industrial systems that emulate healthy natural systems. The central principle of eco-effectiveness is that "waste equals food." The concept was developed in response to some of the perceived limitations of eco-efficiency which critics claim only slow down the rate of environmental depletion and don't reverse the production of unused or non-recycled waste".[15]
- **Eco efficiency** – "Management philosophy that aims at minimizing ecological damage while maximizing efficiency of the firm's production processes, such as through the lesser use of energy, material, and water, more recycling, and elimination of hazardous emissions or by-products."[16]
- **Ecological sustainability** – "a bio-centric school of sustainability thinking that, based on ecology and living systems principles, focuses on the capacity of ecosystems to maintain their essential functions and processes, and retain their biodiversity in full measure over the long-term contrasts with technological sustainability based on technical and engineering approaches to sustainability"[17]
- **Ecosystem** - the interactive system of living things and their non-living habitat[18]
- **Ecosystem redesign** - a coherent framework for redesigning our landscapes, buildings, cities, and systems of energy, water, food, manufacturing and waste through the effective adaptation to and integration with nature's processes[19]
- **Energy efficiency**: "Energy efficiency improvements refer to a reduction in the energy used for a given service (heating, lighting, etc.) or level of activity. The reduction in the energy consumption is usually associated with technological changes, but not always since it can also result from better organization and management or behavioral changes ("non-technical factors")."[20]
- **Energetic use**: incineration of waste material that includes the use of the generated heat and energy for other processes
- **(Final) disposal**: see MOVECO fact sheet "Circular Economy: Terms & Definitions"

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[14]Merriam Webster dictionary

[15]https://sustainabilitydictionary.com/2005/12/03/eco-effectiveness/visited26/02/2018

[16]http://www.businessdictionary.com/definition/eco-efficiency.html-visited 01.03.2018

[17]Orr D (1992) Ecological literacy: education and the transition to a post-modern world. State University of New York Press, Albany.

[18]Tansley AG (1935) The use and abuse of vegetational concepts and terms. Ecology 16:284–307 doi:10.2307/1930070

[19]with adaptations from https://www.researchgate.net/publication/301966198_Regenerative_Development_regenerative_development_and_Design (26.06.2018)

[20]https://hub.globalccsinstitute.com/publications/energy-efficiency-recipe-success/definition-and-scope-energy-efficiency (26.03.2018)

- **Incineration**: Waste destruction in a furnace by controlled burning at high temperatures. Incineration removes water from hazardous sludge, reduces its mass and/or volume, and converts it to a non-burnable ash that can be safely disposed of on land, in some waters, or in underground pits. However, it is a highly contentious method because incomplete incineration can produce carbon monoxide gas, gaseous dioxins, and/or other harmful substances.[21]
- **Innovation** - production or adoption, assimilation, and exploitation of a value-added novelty in economic and social areas[22]
- **Landfilling**: "The disposal and burying of solid waste. The degradation of the waste results in the creation of local air and water pollution."[23]
- **Lean production** - approach to management that focuses on cutting out waste, whilst ensuring quality[24]
- **Life-cycle** - series of stages in form and functional activity through which a system passes between successive recurrences of a specified primary stage[25]
- **Life-cycle analysis**: see MOVECO fact sheet "Supporting Tools for a Circular Economy"
- **Life-time** - the duration of the existence of a given particular system[26]
- **Locational patterns** - the patterns that depict the distinctive character and potential of a place and provide a dynamic mapping for designing human structures and systems that align with the living systems of a place[27]
- **Negative externality** - occurs when production and/or consumption imposes external costs on third parties outside of the market for which no appropriate compensation is paid[28]
- **Optimization** - finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones[29]
- **Permaculture** - a system of agricultural and social design principles centered around simulating or directly utilizing the patterns and features observed in natural ecosystems[30]
- **Place** - the unique, multi-layered network of ecosystems within a geographic region that results from the complex interactions through time of the natural ecology (climate, mineral and other deposits, soil, vegetation, water and wildlife, etc.) and culture (distinctive customs,

[21] http://www.businessdictionary.com/definition/incineration.html (27.06.2018)
[22] with adaptations from http://www.ericshaver.com/the-many-definitions-of-innovation/ (27.06.2018)
[23] https://www.ceguide.org/Glossary (26.03.2018)
[24] with adaptations from https://www.tutor2u.net/business/reference/introduction-to-lean-production (27.06.2018)
[25] https://www.merriam-webster.com/dictionary/life%20cycle (26.06.2018)
[26] With adaptations from https://en.wikipedia.org/wiki/Lifetime (26.06.2018)
[27] https://www.researchgate.net/publication/273379786_Regenerative_Development_and_Design (25.06.2018)
[28] with adaptations from https://www.economicshelp.org/micro-economic-essays/marketfailure/negative-externality/ (26.06.2018)
[29] http://www.businessdictionary.com/definition/optimization.html (26.06.2018)
[30] https://en.wikipedia.org/wiki/Permaculture(27.06.2018)

expressions of values, economic activities, forms of association, ideas for education, traditions, etc.)[31]

- **Recommendations and opinions** - shall have no binding force [32]
- **Recycling:** see MOVECO fact sheet "Circular Economy: Terms & Definitions"
- **Refurbishment:** "The refurbishment of something is the act or process of cleaning it, decorating it, and providing it with new equipment or facilities."[33]
- **Regenerative design** - a system of technologies and strategies, based on an understanding of the inner working of ecosystems that generates designs to regenerate rather than deplete underlying life support systems and resources within socio-ecological wholes[34]
- **Regenerative development** - a system of technologies and strategies for generating the patterned whole system understanding of a place, and developing the strategic systemic thinking capacities, and the stakeholder engagement/commitment required to ensure regenerative design processes to achieve maximum systemic leverage and support, that is self-organizing and self-evolving[35]
- **Regulation** - shall have general application. It shall be binding in its entirety and directly applicable in all Member States. – Source - Article 288 TFEU, [36]
- **Remanufacturing:** "The process of cleaning and repairing used products and parts to be used again for replacements."[37]
- **Restorative design** - sometimes called restorative environmental design; a design system that combines returning polluted, degraded or damaged sites back to a state of acceptable health through human intervention[38]
- **Resource efficiency**: "A percentage of the total resources consumed that make up the final product or service."[39] re-use: see MOVECO fact sheet "Circular Economy: Terms & Definitions"
- **Secondary resource/ secondary raw materials:** "Waste materials that are recovered, recycled and reprocessed for use as raw materials."[40]
- **Servitization** - refers to industries using their products to sell "outcome as a service" rather than a one-off sale[41]
- **Source to sink** - simple linear flows from resource sources (farms, mines, forests, watershed, oilfields, etc.) to sinks (air, water, land) that deplete global sources and overload/pollute global sinks[42]

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[31]https://www.researchgate.net/publication/273379786_Regenerative_Development_and_Design (25.06.2018)
[32]http://eur-lex.europa.eu/summary/chapter/environment.html?root_default=SUM_1_CODED%3D20,SUM_2_CODED%3D2003&locale=en
[33]https://www.collinsdictionary.com/de/worterbuch/englisch/refurbishment (26.03.2018)
[34]Mang, Pamela & Reed, Bill. (2017). Update Regenerative Development and Design 2nd edition.
[35]https://www.sciencedirect.com/science/article/pii/S2212609015300327 (26.06.2018)
[36]http://eur-lex.europa.eu/legal-content/en/TXT/HTML/?uri=CELEX:12016E288
[37]https://sustainabilitydictionary.com/2005/12/03/remanufacturing/ (26.03.2018)
[38]https://www.researchgate.net/publication/273379786_Regenerative_Development_and_Design (24.06.2018)
[39]https://sustainabilitydictionary.com/2005/12/03/remanufacturing/ (26.03.2018)
[40]https://sustainabilitydictionary.com/2005/12/03/remanufacturing/ (26.03.2018)
[41]https://www.k3syspro.com/servitization/(24.06.2018)

- **Stewardship** - ethic of companies, organizations and individuals that embodies the responsible planning and management of resources[43]
- **Sourcing:** "the act of getting something, especially products or materials, from a particular place"[44]
- **System thinking** - holistic approach of analysis and planning that focuses on the way the parts of a system interrelate each other and how systems work over time and within the context of larger systems[45]
- **Technical metabolism** - "Modelled on natural systems, the technical metabolism is MBDC's term for the processes of human industry that maintain and perpetually reuse valuable synthetic and mineral materials in closed loops"[46]
- **Technical nutrient** – "A material that remains in a closed-loop system of manufacture, reuse, and recovery called the technical metabolism, maintaining its value through infinite product life cycles "[47]
- **Upcycle** – "to recycle (something) in such a way that the resulting product is of a higher value than the original item: to create an object of greater value from (a discarded object of lesser value)"[48]
- **Upcycling**: see MOVECO fact sheet "Circular Economy: Terms & Definitions"
- **Waste**: see MOVECO fact sheet "Circular Economy: Terms & Definitions"

More: https://www.ceguide.org/Glossary

[42]https://www.researchgate.net/publication/273379786_Regenerative_Development_and_Design (25.06.2018)
[43]https://en.wikipedia.org/wiki/Stewardship (24.06.2018)
[44]https://dictionary.cambridge.org/dictionary/english/sourcing (26.03.2018)
[45]https://searchcio.techtarget.com/definition/systems-thinking(27.06.2018)
[46]Cradle to Cradle terminology – MBDC-http://www.c2cproducts.com/detail.aspx?linkid=1&sublink=26
[47]Cradle to Cradle terminology – MBDC-http://www.c2cproducts.com/detail.aspx?linkid=1&sublink=26
[48]Merriam Webster dictionary

6. RESOURCES

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European Commission. 2016. Closing the Loop: An EU Action Plan for the Circular Economy. European Commission, June 28, 2016. http://ec.europa.eu/environment/circular-economy/index_en.htm

Effective Industrial Symbiosis - https://www.ellenmacarthurfoundation.org/case-studies/effective-industrial-symbiosis

Ministry of Environment and Energy, Danish Environmental Protection Agency, 2001 The Danish Model for Sustainable Waste Solutions Transferring know-how and expertise from Denmark to international solid and hazardous waste management projects

Page 4: Figure 1 - See Jonathan Krones - A beginner's guide to industrial ecology - https://www.researchgate.net/profile/Jonathan_Krones/publication/265566424_A_Beginner%27s_Guide_to_Industrial_Ecology/links/5526a3150cf2f6e6516a02e5/A-Beginners-Guide-to-Industrial-Ecology.pdf

Online video sources

Using Industrial Ecology to Close the Loop on Waste - https://www.youtube.com/watch?v=nSKjY9yhFjI

Kalundborg Symbiosis - https://www.youtube.com/watch?v=1yCYGOxnpSY

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