New connections to create self-generate and self-maintain production systems

C. Ceppa
Department of Architectural and Industrial Design,
Politecnico di Torino, Italy

Abstract

The research, in collaboration with Neosidea Group, is about the proposal of an instrument for analysis based on the concept of an open system that would allow the configuration and realization of networks of connections among different companies in geographic proximity, to achieve zero emission by implementing a sustainable management of their wastes. The goal is to design a system for processing information, that can organize data relative to output (waste), input (resources) and local companies. The processing system was also supplemented with the function of geo-locating businesses and materials This provides a solution and that gives not only information regarding new areas of application of the outputs but also determines with precision and localizes by territory the flows of material within a local network whose nodes are represented by the companies present on that territory; this promotes the local businesses and evaluates market opportunities of areas currently not yet exploited according to the systemic approach. Until now the area of application was the territory of the Piedmont Region. The advantages of such an approach are environmental and economic; it is possible to reduce the cost of eliminating waste, increase the profits from selling the company's outputs, while reducing environmental costs (air-pollution caused by the transportation of materials); the use of already existing materials in loco removes the need to exploit virgin raw materials. The functions of the software are: 1. producers of waste can determine which local companies could use its output as input, or find out which companies produce the outputs that it needs as resources; 2. it is an effective instrument for evaluating the entire production process, and also becomes a means for obtaining feedback: if the software doesn't give any results, it means that there are some problems in the process or in the input used.

Keywords: software, sustainable local networks and production, systems design, sustainable waste management, sustainable development, output-input, autopoietic system, reuse of waste, new local flows of materials.

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1 Introduction

Human activities on the local territory and the way natural resources are used, are the main causes, directly or indirectly, of the increase in environmental problems. In all human productive activities, whether they are farming or industrial, some of these used resources are returned to nature in the form of solid, liquid or gaseous waste in a way that is not predetermined or defined but random and inconstant throughout time. In the past few years the growth and volume of waste produced has reached distressing levels in Italy as in the rest of the world. On the one hand we find ourselves having to deal with substances that are difficult to eliminate and on the other hand we are witnessing a growing energy crisis and a worsening impoverishment of primary resources. The destruction or fragmentation of natural habitats, the excessive exploitation of the soil and resources for the purpose of mining, the introduction of allochthonous species (e.g. Chelazzi *et al*. [1]) to the detriment of autochthonous ones, the loss of biodiversity, the pollution of water, air and soil: these are only some of the consequences of the countless uncontrolled human activities on the environment. In the past few years there has been an attempt to remedy these problems. Researchers, entrepreneurs, economists and politicians have started focusing on the concept of sustainable development for the purpose of finding solutions, short and long-term, that can change the current production and consumption system into a system that not only we can use now but also future generations will be able to use. This is the only way to ensure all living things an environment that enables them to take care of all of their needs. For the most part these efforts produce "limited" actions because they are independent of each other, borne by single entities and not by a network of shared competencies. This is why today it is increasingly urgent to have the mediation competencies typical of Systems Design theory in order to analyze and try to make connections between a multitude of scientific and humanistic disciplines to answer questions and deal with issues that are environmental, social, cultural, political and economic. Partially influenced by the first law of ecology stated by American biologist Barry Commoner, (e.g. Filippone *et al*. [2]) according to whom "every entity is connected to every other entity", our research project aims to build a new network of relations and competencies whose nodes are represented by the various actors in each community (manufacturers, consumers, and public agencies) through whom the flows of knowledge and materials are conveyed. The contribution of Systems Design to the valorization of resources and protection of a territory is vital: the use of local resources allows development that gives priority to the local community and makes it possible to create autopoietic production setups that self-generate and self-maintain in terms of energy, production and procurement of resources (inputs) and the management of waste (outputs).

2 Thinking by connections: output become new resources

To promote the growth of autopoietic productive units we must examine the current production lines not by breaking them down into single independent sequential phases that are separate from each other but by studying the complexity of the whole of the parts according to the studies developed by the ecologist brothers Eugene P. and Howard T. Odum (e.g. Chelazzi *et al*. [1]). These men were among the first to conduct analyses on energy and the transfer of materials in complex natural ecosystems. These ecosystems were also observed by English botanist Arthur Tansley as an open-loop system that exchanges material and energy with other ecosystems. To understand the complexity of a system made up of relations between various players and a heart of energy and material flows, we are helped by examining "The System" par excellence: Nature. According to Leonardo da Vinci (e.g. Capra [3]) "in my inventions nothing is missing and nothing is superfluous"; in fact in nature there is no concept of waste because what one species eliminates is what another species uses for its nourishment (e.g. Capra [4]). Even surpluses are metabolized by the system itself. If these conditions, essential to any living system, are transferred to the world of production by applying the first principle of Systems Design according to which the waste (output) of one productive system can be used as a resource (input) for another, we will be promoting the type of production that moves towards zero emissions (e.g. Bistagnino [5]). In such a scenario all the actors involved in the production chain will start to reason by connections. Faced with the incapacity to introduce new techniques for managing the problem of waste, we are still using dumps. Nonetheless these should be considered a transitory and temporary solution. Therefore systemic methodology proposes a new approach that stimulates people and companies to reduce all forms of waste and helps valorize the remaining outputs by giving them a new economic and legislative value. This way not only the so-called waste products are elevated to a status of materials worthy of proper, controlled and more sustainable management, but they can "move" within the production chain with new positivity and dignity. The production process is no longer as a sequence of actions independent from one another but is considered in its entirety. In a world of growing complexity like ours, and particularly in consideration of the future of humanity, we need to let go of our exclusive focus on the "product" and its life cycle and extend our gaze to the whole of relations generated by the production process. Systemic theory is based on defining and creating a world made up of qualities that are often not quantifiable, connections that are apparently invisible but indispensable to life. It is a world not composed of "things" but relational systems that concretize what we observe (e.g. Barbero and Campagnaro [6]) and generate. The perspective of Systems Design challenges current industrial setups, emancipates us from a consumerist vision based exclusively on the product, and proposes a new production methodology. It considers humans as part of an ecological context whose interconnections and interdependencies are acknowledged and designs new flows of material and energy in the network of connections between different production units.

3 Systemic software: a tool to generate new networks in which know-how, well-being, materials and energy transit

Our current farms and industries throw away most of the resources they take from nature. Let us look at the case of beer. To produce this alcoholic beverage only 8% of the nutrients contained in barley or rice are used for fermentation. In the company itself over 90% of the water used in the process does not end up in the bottle or can (e.g. Pauli [7]) but is thrown away as waste, a material without value. To curb this phenomenon we need to create an instrument for making the changes needed on the level of the management, organization and procurement of energy and resources. We can start seeing the importance of creating an IT instrument for study and analysis based on the concept of an open-loop system that can help neighbor companies, according to their business purpose or geographical location, to organize themselves into "ecological networks" to achieve production that moves towards zero emissions by means of sustainable management and the valorization of waste. Moreover, profits can be obtained from the sale of these outputs (waste). This would create new flows of material that would connect different companies. These enterprises could reach a condition of reciprocal advantage by allowing the reutilization of the materials put out by their production processes. The constant exchange of information and sharing of knowledge between the players involved allows a continuous systemic culture to spread, along with the concepts of prevention and the ongoing improvement of the environment. In such a system the flows of materials generate (e.g. Eldredge [8]) internal links and relationships through single local systems can be defined. These systems would connect the various systems on a regional level and ultimately on a global level. Underlying these concepts we find the fundamental ways to procure resources in an ecosystem: the production of material in loco by using energy obtained from the surrounding environment and the importation of material produced and released by other ecosystems (e.g. Chelazzi *et al*. [1]). In other words, autochthonous production could use allochthonous inputs from external systems because they are closely connected and interdependent on each other. In this specific case the territory being studied is Piedmont Region. Its production is mainly metalworking, textiles, agriculture and cattle breeding. The starting point is to consider that the waste from these production processes, currently thrown away and not valorized, abound in precious resources for other manufacturing activities. According to the systemic methodology, production systems are observed according to their internal and external relations (with related industries), for the purpose of energy use, emissions control, procurement, the transportation of material and the management of outputs on the territorial level. They are redefined during planning and design and the outcome is a ramified, complex, multi-polar and strongly territory-linked operation. In these cases the waste is transformed into a productive resource and new relations are arise between local companies, thereby minimizing the use of external resources and allowing greater clarity in terms of the traceability of the production chains.

Table 1: Example of table, saved in the systemic software, which contains data about a systemic hazelnuts growing.

INPUT	ACTIVITIES	OUTPUT as NEW RESOURCES
rain water	hazelnut growing	hazelnuts
		pruning materials
		branches
hazelnuts	harvesting and washing	hazelnuts to be consumed by men
		hazelnuts to be transformed
		short leafy sheath
		water with soil
pruning materials	grinding	pellets
short leafy sheath	grinding	absorbent layer for animal stables
pruning materials	mining process	tannin
		oleic acid
branches	mining process	charcoal pencils
		gunpowder
hazelnut seedcoat	mining process	oleic acid
		linoleic acid
water with soil	plant-filtering process	purified water
dirty water		
water	food processing industry	hazelnut shell
hazelnuts to be transformed		top-grade seeds
		dirty water
		hazelnut seedcoat
		flour
		hazelnut oil
hazelnut shell	manufacturing industry	pellets
hazelnut oil	manufacturing industry	essential oil
tannin	tanning industry	leather
oleic acid		

This also helps determine which local activities can be related in an open-loop production system and what types of outputs can be reutilized by other production categories. From the information given on the MUD (Consolidated Environmental Declaration Form on which companies are required to declare the waste they produce, collect, treat or eliminate, send to be recycled or transport) we can see that currently approximately 142,000 tons [9] of the waste produced per year by agriculture, horticulture, aquaculture, forestry, is used as fuel or brought to the dump or destined to biological-physical-chemical treatments for

the purpose of producing compost or mixtures to be eliminated by scattering them on the soil or storing them in permanent warehouses. The same applies to the approximate 75,700 tons per year of waste produced by woodworking. These practices not only prevent exploiting the intrinsic wealth of these materials optimally but also cause a notable squandering of resources that can be used in other type of production. Moreover it is important to note that they also cause potential environmental hazards. To prefigure the use of outputs as resources in a new process, we attentively examine the quantities and qualities of waste produced currently on the regional territory of Piedmont and then categorize them according to their physicochemical and biological properties. We then determine possible fields of use for them. The results show the differences and advantages between the current production process according to a linear structure and the new one that proposes an open-loop industrial system based on sequence: quantity/quality of output> reutilization of output> resources> profits. As a matter of fact we find ourselves facing not only a merely environmental issue but discover that there is a possibility to create a network for selling one's outputs. The implementation of these concepts shows us how important it is to create and use an instrument that allows companies to connect to each other and act locally. This instrument must be created by the combined use of a computer and a network of shared knowledge and communication that allows a flow of different types of information such as texts, images, animations to be transmitted digitally. In specific, we propose the definition, design and realization of a system, the Systemic Software, for processing information based on evolved technological systems that can acquire, catalog and organize information relative to the productive activities in the area of study, the outputs produced and the inputs required as resources; this data is acquired and organized in terms of quantity, type, quality and geographical location on the territory. All the data are correlated with each other by means of a complex logic. The logic and the algorithms that intervene on the acquired information serve to normalize the structures, allowing them to be interlaced and evaluated by evolved technological instruments which serve to render the information in an intelligible and intuitive format for all of those who interface with the Systemic Software. The consultation of the system was designed by following the systemic approach and made usable by means of Web 2.0 technologies; this approach has made it possible to publish an interactive Web portal as a facility that can be used by operators who want to consult it and interact with it. We start with the premise that the availability of new raw materials must definitely be measured according to type, quantity and quality; but it is essential to also evaluate their geographic location. This is the added value that Systemic Software offers companies and the community in which they are located. The processing system, developed in collaboration with Neosidea Group, was also supplemented with the function of geo-locating business is and materials and this provides a solution and that gives not only information regarding new areas of application of the outputs but also determines with precision and localizes by territory the flows of material within a local network whose nodes are represented by the companies present on that territory: by doing this valorize and encourage local economies and provide an

accurate evaluation of market opportunities in areas not yet using and benefiting from the systemic approach. This technology makes it possible to obtain different levels of information regarding new business opportunities related to the companies on the network.

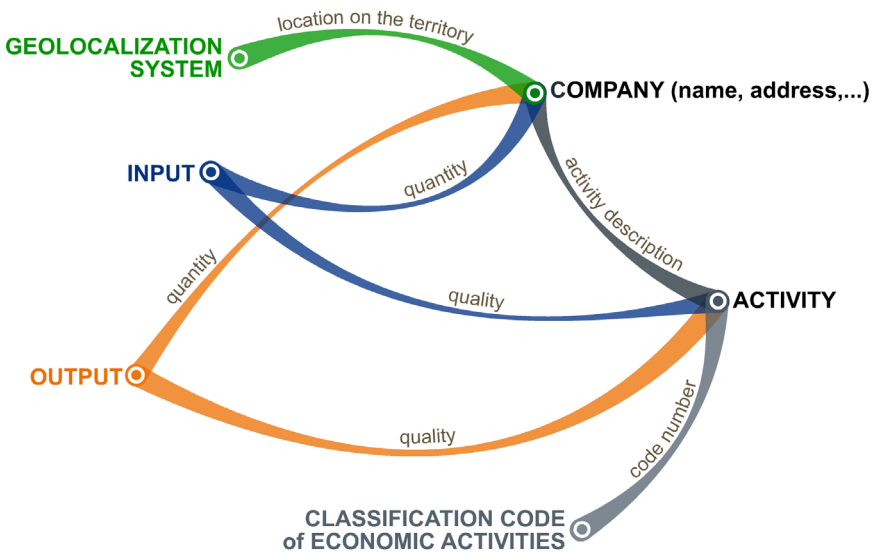

Figure 1: The connections between data saved in the systemic software.

Thanks to the development of a structured implementation logic based on the systemic vision, the information processing instrument or systemic software, is able to provide further information to set up new production chains and new flows of materials and services in favour of all the businesses who join the initiative thanks to a constant updating and comparison among the systemic logics for reusing materials, local productive activities and the territory itself (e.g. Ceppa *et al*. [10]). With the creation of this software we are proposing that short chains be set up in the production sphere that allows operators to contact local companies to procure resources or set up operations to reuse outputs for the purpose of reinforcing the bond with the local territory. According to this logic, the radius of action for the exchange of materials will not be greater than 60 km. This will reduce the time needed for procurement and the impacts of long-distance transportation. The greatest innovation offered by this approach consists of raising the awareness of producers that the problem of waste can be solved by activating complex relations in which the outputs of one productive process connect the nodes, which are local companies, of a network in which know-how, well-being, material and energy transit. The advantages of such an approach are environmental and economic; among these the most important goal is to reduce the cost of waste treatment and therefore increase the profits from selling the company's outputs, reducing environmental costs, such as the consumption of

energy, pollution and traffic caused by the transportation of materials; the use of already existing materials in loco removes the need to exploit virgin raw materials. The functions of the systemic software are fourfold:

- it gives output producers the possibility to determine which local companies could use their outputs as inputs;
- it tells input-seekers which companies produce outputs they can use as resources;
- it informs different producers about new business opportunities on the local territory that have previously remained hidden;
- it is an efficacious instrument for evaluating the entire production process; it is also an instrument for providing feedback.

Therefore this system can give useful and reliable information regarding one's current production process: if you enter the type of waste produced by your company as a search criterion, and the Software gives no results for possible reutilization of your outputs, this means your current production process makes waste that cannot be reused or recycled. It means your company produces items by using inputs and processes that do not comply with the vision of an open system. Therefore we have observed the need to implement certain changes within the production line, for example to reassess current inputs and substitute them with others that are more environmentally sustainable. Essentially we are proposing an IT network at the service of the environment, a web that speaks to the earthly roots of humanity and the deep need for a revived attention to nature and the resources it offers. The huge amount of data obtained by using Systemic Software is a precious asset and a vital platform for scholars of the environment, researchers, ecologists, public agencies, local administrators and, obviously, for entrepreneurs. The last mentioned actors will be able to work in a more sustainable way and in a growing number of concrete places, whether they are biotopes (e.g. Greco and Scaffidi [11]) or ecotopes, of the local ecosystem. The advantages of such an instrument are that they: improve usability, facilitate use and satisfaction, expand the potential area of users, improve the use of technological resources and local resources, raise the quality of life of society whose health depends on the way it relates to the environment hosting it, valorize the potentialities of the local territory and of the economy itself. The proposal of a technological support of this type arose from the consideration that this "virtual" web allows us to react more rapidly when confronted with environmental issues, involve different areas of users, and have a positive influence on decisions and actions taken by public institutions as well as on producer companies. It is an indispensable instrument for gaining thorough knowledge about one's own territory, discovering and valorizing its potentialities by sharing the knowledge of different people and entities and enabling collaboration participated in by all of the actors involved. We are talking about "an ecological and systemic web", made for the human dimension (e.g. Boscarol [12]) that can create a positive growth-promoting relationship among its users.

4 Results obtained

With this document I would like to illustrate a production chain that starts with a cow farm and ends with the retail sale of final products, passing from the milking phase to slaughter. Till now there have been various critical points within the entire process due mainly to the insufficient valorization and improper use of outputs which are thrown away carelessly. Among them I would like to point out the water which contains certain percentages of urine or milk or blood, in addition to the organs and blood of the animals. By applying the systemic methodology, and using Systemic Software, it was possible to establish new ways to use these resources and create local flows of material. The outputs from the cow farm were sent to other production enterprises: the water with urine content was sent to water treatment facilities to be treated. The manure, sawdust and urine were used in biogas production plants which produce methane and sludge that are excellent ingredients for high-quality compost for farming purposes. The outgoing material of the milking phase is currently thrown away but the water contains a certain percentage of milk. This resource is rich in nutritional value if managed systemically and can be used to feed freshwater fish. Numerous critical points were also found in the slaughtering process. Particularly noticeable was the problem of the squandering of certain fundamental byproducts with a high biological value, e.g. the blood (e.g. Ganapini [13]). In the new web of connections blood is used for the production of soil and natural flower fertilizer. Blood traces were also contained in the water sent to treatment plants and plant-filtering processes. The remains of the meat and some of the animals' organs and entrails give a major contribution to raising

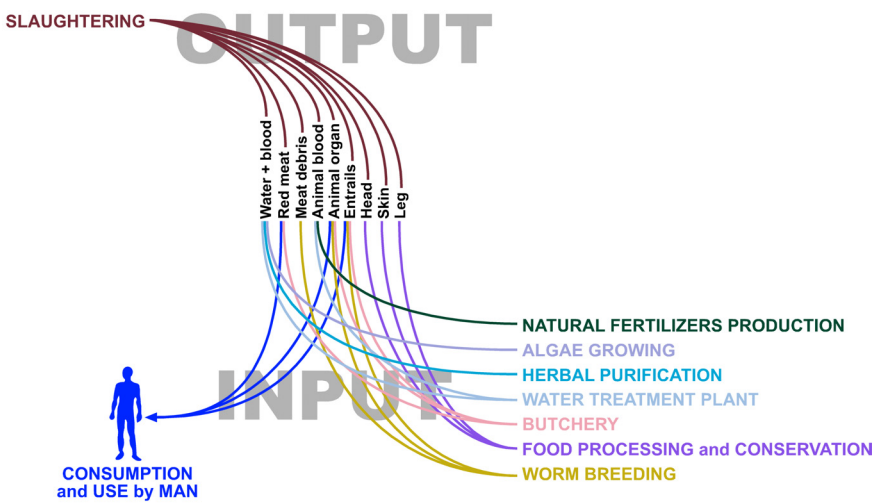

Figure 2: New flows of material show new business opportunities to entrepreneurs, public agencies and local administrators.

worms (from 150 kg of meat, we obtain approximately 300 larvae and worms), an essential food for raising quail. Quail eggs are high-quality food products. The last phase of the chain, the retail sale of the final products, produces outputs, though certainly in lower quantities due to the small-scale operations of the butcher. However they are not of lower quality. Animal bones and fat can be used by companies that process and conserve food products.

5 Conclusion

The proposal of a technological instrument of this type facilitates the raising of awareness by the various actors on the territory, on various levels of expertise, about the numerous possibilities offered by the systemic culture, in particular Systems Design applied to a productive territory. The study therefore aims at making knowledge about the instruments offered by the systemic approach explicit and more accessible. By sharing knowledge and experience through networks and design-driven instruments we can offer an interpretive key for understanding its benefits to the environment and the economy, benefits generated by a possible transition towards a systemic nonlinear type of productive and territorial culture. The network and instruments offer concrete possibilities to transform waste into materials worthy of appropriate, rational and targeted management, and more importantly, profitable reuse. This reinforces the concept according to which an efficacious protection of the environment is not in conflict with the economic growth of businesses. The contribution of systemic design to the valorization and protection of the territory is therefore vital. By using the territory and resources we advance a kind of development that gives priority to the local community and allows the creation of enterprises that are self-sufficient in terms of energy, production and procurement. The systemic approach to the territory allows us to take opportunities, environmental, economic and therefore also business opportunities, and move forward by way of systems. This activates new connections and virtuous processes that valorize local communities or farming and industrial areas. The safeguard of territorial biodiversity and the development of local resources, favored by a systemic approach lead to the generation of a balanced social and economic system that relates to people's needs for well-being according to the rhythms of natural cycles.

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