ECONOMIC PATHWAYS TOWARDS A MORE SUSTAINABLE MATERIAL FLOW. CASE STUDY: PRODUCT SERVICE SYSTEMS

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ABSTRACT
Humankind engaged in the global material flow many substances that fall outside the biogeochemical cycles, but also outside economic cycles. Consequently a linear pattern emerged hindering both the availability of natural resources and the safety of environmental conditions. Closing the loop is an issue of technical innovation but the economic underpinning of material flows indicates the need of a novel model for a more sustainable material flow. Several models already emerged and they are aggregated in a policy document that proposes the model of circular economy. Along with reuse and recycling the rethinking of value chain is an important contribution that will harness consumption's potential to contribute to sustainability. Product Service Systems by widening the system boundaries allow more optimization opportunities to improve eco-efficiency of products.

KEYWORDS: *waste, entropy, value, circular economy, product service systems*

JEL CLASSIFICATION: *Q53, Q57*

1. INTRODUCTION

The exhaustion of natural resources is recognized for several decades as one of the main threats for the future of humankind. Since the first report of the Club of Rome, which clearly pointed the limited pattern of resources on that humans are relying on until the contemporary extensive movement toward sustainability a wide range of alternatives were designed and explored as solutions for this challenge. Nevertheless, the overall consumption of natural stocks is continuing to grow, the path of this dynamic being of great concern.
Humans' power to survive and to improve their wellbeing is stemming in technical solutions that allow the transformation of various natural components according to more and more sophisticated needs. However, by this feature humans are not different from any other species and it is little to be changed in this respect. Instead of judging it is necessary to acknowledge the fact that humans need to have a material support and to further explore at what extent the model of how other species succeeded in the face of the limited resource challenge is appropriate to be adopted or adapted. The relevance of this rational is however limited, its scope being outlined by a human-environment relationship model that considers humans as part of the overall ecological system, the ecosphere.
The pattern of anthropogenic material flows is unsustainable since they consist in linear transfers from a pool of limited resources to a pool of waste that is, on its turn, limited by the space available for its disposal. Although the issue is not so simple, with many interactions determined by the increasing scarcity of resources on the one hand, and the harmful effects of mounting waste

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materials for both human and ecosystem health, on the other hand, it could support a powerful reasoning for change in the pattern of anthropogenic material flows.

The material flows that support human activities are determined by a great variety of needs, starting with basic ones and going up to the cultural and spiritual ones. The up taking of natural components in the material flow seldom could be characterized as direct consumption. For instance, if someone needs stone to build shelter, he or she seldom go out and collect the stone. Most of our needs are satisfied by buying the things or services produced by the firms or individuals who extract them from the environment. The stone needed for building is extracted by mining companies and then it is sold to whoever needs it. Hence, material flows are meant to satisfy human needs and this is accomplished within an economic context in that natural resources are sold and purchased, having an exchange value. The size of this value is expressed in prices and it reflects, according to the current theory of value, the utility of the purchased good for its owner.

Material flows' patterns are determined by the correspondence between their characteristics and human needs, but also by the peculiarities of the economic interaction, having as core the exchange value of products and services. Consequently, the solution pool for improving the sustainability of material flows is to be designed by taking account the economic dimension of material flows. During the last several decades a number of economic solutions attempted to change the anthropogenic material flows' model toward the ecological model. Despite a very straightforward reasoning for this change, it's accomplishment within a market economy context is a great challenge. Within this paper, some of the most advanced models, as theory development, but also as application, will be discussed, followed by an in depth analysis of the Product Service Systems (PSS).

PSS is gained reconsideration along with the bolder and bolder recognition of the ecological model within public policy debates. The events organized by the EU for the celebration of the environment day could be regarded as a springboard for the circular economy that becomes a thorough strategy for the European Union (EU). Accompanying other measures that are supportive for extending the use, reuse, recycling and major restrains on disposal, the enabling of PSS is amongst the economic pathways comprised in this model for improving the sustainability of material flows.

Despite novelty and the widespread corporate reluctance regarding green businesses, the potential benefits of the first comers motivated many manufacturing companies to design PSS and to adapt the business model according to the novel type of interactions with customers. Some of them will be analyzed in order to improve understanding and to highlight advantages and drawbacks in the application of PSS from the perspective of sustainable development.

2. ECOLOGICAL PROFILE OF HUMANS OR WHY HUMANS ARE APPEARING SO UNNATURAL

Human is one of the million species that inhabits Earth sharing the bulk of mechanisms within a complex network of ecological interactions. The ultimate goal of a species is to survive among given conditions and this is accomplished by maximizing the gains on the resources they extract from the environment.

Bran (2010) presented these complex interactions by organizing them in three dimensions, corresponding to the three basic forms of matter: energy, substance, and information.

Ecological model. Energy's transformations are explained by the principles of thermodynamics. The first principle of thermodynamics (Conservation law) states that the total energy of a system is constant, although energy could be transformed from one form to another (for instance from light energy to chemical energy). Further, the second principle of thermodynamics (Entropy law) reveals the restrains of transformation by stating that the transformation of energy from one form to another is not integral, a certain amount of energy being lost as heat that dissipate. This loss is unavoidable and the dissipated heat cannot be captured to be transformed in other forms of energy, although it does not disappear. The amount of energy that is dissipated is the energy that cannot be used, which is unavailable and it is designated with the concept of entropy. Entropy generation is continuous and it is occurring in both, living and non-living systems. Living systems fit within the energy constrains or fight against entropy by two strategies:

- Firstly, the aging of an organism due to the qualitative transformations induced by entropy accumulation is overcome by replicability. All species have a certain mechanism that allows them to produce a new organism with similar characteristics. The survival of the species as living system is secured by reproduction;
- Secondly, the incapacity to preserve energy against dissipation is overcome by capturing energy from environment through photosynthesis or by feeding along food chains that maximize the period of energy preservation. The ultimate energy source of all species is sunlight which is stored in 2-6 successive biochemical packages of organic substance belonging to different species that eat each other. The pool of energy resource is practically endless since solar light will become exhausted only then the sun will fade out. Despite wide availability species are competing for sunlight. The proxy of availability could be the area covered on land or the volume of water populated in the euphotic layer of the aquatic ecosystems (rivers, lakes, seas and oceans).

The substance needed by living systems to preserve energy is procured from environment by a selective up taking. Six chemical elements - carbon, oxygen, hydrogen, nitrogen, phosphorus, and sulfur - are combined with traces of microelements in myriads of organic substances that build organisms of a great variety. This selective up taking is occurring for billions of years from the limited pool of Earth's resources. Although the total amount of each of the six major chemicals is huge, the magnitude of substance flows in the biosphere is also much larger than humans are able to mobilize even in the contemporary industrial world. Nevertheless, biosphere faced no shortage of substances during its billion year existence. The strategy of living systems in this respect is to refill the pool of substances. This is done by decomposing the organic substances in mineral ones that allow a novel up taking. That is why in ecosystems there is no waste. This circular model, known as biogeochemical cycle or circuit) has a simple principle: all the substances produced by a species could be used at least by another species. Dead leaves falling in autumn are of no use for the tree that released them, but they are the feed for many insects, fungus, and bacteria that gradually decompose them in mineral substances ready to be used by plants for packaging energy.

The third of matter, information, draws the line between living and non-living systems. Replicability, coordination and adaptability are key skills for living systems and each of them depends on the ability of this system to hold information. This is stored in nucleic acids such as DNA and RNA made up by several molecules with coding power that are combined in two identical successions that define all visible and functional features of organisms. During the lifetime of an organism DNA plays two roles:

- Coordination of metabolism at cellular levels;
- Transfer of information to a next generation.

By changing to succession of codes in DNA living systems conquered the entire world and overcame major environmental changes. There is almost no known environment where life is not present. Ice ages, volcanic eruptions and other processes, floods etc. modeled the surface of Earth during five billion years. Living systems survived all these changes, despite major structural reorganizations at ecosystem and species level.

Human model. Energy used by humans was for most of their history captured from the same source as in ecosphere, being represented by food, animal and man power. Since the dawns of the industrial revolution this pattern began to change by adding fossil fuels and other energy sources. The main forms of energy excepting food that is directly used now by humans are fossil fuels, wood, and electricity. Fossil fuels account for 80% of total energy consumption. It could be stated that humans are relying on an exhaustible source of energy, the size of its pool being the measure for the length of human society's future.

Humans expanded the range of chemicals that are entering the material flows, along with the introduction of novel substances. Many of the novel substances are not respecting the principle of biogeochemical cycles because there are no species able to decompose them in mineral substances ready to become inputs for a material flow (natural or industrial). POPs, heavy metals and plastics are the most common examples in this respect, but many others have the potential to accumulate due to misbalances between the path of decomposition and the path of generation. All useless substances that are not decomposed with the same path as they are generated are becoming waste.

The genetic information of the human body is mostly similar with other species and is not changed significantly during the history of human civilization. Nevertheless, the ability of the human species to expand its habitat and to sophisticate its living continued to grow. This ability was a product of human mind that enabled humans to handle information faster and faster.

In comparing the models briefly presented it should be taken in account the fact that the ecological model is referring to a wide range of species, while the anthropogenic model covers the behavior of a single species. However the comparison is possible by considering the fact that humans are using exo-somatic devices like tools, cloths, buildings, machinery which allows them to behave like a corporate species, some of these devices replacing to function of various species. It should be also stressed that humans are still connected to the rest of the species by ecological interactions and that the outcomes of their activity influence the state of the ecosphere.

The comparison of the two models indicates the differences that explain the unnatural pattern of human behavior. These consist in:

- reliance on an exhaustible source to overcome entropy accumulation instead of an non-exhaustible energy source;
- widening the range of substances engaged in material flows and generation of substances that have no use for other species;
- outstanding adaptability due to an unprecedented ability to transform information that is far less dependent from reproduction rate.

Why humans neglected the issue of waste for so long and continue to be reluctant or have a resistant social pattern is a challenging question with manifold answers. There is beyond our scope to review all of them. Instead we will try an ecological and an economical explanation.

Ecologically, humans are one of the many species and it is expectable to have a similar ecological behavior, at least as basis, beneath rational interaction. It should be stressed that human is a single species, while the ecosphere is made up by millions of species. Do the other species produce materials that are for no use for them? Yes, all species release in the environment a certain amount of substance or at least their bodies after death. What are species doing for this waste? Some of species hide it, other use it for marking territory, although generally species do not have the "technology" to transform their waste in mineral substances except the species that have mineral substances as waste (e.g. decomposing bacteria). As conclusion we could say that human behavior is an ecologic one or that naturally humans have no concern regarding the waste produced, assuming that there are other species that could use that waste.

From the extraction of useful substances until their use in various products or as support for services the material flow is regulated by economic principles according to that what is useful for humans will have an exchange value, while what is not will have any such value. The mounting waste is made up by materials with no exchange value or the ones that are useless. To prevent waste accumulation all waste that has no exchange value should fall in the category that can be used by at least one other species. In addition, the flow of this waste should fit the capacity of other species to use them.

The unnatural pattern of humans is given not by the fact that they are producing substances of no use for their self, but by the fact that these substances are for no use for other species or exceed their capacity to use them. Anthropogenic material flow could be represented by a line, a funnel that channels substances from a pool of resources toward a pool of waste. Since nor the pool of resources, nor the pool of waste is unlimited it results that the material flow will be hindered on the one hand by exhaustion of resource pool and, on the other hand by the filling of waste pool.

3. ENTROPY AND VALUE INTERPLAYS ON THE ECONOMIC GROUND

Material flows engaged by humans are regulated by economic rules. In order to change the pattern of these flows it should be understood how these rules are operating. A comprehensive analysis in this respect was made by Georgescu-Roegen (1994) who emphasized the clash between the physical and economic principles. This explanation focused on the concept of entropy, stemming in the effects of the entropy law. The model was extended to resources and it resulted that all forms of matter that need more effort (energy, substances, information) to be spent for their use than the utility resulting from that use should be considered waste or having high entropy and being unavailable for use. This means that these forms of matter will be withdrawn from the pool of resources. In economic terms, high entropy matter could not be used because the price of extracting useful substances is higher than the price of that substance on the market. For instance, a municipal landfill contains aluminum due to the dumping of canes, but extracting aluminum from the landfill would cost more than the value of the extracted metal on the market.
Entropy generation by the use of energy cannot be overcome since dissipated heat cannot be collected. In this respect the effect of the entropy law is irreversible. Nevertheless, in case of substances that are comprised in material flows the issue is different, because the recovery of the useful substance is depending on the balance between effort and exchange value, which both could be influenced by various levies toward a desired direction.
How this could be made possible is explained by Bran (2001 and 2010) who pointed that the material support used for establishing the exchange value of goods and services should be reconsidered. Such a paradigm shift already occurred then the state of higher demand than supply of goods was replaced by the state of higher supply than demand. The shift was from labor based value theory to utility based labor theory. The next shift should cover the shortage of resources needed for goods production and Bran (2010) proposed the low entropy as support for the calculation of the goods economic value. Thus lower the entropy higher the value of a resource will be. For the estimation of entropy the relative scarcity could be used.
Waste is accumulating because each generator, individual or corporate, takes the effort only to evacuate the waste, with no consideration regarding the possible content of waste in useful materials. At the landfill, to separate useful materials would take the effort of all generators, which is not available at the sight. If each generator makes a little effort to select apart the materials comprised in their waste, then the effort of a possible user, for instance a recycling company, will be less. By selecting apart waste materials their generators reduce the entropy of that material, improving its potential to be used as a resource of substance. This could be also stated as instead of dissipating useful substances it is necessary to dissipate the effort needed for recycling.
This could result in a disutility for consumers who will be pushed to discover ways of reducing this effort by avoiding waste generation through increasing the length of use for certain products or simply through giving second thoughts before the next purchasing.

4. ECONOMIC MODELS PROPOSED FOR SUSTAINABLE MATERIAL FLOWS

The unsustainability of the anthropogenic material flow is noticed for a long time. Among the proposals to correct it we found several currents of thoughts that are stemming in models proposed in the early era of the environmental movement. These were captured by Tukker (2013) and are represented by:

- Performance economy;
- Cradle to cradle;
- Industrial ecology;
- Biomimcry;
- Blue economy.

Performance economy is a model is based on a vision of economy in loops. According to this model the goals to be pursued are: product life extension, long life goods, reconditioning activities and waste prevention. It is also stressed the need to sell services rather than products, envisioning a functional service economy.

Cradle to cradle model was developed by German-American collaboration and went up to a certification system. The principle of biogeochemical cycles is core for this model that stresses its consideration in the early stage of product design.

Industrial ecology produced industrial ecosystems or industrial symbioses. Despite the borrowing of the ecological model, the proposals are economic ones or at least pursue to reproduce the ecological model within economic restrains. The principle of biogeochemical cycles is the core of the industrial ecosystem model. In this model, various corporate actors like manufacturing units, power plants, constructors, public administration etc. are acting like a species of an ecosystem. Each actor has energy and substance inputs and outputs. In order to represent an industrial ecosystem the material flow among the actors should be circular by respecting the principle that all substances produced has to be useful for at least another actor, waste and pollutants included. According to Ehrenfeld (2004) most of the economic challenges could be overcome by facilitating information exchange and communication and Ioan and Radulescu (2009) considers that public administration should assume the role of information broker in order to reduce the costs of each partner.

Several industrial ecosystems are functional. Amongst the first ones it could be mentioned Danish industrial ecosystem of Kalundberg (Bran and Ioan, 2013). Further modern industrial development use the concept of industrial ecosystem as basis for the design of novel industrial platforms. These are planned in such a way that eco-efficiency could be maximized by reducing the costs related to water use and treatment and by increasing the availability of renewable energy.

Biomimcry is a current of thought that builds on the premises that within ecosphere we could find the solutions for the environmental challenges and innovation should be inspired by nature. This should be performed by considering the following principles:

- Nature as a model - nature's solutions should be carefully studied and explored to assess at what extent they could be adapted for human purposes;
- Nature as measure – sustainability of innovations should be evaluated against ecological restrains;
- Nature as mentor – the value of ecosystem services should be established by taking in account not only the material flows (substances that could be extracted, energy that could be captured), but also the potential for learning, for finding solutions for current and future challenges.

Blue economy is a model of a cascade economy in that waste should be inputs for a novel value added chain. Very similar with the industrial ecosystem, this model outstands by the focus on gravity as primary source of energy for human activities.

Improving the sustainability of material flows is a goal that raised no major issues for technical innovations. What is more problematic is how to integrate these innovations in an economic context that by positive feed-back will continuously improve sustainability. This challenge is addressed by the recent report of the EC (2014), which lies down the policy roadmap of a circular economy. Fact is, the concept of circular economy is not a novel one and it already supported the research and activity of many sustainability pursuing organizations. Out of them the Ellen MacArthur Foundation outstands by its focus and reports that organize information and knowledge in the field.

Circular economy is an economy in that products are used for longer periods, materials are recovered from wastes, and energy is used efficiently. What should outline circular economy from the regular one is the pattern of added value generation and preservation. All the processes that enable the circular economy are already undergoing within the current economic contexts. Nevertheless, they are sparse, small scale and by far less attractive for the majority of investors who bear the burden of short-termism. Hence the European vision of the circular economy assume that enacting it requires changes throughout value chains, from product design to new business and market models (EC, 2014).
The roadmap toward circular economy, according to EC (2014), is outlined by the following fields of action:

- Design and innovation by pursuing goals like:
    - reducing the quantity of materials needed to deliver a certain service;
    - lengthening the product life;
    - reduction of energy and water use during manufacturing;
    - reducing the use of substances that are difficult to recycle and harm ecological processes by persistence and/or toxicity;
    - increase products friendliness to their user by reducing maintenance related issues and improving their flexibility;
    - development of maintenance service sector;
    - increasing waste prevention and selection by consumers;
    - facilitation of clusters that are minimizing waste and by-products (industrial symbiosis);
    - enhancing the consumers' choices by renting, sharing, and lending services as alternative for the ownership of products (Product Service Systems).
- Streamlining investments:
    - design and redesign policy levies and accounting systems in order to create more powerful incentives for investments and expenses that are supportive for the circular economy;
    - outline and integrate specific requirements within Green Public Procurement;
    - strengthen funding opportunities that support the transition of businesses and consumers toward the new patterns of production and consumption of goods and services.
- Valuing supportive business and consumer initiatives:
    - Production: sustainability standards, voluntary schemes, industrial symbiosis;
    - Distribution: improvement of information regarding products content and environmental characteristics (recyclability, toxicity etc.) toward a standardized form of "product passport";
    - Consumption: collaborative consumption models that increase the value of underutilized products.

Circular economy became a policy program on the ground of increased scarcity of key material inputs. Since this incentive is to become stronger within current and fore coming economic trends it is expectable that all actions in this direction to be accelerated by various policy interventions. Strategic management should cover this issue for securing a competitive ground and operational management should be prepared to adapt to novel challenges.

5. PRODUCT SERVICE SYSTEMS

The current pattern of value creation in developed economies has a strong correlation with the use of substances and energy. Despite efforts invested in reducing the environmental impact of human activities by decoupling economic growth from environmental degradation, the so called rebound

effect, determined by the increasing of consumption due to lower prices or more numerous consumers, is offsetting many of the progresses made in efficiency improvement.
Up to date most of the changes were made on the production sights. Processes involved in production of goods were cleaned seriously resulting in a far less pollution emission per unit of products than two-three decades ago. Further, the environmental performance of products was also improved significantly. For instance, the carbon dioxide emission per km was reduced from 172 g/km in 2000 to 140 g/km in 2010 (figure 1).

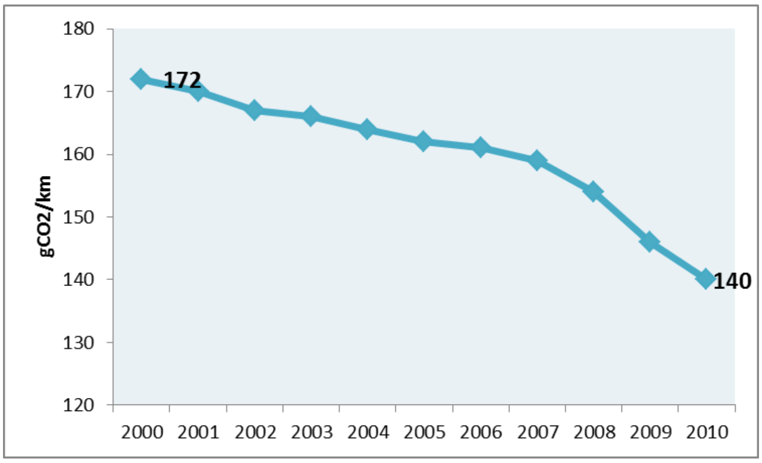

Figure 1. Carbon dioxide emission per km for passenger cars
Source: own representation using EEA data

The size of packages for many products and the size of products were reduced, resulting in higher efficiency of the substances used in production. Innovations also boosted leaps in the efficiency. For instance, wireless internet connection reduced the need of materials for wiring internet users. Nevertheless, cannot offset the growth determined by increased consumption and coining the need to find another field of intervention with meaningful potential for improvement.
Products are manufactured and then consumed. The second stage is beyond the scope of producer, occurring on the grounds of the owner who pursues to harness all the utility of the purchased good. In this area less intervention and analysis was performed, although for more than a decade various reports and research indicated the need to interfere within consumption.
Consumers were neglected, because, according to the economic principles, they will maximize the benefits of a purchased good. However, in a consumption society where purchasing is driven more by social patterns than by material needs, many consumers fail to harness the benefits of a range of products by underutilising them.
Increasing consumption is a major means to generate added value and economic growth. Hence, businesses refined a variety of marketing tools that pushed consumption by creating needs more or less justifiable in the perspective of sustainability. This phenomenon is coined as consumerism and it leads to productivism, meaning a waste of materials for producing goods that are not necessary, but the need of that is induced by persuasion and social patterns creation (Bleahu, 2001).
Economic growth is linked to perceived value creation more than to products circulation within the economy. In other words, for grounding economic growth the production of goods could be avoided as long as perceived values is created and this value could be created by replacing partly a product with the service provided by it to its owner.
Product Service Systems (PSS) are defined as a marketable set of products and services that fulfill the user's need (Goedkoop et al., 1999). Another definition claims that PSS are a result of an innovation strategy, shifting the business focus from designing and selling physical products only,

to selling a system of products and services which are jointly capable of fulfilling specific client demands (Manzini and Vezzoli, 2003).
The product/service ratio can vary in terms of function fulfilment or economic value (figure 2), but also over time, because of technological progress, economic optimization and changing needs (figure 3).

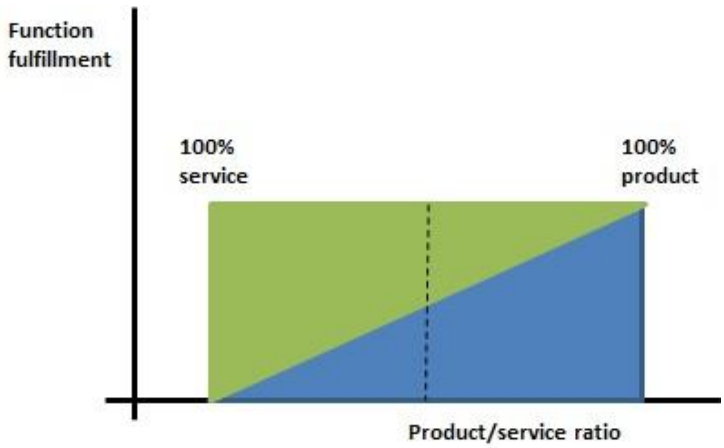

Figure 2. Product/service ratio variation against function fulfillment
Source: Goedkoop, M.J., van Halen, C.J.G., te Riele, H.R.M., Rommens, P.J.M. (1999). *Product service systems. Ecological and economic basis.* p.20.

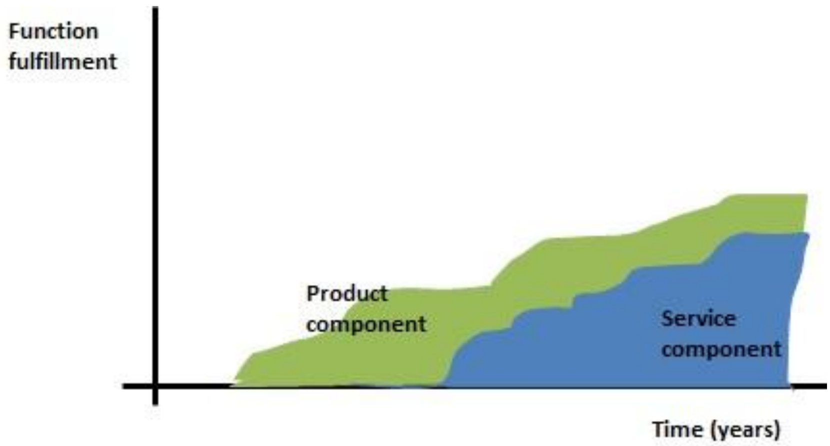

Figure 3. Product/service ratio variation over time
Source: Goedkoop, M.J., van Halen, C.J.G., te Riele, H.R.M., Rommens, P.J.M. (1999). *Product service systems. Ecological and economic basis.* p.20.

Shifting from products to a PSS enables the company to move progressively towards a new way of interacting with its clients. Instead of delivering material products, a combination of products and services is delivered in order to satisfy/fulfill a customer demand. The maximization of utility for the given products is achieved integrating services along with products.
From the perspective of the producer PSS supposes a new relationship with the stakeholders of the value chain, usually a more information intensive communication. The interest area is extended above the product’s life cycle (comprising pre-production, production, distribution, use and end-of-life) to other products and services that could influence the utility of the product.
As long as the consumer is regarded the PSS enable the consumer to achieve something, to satisfy a need. The design of PSS necessitates more effort invested in marketing, which could lead to larger market share or opening of new markets.

PSS are not sustainable per se, but their characteristics create a good potential to develop sustainable solutions for a continuous economic growth. This potential is given by the fact that by PSS the optimization is performed over a broader system with more opportunities (figure 4). Thus, the eco-efficiency potential of PSS relies on system optimization against the converging interests of stakeholders.

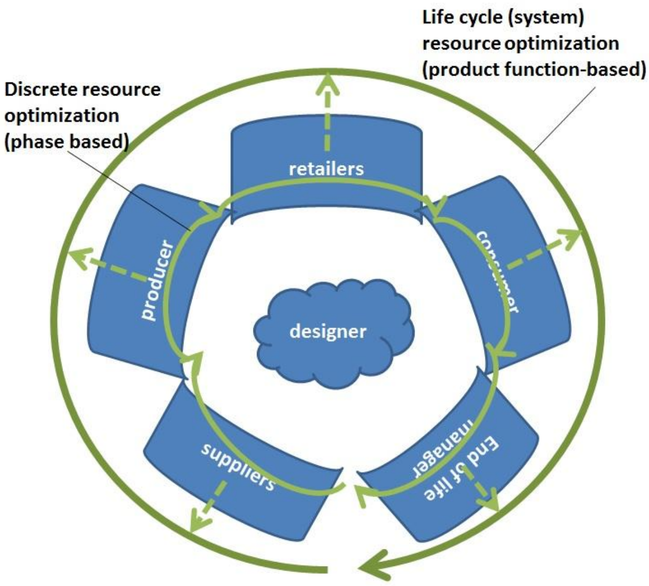

Figure 4. Widening of optimization opportunities at system level
Source: Manzini, E., Vezzoli, C. 2003. *Product service systems and sustainability. Opportunities for sustainable solutions,* UNEP, pg.6.

PSS for a product reveal the potential for optimization between broader limits. This could be made at another level by considering interactions between other products and services. The improvement of system eco-efficiency is coined as win-win potential and it resulted in three business models: services providing added value to the product life cycle (e.g. maintenance and upgrading service sold with a product); services providing final results (e.g. certain indoor thermal regimes), and services providing enabling platforms (e.g. agricultural consortia).

The main barrier to adopting PSS in developed countries is the social pattern that favours individual ownership instead of collective consumption. In developing countries, collective use and ownership is a more common social pattern, but access to technological information and knowledge may hinder the applicability of PSS.

For the illustration of PSS we present a case of agro-food products. Consumers subscribe to a certain producer of agro-food products, and the producer provides the set of agreed products once a week. The products are packaged and delivered to the customers address. The functions of this PSS can be identified on the following plans:

- Financial – the fixed price guaranteed to producers allow them to acquire modern technologies or to adapt to customers' needs (e.g., organic food). For the customer the price should be lower than buying similar products in the store;
- Optimizing consumption: the customer get a fixed amount, which is established considering rather the lower than the upper level of the consumption;
- Surprise effect: the package of products could be a surprise by itself, but it also could contain recipes for cooking and additional information regarding the nutritional value of the food;
- Availability – locally produced food becomes more available for customers;

- Known history of producer – the customer may visit anytime the producer and establish social interactions with him/her;
- Freshness – food products are harvested knowing exactly the time of delivery, fact that enable farmer to pick the most appropriate moment.

The success of such PSS is relying on the management of the entire chain from agricultural production to the final consumer, including packaging, transportation, and delivery. The emotional value of product should be also considered since the consumer knows how they are produced and who are producing them. In Romania, there are already established such systems, although due to high prices they are available only for high income consumers.
Other PSS examples include laundry service with washing machines, car sharing, solar heat services, toy libraries and others.

6. CONCLUSIONS

Improving the sustainability of material flows is an urgent social need, since population growth and affluence are predicted to continue over the next decades and the limits of natural resources are not expanding. The natural model of continuously looping flows of chemicals that support the entire ecosphere is considered by more and more scientists as being appropriate for achieving sustainability.
The brief revision of human's ecological profile revealed that the main difference is given by the fact that humans are a single species and that they are using a much broader range of chemicals that cannot be used by other species. Further, the current linear pattern of material flows is the result of a value paradigm that fails to capture the low entropy potential of various forms of materials. These drawbacks can be reduced by rethinking human society, but especially the economic scene in such a way that all substances, including the ones from waste, are carrying a value potential.
The value of waste materials gained impetus recently since rare metals used in industries with key importance for economic growth and wellbeing are facing higher import prices accompanied by possible critical geopolitical interferences. This economic and politic interest busted the political initiative at European level and resulted in a general framework for action toward a zero waste economy. Although value and profit making is involved, many barriers of circular economy could be removed by improving coordination, communication and applying innovative solutions based on system thinking.
That is why the recent formal reinforcement of the circular economy of EU level considers various ways, including PSSs. On their turn, PSSs are having a great potential for reducing and reshaping material flows toward sustainability. This potential is arriving from various characteristics, although the most important is the increase of optimisation opportunities by widening the scope of entrepreneurial system covered by the converging interest of profit making. This will include the followings: designer, supplier, producer, retailer, consumer, end of life manager. By belonging to the same system, these actors will find the best ways to optimize their material flow, by both reducing consumption and enabling recycling. It should be also mentioned the fact that the interactions occurring between the subsystems will be also novel optimization opportunities for improving sustainability.
Powerful social patterns based on individual ownership may hinder the progress in this direction. Thus the most widespread social pattern is based on private ownership of goods in order to harness the utility delivered to the consumer. In the PSS this pattern needs to be broken in various ways that could be perceived as interference with basic rights, although they in fact do not alter them. Nevertheless, by applying an innovative design of PSS some of these drawbacks can be reduced.

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