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Silvia Barbero

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Local Bio-Energy Promotes Distributed Economy for Sustainable Development: Systemic Design Approach and Case-Studies

Silvia Barbero, Politecnico di Torino, Piedmont, Italy

Abstract: Local economic development is of considerable significance within the cultural context in which it operates and is currently becoming an increasingly important part in international cooperation. The possibility to enable scenarios of bottom-up economic and social development, led by local actors, is gaining ground in the last decade. In this context of steady change, the design process with its principles and practices is crucial for aware and structured growing. The implementation of a design approach that goes beyond a specific and punctual solutions is needed, so it tends to create connections between local material, energetic and informational resources, generating multiple and complex solutions. In particular, In Systemic Theory, the economic, social and environmental benefits are required through the flows and the efficiency in the use of resources. I practice this approach in the energy sector because it is a common good, considered as need that is fundamental and shared by the society, but also an individual right to increase our own capability. The so-called green Energy, derived from renewable sources (biomass, ...) or free goods (sun, water, ...) is crucial for the development of an area, because it guarantees autonomy and upkeep. To corroborate this theory, I analyzed the Swedish territory, which since the Nineties studies and develops integrated systems for environmentally responsible energy production. The analyzed best practices satisfy the complexity and development of the territory in a sustainable manner. The comparison between different realities helps to highlight what are the key drivers and the barriers for the development of small bio-energy spread in the territory and confirm/modify the theory if Systemic Design.

Keywords: Systemic Design, Network of Enterprises, Small Scale Production Systems, Local Sustainable Development, Distributed Economies

Overview

WE LIVE IN an age that has achieved an extraordinary degree of sophistication in terms of products and production systems, and yet at the same time we find ourselves damaging our environment. Moreover, there is a widespread crisis currently afflicting the economic system, and the constant impoverishment of social relationships caused by exasperating goal of economic growth. Our industrial world follows a straightforward logic of gaining at the expense of social and environmental aspects: a linear industrial model characterized by cause/event phenomena, the solving of technical problems, and the study of specific strategies. [1]

The theories of industrial ecology and thereafter Systemic Design look at making better use of material and energy flows in order to model our production and energy systems after Nature. Material and energy loops are open in order to decrease environmental impacts and resource depletion. Many industrial ecosystems have come about naturally through better business, while others have been facilitated through external actors. [2-3] However, as these

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theories and ventures may be innovative for the industries, they are still no doing more than solving problems that arisen from environmental pressure and economical revisions. In order to provide further strength to an industrial ecosystem, new players and innovations must be designed and altered with time. The theory of Systemic Design offers a scientific way of design a complex industrial system with environmental, economical and social benefits [4]. Looking ahead the development of a multidisciplinary vision becomes crucial, towards the emergence of a new culture of sustainable economic and technological innovation and process inspired by the dynamic operation of Nature.

Methods

In order to make current industrial ecosystems and energy systems more innovative and adapted to changes, Systemic Design theory should be applied and analyzed [5]. This research will be completed by reviewing this theory with seven case studies developed in Sweden in the last twenty years. In that way is possible to deliver similarities and differences of open networks, adapted for changes. First of all they are chosen from a series of different cases as the best actually in Sweden for they complexity in solving problems not only technical, towards efficiency and sustainability, but also economical, social and environmental ones, further more they follow some of the Systemic Design principles.

The Systemic approach is based on five principles that serve as guidelines in designing and in analysing the cases. In general this approach shows how the industrial process should learn from natural world:

1. Output>Input. As in Nature what is not used by a system becomes a raw material for the development and survival of someone/something else, in production processes the waste (output) of a system become an opportunity (input) for another one, creating new economic opportunities and new jobs (often, green jobs)
2. Relationship. The parties themselves that compose it, or the various stages of production, are a system. All over the world living systems can be found nested in other systems or as part of communities or organizations. The properties of a system, whether living or not, are born from interactions and relationships between constituent parts. The study of the relationship affects not only the relationship between the system components, but also those that exist between the system and larger systems that surround it.
3. Act locally. As an ecosystem is deeply influenced and shaped by its habitat, the same happens for any other type of system in which it is important that the context stays "local". A background of this kind enhances the resources typical of the place, not only the material ones but also the social and cultural ones. Based on the opportunities provided by the context, it is possible to create new opportunities by reducing the problems related to the adaptability of a "general" solution.
4. Autopoesis. Self-maintaining systems sustain themselves by reproducing automatically, thus allowing them to define their own paths of action. A system is naturally led to balance and preserve itself alone.
5. Man at the centre of the project. The human being is inserted into the system in which it lives and activates its own relationship with the environment, the culture and the society. In this model the various activities of living and production co-exist in equal and

each have their essential function in the relational system benefit: no precedence over the other, but each exists thanks to all the others.

This model is inspired by the foundations of Generative Science, based on the assumption that as a result of any transformation of the resource, all by-products are designed to add generative value to careful evaluation. Systemic Design provides a framework supporting the evolution of a new economy with different sets of industrial relations, where long-term sustainability and success of a network of interdependent activities are prioritise over maximising economic growth, development or competitive advantage for individual entities [6].

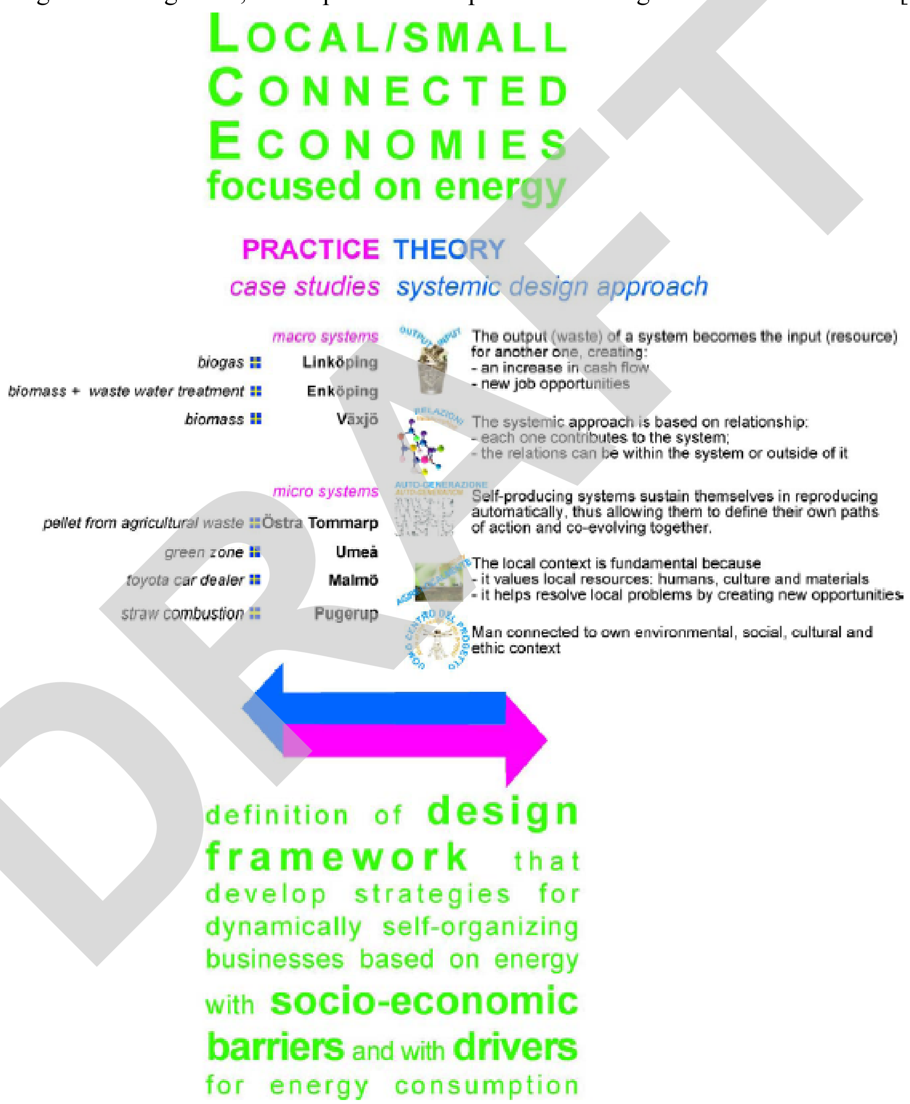

Figure 1: Structure and Goals of the Research

Case Studies

The chosen best practises are divided for dimension in macro and micro systems, in the first case the projects involve entire communities or municipalities, and in the second they involve only a building or an industry (Figure 1). Every best practice is analysed in according to a series of variables that include qualitative and quantitative aspects. The report gives the localization, the background and brief description, the environmental benefit, the creation of new jobs, the main actors and the main activities, the funds and financing, and the future projects related to it.

Improvements for further innovation and future progress based on Systemic Design principles will then be produced based on the review of the cases. The goal of this research is to give a review of what could be done to better suit the industries for the future based on current best practices.

In this paper, two cases are presented, one example for macro and one for micro system, because they are enough to understand the kind of projects taken in consideration in that research and in which way they are analysed.

Macro System: Linköping

In September 1989, the management of the city of Linköping, the transit authority, Tekniska Verken and KFB were taken to start up the first modern biogas project with modern equipment in the World.

In the town of Linköping, a test of biogas-powered buses began in 1991; in its first phase, 6 busses using converted diesel engines were used, but the whole initial year proved troublesome. 1992 started better and went better. Since 1997, all public transport busses (approximately 60) and some passenger cars run on biogas, and finally in November 1999 was taken the decision to re-write the contracts for bus operations and formally makes the pilot project. Biogas, has grown considerably since the introduction, there are now over 1200 personal vehicles, 89 biogas busses and 30 heavy vehicles in the Linköping region [7].

The objective of this project is to develop an integrated system for the transformation of difficult waste to useful biogas and to develop a public transport system with city buses fuelled with the biogas. The strategic aim is to connect city and rural areas to each other.

The cities insight in societal values by providing high quality environment was the driver of the initial project: noise and pollution has been reduced dramatically in sensitive areas during the expansion of the biogas project. The reduction in Table 1 has been provided by political and industrial decisions.

Table 1: Environmental Benefit

Greenhouse gasses	-80%
NOx	-70%
CO2	-90%
Particulate matters	-90%
Noise	-50%
Performance in busses	-10%

Linköping were successful in providing early improvement in decision making among the staff. After that, the staff were increasingly involved in technical and administrative development. Good timing, sufficient funds, dedicated staff and good portion of good nerves are some of success factors.

The basis of the region's unique expertise in biogas production is, of course, the joint biogas venture by Tekniska Verken, the City of Linköping and Östgöta Trafiken in early 1990s. A further factor underpinning the rapid development of this know-how is the close collaboration between Tekniska Verken and Linköping University. They joined forces to quickly learn what they need to know, the process was stabilised, and production could increase.

The system could not have been developed without external financial support. The lack of industrialization of the total concept made risk too big to carry the whole financial and intellectual burden by themselves. Attracting money also attracts willingness to contribute with know-how and intellectual capacity. If these type of installations have been more common, standardized and frequent, prices would have been low enough to provide it for lower cost at local risk [8].

The future plans aims for increased biogas production and new public refuelling station, because some of the bottlenecks are comparatively inexpensive to expand. Expansion allows sales to other consumers than busses, being the lowest paying customers in the automotive sector.

Biogas firms of the region tend to focus on large scale production plants located near areas of large material flows. Though more should be done to encompass small scale plants into the mix for greater expansion, material flows and coverage. In the future connecting local farms to a biogas grid may ease raw material handling costs, and allow for a larger network of biogas production.

The work of local organizations, researchers and businesses is by far not complete. Biogas research continues to expand as well. Biogas research also is beginning to become a major focus at Linköping University: recently an initiative was started to begin a Biogas Research Center composed of an interdisciplinary team of researchers.

Micro System: Östra Tommarp

This project was carried out from 1 January 2006 to 30 November 2009. It was targeted towards developing and implementing an innovative method to reduce greenhouse gas output at the agricultural sector.

The project involved the seed industry, combustion technology industry and academia. It resulted in a complete facility for agricultural waste reduction, renewable energy supply, carbon neutral fuel production, as well as a demonstration system. Two partners were involved– the seed company Skånefrö AB and the combustion technology company HOTAB, co-funded by the EU LIFE Environment Programme.

The objectives of the BIOAGRO project was to successfully demonstrate an innovative technique that enables seed waste to be converted into energy in an integrated system comprising dose scales, mixer, pellet machine and heating boiler. Ash should be returned as nutrients to the agricultural fields. Carefully selected and tested additives should control the emission of sulphuric, hydrochloric acid, as well as reduce sintering of the ash. Skånefrö´s use of oil and electricity for heating can now be replaced (and only used as a backup security system in case of furnace breakdown) by heat produced out of residues from the company's own seed production operation. At the end of the project the pellet throughput is above 3 metric tonnes per hour. The pellets are showing the high quality characteristics of a dense structure with a smooth, hard surface for convenient feeding into storage and transport [9].

From the project finalisation, the beneficiary does not longer have to use electricity to heat the office and other buildings at the company premises. In fact the system now has district heating capacity and investigations are in hand to explore the possibility to link the BIOAGRO system to a new grid for providing heating to the nearby community.

The results from the project are:

1. Reduction of greenhouse gases
2. Reduction of combustible waste from grain production (with 100%) and total waste (with 95%): full utilization and capture of all seed residues from the beneficiary's production.
3. Eliminating costs for heating with oil and electricity (by 99%)
4. Ash is regained as plant nutrient (100%)
5. Less discharge of organic substances (with 20%), sulphur acid (86% in some measurements) and hydrochloric acid (70%) compared to existing techniques

To enable the Skånefrö's personnel to use and maintain the operation of the boilers, a partner technical company experienced in heating technology for biomass fuels (HOTAB) held education sessions for the operators of the BIOAGRO boilers. These mandatory sessions were held during full-day workshops together with practical tutorials on the BIOAGRO boilers. After the education and completed test runs, the target of demonstration and evaluation of the boilers and burners was reached.

The BIOAGRO system strengthens regional development by generating more jobs in rural areas. The rural focus of the system is also in congruence with the employment strategies within the Lisbon Strategy for Growth and Jobs, aiming towards the creation of jobs connected to rural and sustainable development. The additional employment generated from the BIOAGRO system at current capacity is on average 9 people working full time. The skill set required ranges from post-graduate engineers to high industrial experience. During the construction phase of the system some workforce as well as companies from outside Sweden has been employed.

There is a perceived need to ensure that public funds used for financing research and development within universities is getting utilised and transformed into useful applications for society.

The project sets out to demonstrate an innovative method which is transferable to the whole European agriculture sector, constituting a breakthrough in finding an alternative to fossil energy and thus having the potential to assist substantially in reducing the discharges of greenhouse gases in Europe.

The BIOAGRO actions consist in producing and using a high-quality pelletized fuel from grain, waste from grain, seed and grass in a small scale. The pellets will be demonstrated in small units (pelleting machine, heating boilers, burners) easily adapted to different agricultural crops, enabling quick change between different recipes with and without additives. Mixtures of additives together with seed waste will produce a homogenous, cost effective agro fuel (pellet) with low environmental impact. The system can be regarded as more sustainable in comparison with other agro fuel systems, since only non-food biomass is used.

One of the main challenges have been the planning and preparing for the building, construction and installation, in order to coordinate all technical, safety and environmental aspects, as well as the installation of prototypes and equipment (machineries and boilers).

The project implementation faced obstacles that made the process slow and difficult as for instance repeated formal complaints from neighbours delaying the planning and building permissions. Guarantee conditions imposed belatedly by the supplier of the main pellet press caused further constraints. Major technological problems in the material handling systems were faced, with equipment suppliers unable to suggest solutions applicable to the special conditions imposed by the variety of the biomass raw materials. The project management was able to overcome these challenges through a combination of persistence, positive attitude and innovativeness.

In order to further promote the commercial development of the BIOAGRO concept, it was decided to form a new company: BIOAGRO ENERGY Österlen AB. It was formally established after the end of the project, the 1st January 2010. It is a production facility that turns dried agricultural residues into a pelletized fuel and provides district heat supply to the local area. The aim is that the new company shall promote pellet production and pellet sales, as well as the use of the BIOAGRO development platform and its system solution for countries in need of local, environmentally friendly and cost-effective fuel.

A future activity, which is at the planning stage, is to use the BIOAGRO pellets to produce *biochar* as a new "Carbon Negative" technology based on pyrolysis. By adding biochar production to a BIOAGRO system, the whole system can actually remove greenhouse gases from the atmosphere.

Conclusion

The lessons extracted from these two cases and the others analyzed by the whole research are designed to guide the development of other production and product systems aligned with Systemic Design. Networks can bridge the gaps to sustainability and research coordinators can facilitate the creation of conditions for a self-sustaining network committed to sustainable approaches [10].

These systems, based on renewable energy, teach how the creation of sustainable infrastructures and agile energy systems could develop a region. So the conclusion is that Green Energy produced in small plants and distributed in the territory helps the success and the sustainability. Reading in the right way the environment is possible to design the right technology that produce bioenergy and that is connected with other renewable resources. Such agile system can be a new paradigm for both energy efficiency and reliability for any Region or Country (Figure 2).

Systemic Design generates Local Economic Development to establish the conceptual base and the analytical skills that are needed to harness local and regional economic change. Looking ahead the development of a multidisciplinary vision becomes crucial, in that way various skills are brought together, towards the emergence of a new culture of sustainable economic and technological innovation and process inspired by the dynamic operation of Nature, that is the system for excellence.

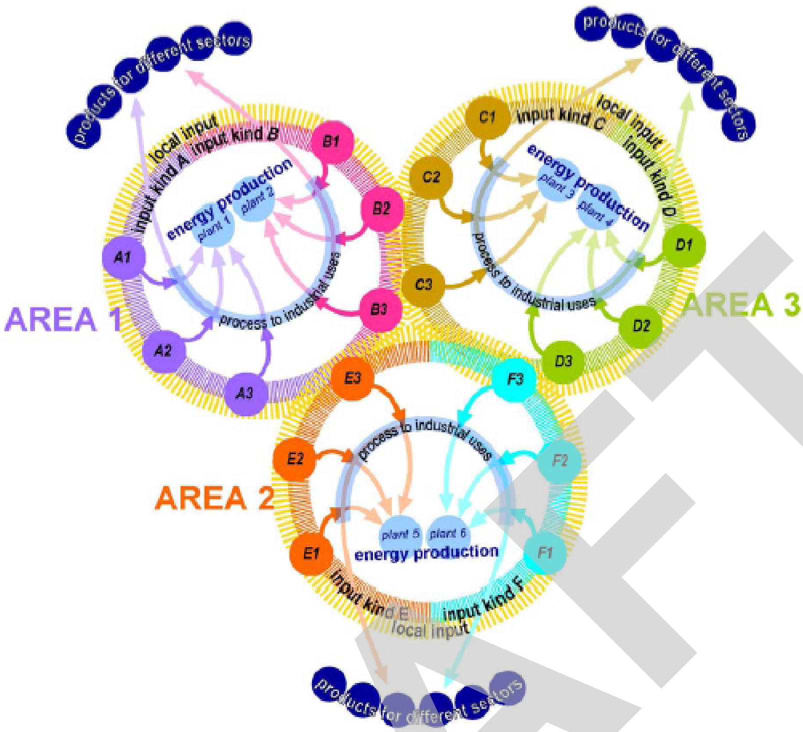

Figure 2: Agile Bioenergy Systems

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About the Author

Silvia Barbero
Degree in Ecodesign, II level international master in Systems Design, and now she is a PhD candidate in Productive Systems and Industrial Design at Politecnico di Torino. She applies to work and didactics individual involvement in ecodesign and environmental sustainability. She is cooperating with Tecnogranda, Scientific and Technological Park in Dronero and Agrindustria snc in Cuneo, in order to put on the systemic paradigm in industrial production. Since 2005 she has been lecturer of Environmental Requirements of Industrial Product at the degree in Graphic & Virtual Design, at Politecnico di Torino. She write for many international and national journals and her last book is Ecodesign, edited by Ulmann (2009).

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