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Industry ecology: an ecological economy view

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ABSTRACT

Traditional linear industries led to dwindling resources and even exhaustion, as well as environment pollution, it is a short-sighted unsustainable development mode of the economy. Industry ecology is to realize the harmonious development between economy and nature ecology by planning industrial systems according to material cycle in the natural ecological system, and to establish the circular economy mode of “resources-products-renewable resources”. There are strong similarities between the enterprises in an industrial eco-system and organisms in a natural eco-system, the paper first conducts a comparison of the natural eco-system and the industrial eco-system in several features, such as diversity, cyclic orientation and food chains, then discusses the functional benefits of an industrial eco-system in environment, economy and society, after that this paper points out that industry ecology is conducive to completely change the current way of economic growth mode, it is one kind of ecological economy pattern and a sustainable economic development model.

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Introduction

Since the beginning of last century, the rapid development of the world economy brought unprecedented pressure to ecological environment, depletion of resources, pollution and environment degradation. Resource and environmental issues have become increasingly prominent day by day. While enjoying economic prosperity, mankind sacrifices hygiene, health, pleasant environmental conditions, and peace of mind. People have to rethink about the consequences and try to find a new model of development for the sake of sustainable development for future generations. With the efforts from the end treatment of environmental campaign to the sustainable development strategies, people are realizing that the solution to the resource and environmental issues lies in the implementation of the development strategy of economic ecology, total control from the source, changing the original over-demanding operation mode, the recycling of natural resources, the development of renewable resources, the transformation in the direction of restoring the natural environment and expansion of the environmental capacity.

Ayres R. U., Kneese AV. (1969) brought up the concept of “industrial metabolism” for the first time while studying the flow of materials, based upon which Ayres put forward the epoch-making concept of “industrial ecology”. In 1983, six Belgian scholars co-authored and published an important book “The industrial ecology of Belgium”, which iterates the Belgian economy from the perspective of material flow and energy flow instead of the conventional monetary format. The industrial ecology concept was indisputable in its very early stages of development in the mid-1970s, in the context of the flurry of intellectual activity that marked the early years of the United Nations Environment Program (UNEP). Set up following the 1972 UN Conference on Human Environment in Stockholm, UNEP had as its first director Maurice Strong, who is presently a special adviser to the president of the World Bank. One of his close collaborators at the time was none other than Frosch A., who was to make a decisive contribution to the revival of the

concept of industrial ecology thanks to an article published in 1989 in the monthly magazine *Scientific America*. In the article, Frosch A. and Gallopoulos offered the idea that it should be possible to develop industrial production methods that would have considerably less impact on the environment. This hypothesis led them to introduce the notion of industrial ecosystem. Projections regarding resources and population trends lead to the recognition that the traditional model of industrial activity in which individual manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of should be transformed into a more integrated model: an industrial ecosystem ...The industrial ecosystem would function as an analogue of biological ecosystems (Plants synthesize nutrients that feed herbivores, which in turn feed a chain of carnivores whose wastes and bodies eventually feed further generations of plants). An ideal industrial ecosystem may never be attained in practice, but both manufacturers and consumers must change their habits to approach it more closely if the industrialized world is to maintain its standard of living and the developing nations are to raise theirs to a similar level without adversely affecting the environment. They maintain that the way to promote the harmonious development of man and nature is to transform the conventional industrial model into an industrial eco-system, i.e. to enhance the recycling of waste and resource conservation and to establish a unified model of production. The recycle process to reuse the “upstream waste” is realized by the production process of cooperative enterprises within the system. Frosch (1996) believed that an industrial eco-system of industrial metabolism is composed of a series of businesses which are located closely geographically and compensate one another in resources. Basically it is a systematic organization constructed by relationships of industrial co-existence such as enterprises share equipments within the system exchange waste and extra energy (Lambert and Boons, 2002) etc.

Industrial ecology is an industrial recycle system with the most optimum production, the most suitable consumption and

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the minimum waste emitted from the existing industrial system by using the waste of one process as the raw material of another one, finally a recycle flow is set up for material resources, energy, human resources and information, etc. The related study in this field is mainly focused on three levels (Evans and Stevenson, 2000). The first level is for an enterprise to explore internally how to best utilize all sorts of resources and minimize waste emission by making the production process collective. The corresponding technologies include clean production, green manufacture, etc. The second level is to consider the cooperation of different enterprises within an industrial system with the enterprises to simulate the producer, consumer and dissolver of the natural eco-system and to form an Eco-Industry Chain in which the enterprises are chained together by resources. Greater economic, environmental and social effects and benefits are achieved through co-existence and co-operation. The third level is to set up an industrial co-existence network in a region or a country, and achieve material recycling in a wider area.

The industrial eco-system is a new economic development model and it is an ecological economy of sustainable growth. A comparison of the natural eco-system and the industrial eco-system is discussed in this paper, while the functional benefits of an industrial eco-system is studied.

A comparison of the natural eco-system and the industrial eco-system

The natural eco-system is the most completely developed system in the biological circle. All sorts of organisms connect influence and interact with one another via certain structure within the eco-system so that the whole eco-system develops stably and balanced. Various biological species play different roles in an eco-system. The producers, the most fundamental component, are autotrophy which includes all green plants and some germs and is able to make organic substance from inorganic compounds. The consumers are those who can't produce organic substance from inorganic compounds. They are heterotrophy who relies directly or indirectly on the organic substance generated by the producers. The decomposers are also called redactors, which are the street cleaners of an eco-system who continuously decompose the complex organic substance to the simple inorganic compounds, which finally return to the nature.

There are strong similarities between the enterprises in an industrial eco-system and organisms in a natural eco-system. Firstly among various organisms and between organisms and the natural environment a web of nutrition structure is established, while in an industrial eco-system, relationships among enterprises are set up via offering products or some kind of service; Secondly an organism has metabolism function, which converts various organic and inorganic compounds to nutrition that they can utilize and the waste of which is excreted. Similarly, enterprises, through a variety of processes, can make the raw materials into semi-processed products or end products, at the same time producing a variety of waste.

In addition, in a natural eco-system a variety of waste can be dissolved and absorbed by different species, and turn into organic or inorganic compounds again. Nothing is truly wasted, in an industrial system there is a relationship among enterprises of using energy, material and water sequentially, the by-product of one enterprise is a very valuable resource of another enterprise. When the concept of industrial metabolism is applied to an industrial park, an industrial network of co-existence starts to emerge.

The following table describes the features comparison of the natural eco-system and the industrial eco-system.

The key features of natural and industrial ecosystems are comparatively listed in Table 1. If we follow the concept of ecosystems, man-made systems such as industrial complexes, a city, or a region, the demand of raw materials (including crude oil) to be abstracted from natural resources could be tremendously reduced. Consequently, the cost of raw material acquisition would decline, and profits would correspondingly rise. To be expected are positive effects on the short and on the long run. The industrial system would approach the state of sustainability. Obviously, application of industrial ecology is a most capable instrument of sustainable development (Michael von Hauff, Ppetter, 2008).

The functional benefits of an industrial eco-system

Industrial ecology is an interdisciplinary framework for designing and operating industrial systems as living systems interdependent with natural systems. It seeks to balance environmental and economic performance within emerging understanding of local and global ecological constraints. Some of its developers have called it "the science of sustainability". Industrial ecology helps companies become more competitive by improving their environmental performance and strategic planning. It helps communities develop and maintain a sound industrial base and infrastructure without sacrificing the quality of their environments. And it helps government agencies design policies and regulations that improve environmental protection while building business competitiveness.

Through the composition of independent enterprises and the coordination of their cooperation to promote the exchange of materials, energy, water resources and by-products among enterprises from within, an industrial eco-system evolves into a recycle industrial system with minimum cost and the most effective and beneficial economically and environmentally. An industrial eco-system can reduce the usage of raw materials, reduce pollution, increase energy efficiency, decrease greatly the amount of waste from the production process, slow down the pace of the earth becoming full (H. E. Daly, 2004), and fundamentally solve the contradiction between the economy growth and the ecological environment in the development of a region. Many enterprises in an industrial eco-system establish close connections in using resources, sharing information and utilizing by-products, and a network of co-existence and co-operation comes into being, which enhances trust between enterprises and helps to reduce transactional cost including the cost of negotiation, the cost of executing contracts and cost of contingency. In an industrial eco-system an enterprise is green, and it develops ecologically in accordance with the requirements of a recycle economy. It is very helpful to establish a good social image of the enterprise, improve customer satisfaction, overcome the "green commercial barriers" in international trade, and improve the product competitiveness in the international market.

Industry ecology: an ecological economy view

Sustainability can be observed as a problem complex arising from ecological demands of economic activities exceeding the Earth's carrying capacity. Carrying capacity is determined by the ability of planetary sources (material and energy resources, land area, biomass) and sinks (atmosphere, water, soil) to regenerate themselves (to reproduce resources, to assimilate waste) in a given time period (Reichel, A., Seeberg, B., 2010). According to the research (Wackernagel, M., 1996), economic activity today

is exceeding the carrying capacity of the Planet by more than 30 percent e.g. humanity is using up resources faster than nature can regenerate them. In other words, humanity has started to become an ecological debtor for roughly the last 25 years.

Ecologic sustainability rests upon securing the basis of life and industrial production without compromising global and the long-term function of the environment. Now we are facing a major difference between the ecologic economy and the neo-classical environmental economy. Environmental damage cannot be resolved by the insertion of nature into the economy, rather it is much more important to bring the economy back into harmony with nature, i.e. to integrate it with nature (Common and Stagl, 2005). It has become increasingly clear that the only way out to solve the growing problem of resources and the environment lies in developing industry ecology, we need to control human economic activities within a range the ecosystem can withstand, and the production activities should be conducted to best suit the natural status, so that the relationship between mankind and nature becomes more harmonious and unified.

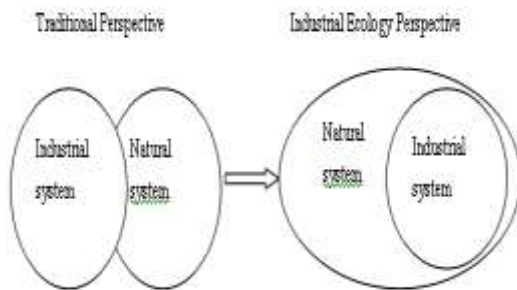


Fig. 1 Industry evolution
Resource: Jingfu Guo (2010)

From the eco-industrial development evolution, it is not difficult to see that industrial ecology has the characteristics of both natural science and social science. The core essence of the eco-industrial system is the layer of material circulation and delivery of energy use, not only to solve environmental problems, more to solve the problem of scarcity of resources or resources of economic efficiency, that is, resources of the correct disposal (Effective) and efficient use (Efficiency) problem. The main body of the eco-industrial system is industry; its development connotation is the economic efficiency of resource application and adaptation to environment. It is essentially the evolution of resource division and its ultimate goal is harmony between industry (economic activities) and natural environment and sustainable development of industry. In the eco-industrial system, enterprises rely on regional coexistence cooperation,

resource's efficient use to transfer traditional linear production line into a feedback cycling mode, from a separating mode into an integrated cycling mode between industry and environment. Compared with traditional industry, eco-industry is sustainable and harmonious development in guiding ideology, low mining, fully utilizing and little discharging in resource utilizing, clean production, procedure controlling, little input in environment protection, system inner resource, pollution recovery interior in waste disposing, ecological and green consumption in consumption ideas etc.

The industry ecology is conducive to completely change the current way of extensive economic growth mode, to achieve economic, ecological and social benefits of organic unity. Therefore, the ecological industry is a new, sustainable economic development model, it is one kind of ecological economy pattern.

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Tab.1 Features of natural ecosystems and industrial ecosystems

Features of natural ecosystems	Features of industrial ecosystems
Diversity of species	Diversity of enterprises regarding branch affiliation and size
Cyclic orientation of material and energy flow	Cyclic orientation of material, energy flow
Sectoral cross-linkage of material and energy flow	Cross-connecting enterprises belonging to different branches with respect to flow of raw and waste materials as well as flow of virgin and used energy
Establishment of food chains and recovery chain	Recovery of valuable substances from waste materials, and return of these substance into the cycle of materials
Feed-back and feed-forward control mechanisms	Feed-back and feed-forward control mechanisms

Tab. 2 Effects and benefits of an industrial eco-system

Functional Benefits	Definition
Environmental benefits	Reduce environmental pollution and waste emission; improve environmental recoverability and ecological adversity
Economic benefits	Reduce the cost of management and transaction of an enterprise; increase the efficiency of resource utilization
Commercial benefits	Lift the enterprise image, improve customer satisfaction and competitiveness
Social benefits	Neighborhood satisfaction; promote sustainable development