

A Prototype of Hot Spring Ecological Industrial Park

Yu-Ting Hung, Assistant Professor, Department of Tourism Management
Chia Nan University of Pharmacy and Science, Tainan, Taiwan

ABSTRACT

Tourism in hot spring areas has been popular in Taiwan recently. However, hot spring resources are limited and scarce, so it is important to use hot spring resources effectively and appropriately, and study hot spring industrial symbiosis and industry chain. Therefore, the study constructs a hot spring industrial park model through ecological viewpoint. PDCA cycle is adopted to install the operation mechanism of the park, examine its fitness-for-use, so it can serve as a reference when managing hot spring EIPs in the future.

Keywords: hot spring industry, industrial symbiosis, eco-industrial park

RESEARCH BACKGROUND

Tourism industry is gaining popularity in recent years, and hot springs have become one of the important aspects in its development. Therefore, the employment of hot spring resources and the development in hot spring areas are becoming more valued in Taiwan, where hot spring resources are abundant. However, the exploitation of major hot springs started early, but mostly without systematic planning and management, leading to poor operation and conservation of hot spring water resources. According to the report of Industrial Technology Research Institute, the area detected as containing hot springs covered 1.4 km² in 1974. But in just 20 years, it decreased by more than 30%, and only 0.96 km² were left in 1993. The water level and temperature of hot springs also declined significantly. The underground water level in hot spring areas dropped a few meters in average, and in the past 10 years, the temperature probably had declined by almost 10°C. These are all warning signs showing the consequences of poor application and management of hot spring resources in Taiwan.

In addition, the diminishing of global resources and the public's awareness of environmental protection have led to the growing emphasis on value-adding employment of natural resources, which is mostly approached by resource reuse. However, reusing resources is not a cure for all, leading to the emergence of "industrial ecology" in recent years. Industrial ecologists simulate natural ecological systems by multiple methods when assessing resources application and conservation, maximizing the benefits and minimizing the influence on the environment. They advocate producing more goods and services with fewer resources, and actively take part in pollution prevention and resource reuse projects, to reduce environmental cost and increase eco-efficiency, so to improve the value and efficiency of resource application. Therefore, the study constructs a hot spring industrial park model through an ecological viewpoint. PDCA (plan-do-check-act) cycle is adopted to install the operation mechanism of the hot spring eco-industrial park (EIP), examine its fitness-for-use, so it can serve as a reference when managing hot spring EIPs in the future.

INTRODUCTION OF HOT SPRING INDUSTRY IN TAIWAN

Taiwan has an area of 36,006 km² and a population of 23.1 million (2009), making it one of the most densely populated areas in the world (642 per capita/km²). Mountains cover more than 60% of the terrain and the island is not richly endowed with natural resources. Taiwan is a developing country, although its economy has entered a more mature stage in recent years. To meet the needs of enhancing national competitiveness in the global market, a strategic service-oriented industrial plan (which aims at developing international competitiveness of Taiwan as well as encouraging collaboration within local industries) was proposed by the government in 2003, and accompanied by the passage of the Hot Spring Bill. Meanwhile, the 2010 policies were tourism-oriented, especially emphasizing on the hot

spring industry. There are 128 hot spring areas in Taiwan which could be classified into 4 types. The first is muddy hot spring, which is a kind of alkaline carbonate hot springs, murky and containing sulfate, making the water black and satiny to touch. The second is ocean hot spring, the only underwater hot spring in Taiwan. The third is mountain hot spring, accounting for the majority in Taiwanese hot springs. The fourth is culture hot spring, the heritage of Japanese occupation. The influence of Japanese culture could be seen in these hot spring areas.

ECO-INDUSTRIAL PARK

“Eco-industrial park” (EIP) is not devised with a standard definition or interpretation due to the lack of a standardized recognition scheme. Some common operational definitions are provided as followed. Cote and Hall (1995) believes that EIP is an industrial system that can conserve natural and financial resources, and reduce costs and liabilities of production, material, energy, insurance and treatment. It can improve operation efficiency, quality, the health of the staff and public image, and offer potential opportunity to raise income for the industry by selling waste materials.

President’s Council on Sustainable Development (PCSD) (1996) defined EIP by two paragraphs as followed:

A community of businesses that cooperate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat), leading to economic gains, gains in environmental quality, and equitable enhancement of human resources for the business and local community.

An industrial system of planned materials and energy exchanges that seeks to minimize energy and raw materials use, minimize waste, and build sustainable economic, ecological and social relationship.

Lowe and Warren (1996) defined EIP as a community where production and service industries are based on common assets. Industries seek approaches to reinforce environmental and economic performance by co-managing issues concerning environment and resource (energy, water and materials) application. Through collaboration and cooperation, business community pursues its collective interest, which is greater than the sum of the individual interest of each industry. Even if the performance of individual industry is optimized, the sum of the each industry’s optimal performance cannot surpass the collective interest of the park.

Taking the abovementioned definitions (Frosch,1992; Graedel,1994; Graedel and Allenby,1995; Allenby,1996) together, six major aspects covered by the idea of EIP is revealed: industrial ecology, ecological design, environment, society, economics and management. It leads to a more precise definition: to plan, design and operate the industrial park from an ecological standpoint, forming a symbiosis among industries in the park and a closed-cycle eco-network, so to create collective interests for all industries and improve environmental, economic and social performance.

PROTOTPYE OF THE DEVELOPMENT MECHANISM OF A HOT SPRING EIP

The Ecological Features of a Hot Spring Industrial Park

The features of the eco-system in a hot spring industrial park include diversity, inertia and resilience. Diversity refers to the system’s ability to recycle and reuse material and energy under pressure. A complex closed cyclic chain is formed via various participants in the eco-system in which material and energy flows in a closed circulation, as if they are continued being recycled and reused. Inertia illustrates the particular business characteristics of the hot spring industrial park, usually a fixed operation or business model. It is capable of resisting changes, and significant alternation is not easily triggered by external interference. Resilience means that the park’s management approach should be able to cope with pressure provoked by external changes in the environment. All these features rely on the feedback loop in the eco-system to operate normally. It shows that the relationship between each participant in the eco-system is interactive (needing feedbacks) and correlated (via cyclic system). It also verified principles of “everything is connected to everything else” and “everything must go somewhere.” All the entities involved, be it in a biotic or abiotic form, are connected by chains of input and output, which is balanced by feedback loop system. The relationship is shown in Figure 1.

Figure 1: The Ecological Features of a Hot Spring EIP

The Construction Principle of Hot Spring Industrial Symbiosis Network

Industrial symbiosis network, or EIP and industrial eco-system based on similar principles, all emphasize the implementation of the major principle in industrial ecology: regional synergies (Mirata, 2001). The major application approach is to exchange materials and energy in a mutually beneficial manner in an environment where industries are highly interdependent, and promote other industrial welfare (Manahan, 1999), so to avoid the problem of waste treatment. Another relevant issue is to connect, vertically as well as horizontally, traditionally separate industries, and form a network of cooperation that enhances industrial competitiveness by physical exchange of water, materials, energy and by-products, etc. Therefore the key to industrial symbiosis is to achieve regional collaboration and synergy by geographic proximity. As a result, the fundamental premise of industrial symbiosis is the geographical location of industries, and its core is the exchange of materials and resources.

A hot spring EIP contains eight aspects, as showed in Figure2: social ecology, economic ecology, managerial ecology, living ecology, humanistic ecology, community ecology, industrial ecology and environment ecology. Each aspect may have its own definition, but they all share a similar principle: to develop and construct the park with an ecological viewpoint. The purpose is to build an eco-system simulating the natural one via collective environment management and industrial symbiosis, and create collective interests for all industries and improve environmental, economic and social performance. Therefore the operation mechanism of a hot spring EIP should take all these ideas and thoughts into consideration.

The traditional material flow produces various forms of wastes at different stages throughout the process, from exploitation and processing of raw materials, product manufacturing, to product consuming. Most of these wastes are treated directly, such as random emission, incineration, careless dumping, burying in landfills or piling, often without a relevant recycling operation procedure. It continues consuming renewable and non-renewable resources on earth, and the waste increases as the industry's scope expands, which is a linear waste of resources. However, the hot spring industry is highly-dependent on resources. The traditional material flow must be altered into one that has higher efficiency, actively seeking the possibility to reuse wastes or by-products generated. The application value of hot spring water resources should be raised, and single-use of water resources should be avoided, increasing productivity and lowering the cost. Wastes that might be generated at each stage should be minimized as well. The altered flow is shown in Figure 2, illustrating a by-product exchange model, wastes and pollutants' usage model, and a resource symbiosis model. It reveals a way to approach the hot spring industrial symbiosis, mainly through symbiosis models such as by-product exchange development, supply chain coordinating network and strategic alliance.

In addition, based on material cycle theories in the field of industrial ecology, the study will construct the hot spring EIP with cyclic production system, material balance theory in traditional production system, and material balance theory in by-product application production system, as shown in Figure 2. The traditional operation mechanism is designed to maximize the economic profits of individual industry, and not able to achieve the goal of achieving collective interest. Therefore, the mechanism needs to be restructured, so that the park is built centering around ecological principles. The study applied PDCA cycle to explore and restructure the operation mechanism, to boost continuing ecological development, so the eco-system in the park will gradually become more mature.

The development of hot spring EIP in the future will focus on how to employ resources more efficiently. Therefore, industrial symbiosis and by-product exchange are the root of a hot spring EIP. Whether industries could support each other, share resources, reuse waste and exchange by-product are key factors. In the future, in addition to continue exploring hot-spring-related industries, reuse of information technology, energy, water and material resources, and R&D or promotion of development projects like environment monitoring and transportation should also be included. Through diversification of hot spring EIPs, the hot spring industry could become more eco-friendly and develop in a sustainable manner.

Figure 2: The Structure of a Hop Spring EIP Model

The Proto-Structure of a Hot Spring EIP

A hot spring EIP is operated based on ecology, with its mechanism simulating an eco-system and industry clusters as “biocoenosis.” The relationships between clusters are formed according to the compatibility of their characteristics, and various functions are organized neatly by following a specific model. It will achieve a win-win-win solution by making the industrial system a cyclic symbiosis, benefiting organizations or industries that are involved in, and forming a self-sufficient and eco-friendly park. The study adopted PDCA cycle to explore and restructure the operation mechanism. The proto-structure of the park will be explained by each step as followed.

1. Plan

(1) Sector Identification

Because a hot spring EIP is a multiple complex, each organization should have a certain sense of unity instead of being disunited. The operation and development of the park requires the contribution of various units and organizations, in addition to industrial biocoenosis. According to Hung (2009), Taiwanese hot spring industry could be divided into several sectors: hot spring development, hot spring technology application, leisure and health, tourism, hot-spring-related agriculture, hunting and forestry, and application of hot spring in living and housing. These sectors will be organized in the park. In addition, the official management center and necessary infrastructure and construction will also be included, as shown in Table 1.

Table 1: Planning of Sectors in Hot Spring EIP

Sectors	Industries or Infrastructure that will be introduced
Official Management Center	Product Display and Trade Center, Human Resources Training and Education Center, and Administration Center
Public Facilities or Construction	Transportation, drainage system, water supply system, sewage system, hot spring pipeline system, power facilities, parking lots and landfills
Hot Spring Development	Access and Supply of Hot Spring, Water Testing Department, Planning and Development of Hot Spring Area, R&D Department, and Hot Spring Drilling
Hot Spring Technology Application	Technologies include hot spring control and regulation, water treatment, biology, information, and geothermal application
Leisure and Health	Leisure medicine, cosmetology, healthcare, and medicinal herbs
Tourism	Historical hot spring construction, camping, hot spring hotels, and eco-tourism
Hot-spring-related Agriculture, Hunting and Forestry	Hot spring breeding, planting, food, acquisition of "Taiwan Traceability Agriculture Products" certificate
Application of Hot Spring in Living and Housing	Hot spring housing, geothermal power plants, and geothermal heating

(2) Organization

The implementation and organization of hardware in a hot spring EIP is the key to the success of an eco-park, industry symbiosis and regional cooperation. Well-organized public facilities are the basis of eco-development, while a sound organization is the means to achieve the goal. Figure 3 demonstrates the organization and relationship between various units in the hot spring EIP.

- **Production and Service Units of Hot Spring Industry**

It refers to general manufacturing units. The major task of these units are installing or conducting inter-enterprise industrial symbiosis, by-product and waste exchange, environmental design and process improvement.

- **Water Resources Reuse and Treatment Center**

Its major task is to recycle by-products generated by Production and Service Units and return treated materials back to them, or convert by-products into recycled products to sell. Units involved in include sewage treatment system, incineration system, power recycling plants, or other industries that are capable of resource recycling.

- **Official Management Center**

It is the management unit that provides services in the park, and is also the core of operation. A sound and convenient information platform can further increase the rate of resource recycling and by-product exchange among industries, and serve as a consulting and assistance channel of technology, communication, and information for industries. It will also be the forefront service provider to the public.

- **Technology R&D Center**

Its major task is to conduct process technology improvement, recycling technology innovation, management approach improvement, and technology assistance and promotion. It will also cooperate with academic institutes or organizations to conduct research, and assist industries in the park to achieve the production goal of sustainable water resources application.

Figure 3: Operation Division Model and Relationship among Various Sectors

1. Do

Water resources are limited to application, therefore the operative goals of the hot spring EIP are:

- (1) Environment and eco-system protection: include waste reduction, multiple uses of hot spring water resources, water resource exploitation reduction, pollution reduction, etc.
- (2) Efficiency enhancement of hot spring resources application: improve application efficiency through by-product exchange or innovative technology or equipment, in combine with environment management, to diversify the usage of hot spring resources.
- (3) Regional development: provide regional development model that promotes commercial, personnel, economic and natural resources, create job opportunities and income, and establish a cyclic economy.

The executive strategies of the hot spring EIP is listed in Table 2.

Table 2: Executive Strategies of the Hot Spring EIP

Dimensions	Executive Strategies
Environment Accomplishments	<ul style="list-style-type: none"> • Adopt water or energy conservation system or recycle equipment • Conduct green projects • Restore and remedy environment damages in the past • Improve and repair public facilities and constructions to prevent losses result from natural disasters such a typhoon and earthquake • Promote R&D of waste reduction and water resource reuse technology

Environment Governance	<ul style="list-style-type: none"> • Incorporate other industries or organizations to enhance environment performance collectively • Establish an official management center, expand the benefits of industry cooperation, and increase opportunities of resources reuse • Drive regional development in hot spring areas
Environment Commitment	<ul style="list-style-type: none"> • Manage waste discharge volume • Manage usage volume of hot spring water resource • Enhance usage efficiency of hot spring water and various resources • Reduce waste and pollution generated by traditional transportation • Enhance education and training
Environment Management	<ul style="list-style-type: none"> • Cultivate staff's environmental awareness • Coordinate intra- and inter-industrial communication • Integrate innovation technology, e.g. cogeneration and energy exchange • Expand pollution prevention projects
Extension of Environment Symbiosis	<ul style="list-style-type: none"> • Publish information related to the park to the public • Provide education and training venues or activities to the public • Communicate openly with local residents on environment issues

2. Check

Checking is mainly to understand and evaluate the performance of the hot spring EIP. Whether the eco-development of the park is successful is evaluated based on the progress of three operative goals: environment and eco-system protection, efficiency enhancement of resources, and regional development. If the achievement rate is close to 100%, it means that the development of the goal is close to maturity. Formulae of various indicators are as followed.

(1) When evaluating the performance of environment and eco-system protection

a. The ratio environmental-friendly products to other products

Originally, this item was meant to reveal the ratio of environmental-friendly products to all products manufactured in the park. But a statistic of products manufactured in the park is difficult to create since they are numerous and diverse, thus the study adopted the ratio of relevant key environmental industries instead.

- Ratio of relevant key environmental industries= number of relevant key environmental industries/number of all industries in the park

b. Waste reduction

- Achievement rate of solid waste reduction= $100\% - [(\text{assessment of yearly waste sum volume} - \text{goal of yearly waste volume}) / \text{assessment of yearly waste volume} * 100\%]$
- Achievement rate of air pollution reduction= $(365 - \text{assessment of number of days of poor air quality}) / 365 * 100\%$
- Achievement rate of wastewater reduction= $100\% - [(\text{assessment of yearly wastewater sum volume} - \text{goal of yearly wastewater volume}) / \text{assessment of yearly wastewater volume} * 100\%]$
- Achievement rate of CO₂ reduction= $100\% - [(\text{assessment of yearly CO}_2 \text{ emission sum volume} - \text{goal of yearly CO}_2 \text{ emission volume}) / \text{assessment of yearly CO}_2 \text{ emission sum volume} * 100\%]$

c. Multiple usage rate of hot spring water resources

- Multiple usage rate of hot spring water resources= $(\text{hot spring water consumption volume} - \text{hot spring sewage discharge volume}) / \text{hot spring water consumption volume} * 100\%$

(2) When evaluating the usage efficiency of hot spring resources

- By-product exchange rate: the performance is revealed by studying the economic benefits of by-product exchange.
- Resource recycle rate: revealed by $(\text{compost volume} + \text{volume of resource recycled}) / (\text{volume of treated waste} + \text{volume of resource recycled})$, or from statistics created by relevant institutes.
- Resource production/ eco-efficiency= $\text{product or service value} / \text{impact on the environment} = \text{the sum (or collective revenue) of product and service value provided by industries in the park} / (\text{sum volume of waste} + \text{resource usage volume}) - \text{by-product exchange volume}$

- (3) When evaluating the performance of driving regional development
 - a. Regional GNP (average GNP in the region): can be found in statistics created by Budget, Accounting and Statistics Offices in various county and city governments.
 - b. Job opportunity creation: job opportunities created directly or indirectly by the EIP.

3. Act

Nowadays ecological principles have not been applied into hot spring industry, therefore the hot spring EIP drafted by the study is only a theoretical structure. No real case could be acted on yet.

CONCLUSION

The study follows the guidance of ecological theories and refers to domestic and international literatures to construct the development principles and operation mechanism of a hot spring EIP by applying the PDCA cycle. At planning stage, the organization is solidified and sectors are identified. At doing stage, operation goals are drafted, and the eco-system of the EIP is approached through various strategies. At checking stage, performance is evaluated to assess park operation, and serve as a reference for improvement at acting stage later. With the diversification of hot spring resources usage, the prototype model constructed by the study could be taken as the blueprint of development projects of hot spring areas in Taiwan. It can assist to reduce pressure on hot spring resources and environment cost, and increase eco-efficiency and industrial output.

However, the hot spring EIP sketched by this study includes emerging industries that are undeveloped or have great potentials, thus precise output value cannot be found. The study roots in the suggestions provided by experts from industries, government and academia, lacking a substantial confirmation. In the future, if the hot spring EIP is put into practice or the idea becomes more mature, the research procedure, method and model constructed by the study can be the basis of further investigation.

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