

# Conceptual Model for Effective Implementation of Industrial Symbiosis: A Case Study of Mab-Ta-Phut Industrial Estate

Paitoon Termsinvanich

*Environment, Development and Sustainability Program,  
Graduate School, Chulalongkorn University, Bangkok, Thailand  
E-mail: paitoon\_eng@hotmail.com*

Suwattana Thadaniti

*Social and Human Development Program,  
Graduate school, Chulalongkorn University, Bangkok, Thailand*

Dawan Wiwattanadate

*Faculty of Engineering,  
Chulalongkorn University, Bangkok, Thailand*

Doi:10.5901/mjss.2013.v4n1p133

## Abstract

*This paper illustrates effective factors as well as a model for effective implementation of industrial symbiosis (IS) in Mab-Ta-Phut Industrial Estate that was used (MTBIE) as a case study. The study was carried out using questionnaires, in-depth interview, and site survey both factories in MTBIE and waste processor plants in Saraburi Province. Information from the study indicates that policy (on zero discharge, zero waste to landfill and willingness to adjust process), initiator, information (on waste generation), and financial mechanisms are effective factors influencing IS implementation, while technology and public participation are not as effective for the case of factories in the industrial estate. Therefore, a model for effective implementation of industrial symbiosis in industrial estate is proposed and presented in this paper.*

**Keywords:** *Industrial symbiosis; Eco-Industrial Park; Waste generator; Waste processor*

## 1. Introduction

Impacts of industrialization and population growth on environment have been an issue of public concerns world-wide for several decades, especially in developed countries. In the past, industries could be located in any areas and individually emitted pollutants to environment causing difficulty in pollution control. Thus, an industrial park concept has been introduced to set up community of industries which are grouped to obtain advantages of arranging common services (Barrie, 1992) and controlling emissions in the standard level. However, many countries still confront the environmental problem due to accumulation of the impacts. Hence, a concept of Eco-Industrial Park (EIP) as well as Industrial Symbiosis (IS) that aim to create materials and energy interchanging networks among companies had been initiated to provide benefits for both environment and economy for the participating industries and societies (Graedel, Allenby, 2003).

Map-Ta-Phut Industrial Estate (MTPIE) is located in Rayong province, eastern Thailand. It was developed in 1989 by the state enterprise, Industrial Estate Authority of Thailand. Although most industries in MTPIE have been continuously developing and implementing environmental management system in accordance to ISO14001 and trying to control their emissions within emission standard, the accumulated emissions still exhibit environmental problem. This means that the current environmental management method is not sufficient to develop industries in a sustainable way. Industrial production is a dynamic system, and wastes generated from the industries are dynamic as well. Therefore, managing and addressing these wastes have to be dynamic too. Hence, this study aims to find factors effective for implementation of industrial symbiosis and to propose a model for effective implementation of the industrial symbiosis in an industrial estate.

## 2. Literature Review

### 2.1 Industrial symbiosis

Industrial symbiosis is a sub-field of industrial ecology that focuses on resource productivity improvement and environmental problem mitigation by transforming by-products and/or wastes of one firm into a valuable input of another, which brings the change of material flow from linear into a closed-loop one that can improve competitive advantages of the industrial system by reducing production cost while improving environmental performance (Zengwei, Lei Shi, 2009 and Graedel, Allenby, 2003).

Kalundborg's industrial symbiosis is the world's best known example of built network cooperation between five industries and municipality for both economic and environmental benefit (Suavane, 2002) (R. and L. Ayres, 2002) as shown in figure 1.

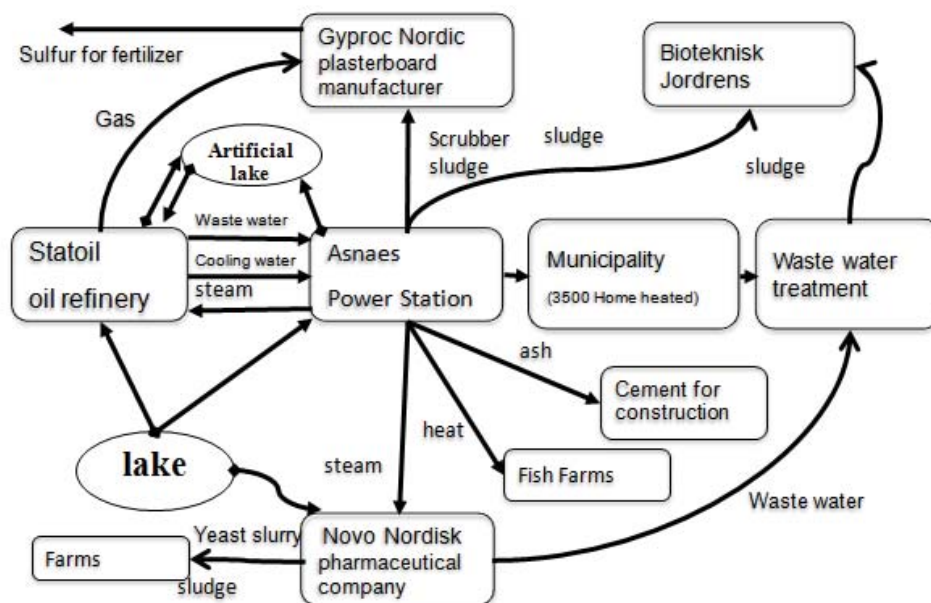


Figure 1 *Industrial symbiosis in Kalundborg's industry.*

Source : (<http://www.coolpicturegallery.net/2009/01/science-of-industrial-symbiosis.html>)

Asnaes Power Station, a coal power plant, the park's heart, generates electricity, steam to pharmaceutical company, refinery plant, municipality and, heat to fish farms. It sends scrubber sludge to plasterboard manufacturer, ash to cement plant and receives and treats waste water from refinery plant then sends its sludge to soil remediation plant.

Statoil oil refinery receives steam power from power plant to produce gas and sends waste water and cooling water to power plant.

Novo Nordisk receives steam power from power plant to production line and sends yeast slurry and sludge to farms and sends waste water to treatment plant

Gyproc Nordic East, a plasterboard manufacturer receives scrubber sludge from power plant to production line and sends sulfur to fertilizer plant.

Bioteknisk Jordrens, a soil remediation plant, receives sludge for production line.

The benefit of this symbiosis conserves energy by 80% in power plant only, decreases CO<sub>2</sub> emissions by 18%, saves around three million cubic meters of water annually, produces 800,000 cubic meters of liquid fertilizer. Finally this adds up to the ottar saving of 160 million euro for the participants per year.

### 2.2 Study area: Map Ta Phut Industrial Estate (MTPIE)

Map-Ta-Phut Industrial Estate (MTPIE) is located in Rayong province, eastern Thailand. It was developed in 1989 by the

state enterprise, Industrial Estate Authority of Thailand, Ministry of Industry, to serve industries that use natural gas as raw material while petrochemicals are the biggest and the most important industries in the MTPIE.

At initial establishment, MTPIE has been considered to be an industrial area that is entitled to receive the most benefits, encouraging investments from both Thai and foreign investors. In 2009, administrative court noticed that Mab-Ta-Phut was pollution controlled border and held over 76 projects.

In addition, although most industries in the MTPIE have been continuously developing and implementing environmental management system according to ISO14001 and trying to control their emissions within emission standard, the accumulated emissions still impact environmental problem.

### 3. Research Methodology

#### 3.1 Participants

7 waste generator respondents of all petrochemical industries participate in this study, 3 up-stream, 2 intermediate and 2 down-stream. 2 Waste processors were referred by waste generator and 2 industrial estates in Map-Ta-Phut area.

#### 3.2 Instrument

The instruments used in this study were questionnaire, general information on environmental policy, operational activities, gathered opinion on IS. The respondent factories were then appointed for site survey as well as in-depth interview to collect further information.

Collected information was then analyzed to identify effective factors for the industrial Symbiosis implementation so that a model for effective implementation can be formulated

### 4. Findings and discussion

#### 4.1 Symbiosis status of the studied factories

- Factory Respondents

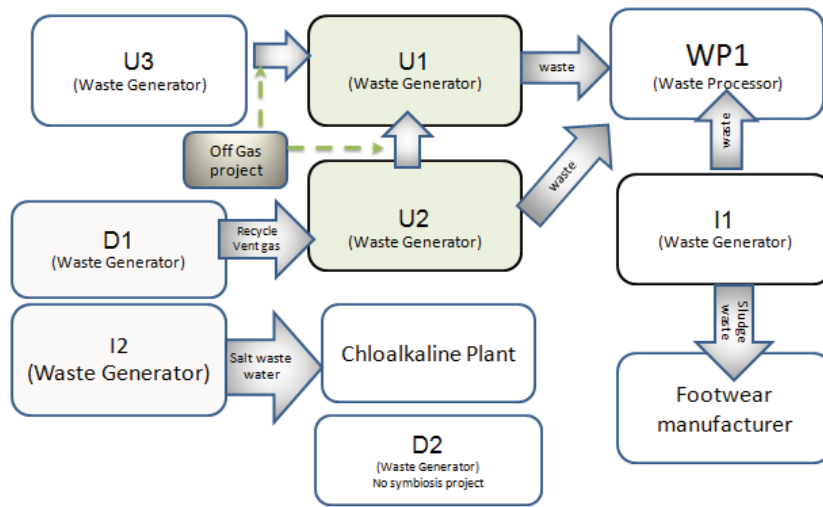
The respondents' factories symbiosis implementation status are summarized in Table 1 and Figure 2.

Table 1: *Respondent Factories of the study and status of IS implementation*

Petrochemical Group	Symbol Used	Numbers of Factory	Products	symbiosis Implementation Status
Up-stream	U1, U2, U3	3	Olefin, Benzene	U2 and U3 send off gas to U1 to be distilled and used. U1 and U2 send waste to WP1
Intermediate	I1, I2	2	PVC, Phenol	I1 sends sludge waste to a Footwear manufacturer and other wastes to WP1 and used in cement kiln. I2 sends salt waste water to Chloalkaline plant.
Down-stream	D1, D2	2	Polyethylene, Polypropylene	D1 sends recycle vent gas to U2 D2 not implement

Note: WP1 is a waste processor in Saraburi province.

Figure 2: Symbiosis status of the studied factories



4.2 Factors influencing symbiosis implementation

Various factors having potential to influence on symbiosis implementation were evaluated and summarized in Table 2.

4.2.1 Factor 1: Policy

All factories in MTP area have policy on environmental management and are certified in accordance to ISO14001: Environmental Management System. According to on site survey and in-depth interview, it is found that all these factories implement symbiosis, except U3, have policy on zero landfill and process adjustment willingness; while D2, without symbiosis implementation, has no policy on both zero landfill and process adjustment willingness. In case of U3, though having no policy on zero landfill and process adjustment willingness, it still implants IS due to consultant initiator. Therefore, policy on both zero landfill and process adjustment willingness is considered as an important factor for symbiosis implementation. Policy on zero discharge is also important for IS implementation. Lastly, 3 out of 6 implementing factories have the policy and strong implementation.

Table 2: Factors influencing on symbiosis implementation

Factors	U1	U2	U3	I1	I2	D1	D2 (no IS)
<b>Policy on</b>							
environmental management	√	√	√	√	√	√	√
zero discharge	√	-	-	√	√	-	-
zero landfill	√	√	-	√	√	√	-
process adjustment willingness	√	√	-	√	√	√	-
<b>Factors</b>							
Initiator	Industrial Estate	Industrial Estate	Consultant	Industrial Estate	Manager	Environment officer	-
<b>Information</b>							
Confidential	√	√	√	√	√	√	√
reveal only distorted quantity	√	√	-	√	√	√	√
<b>Financial mechanism</b>							
incentives at initial project	BOI TAX	BOI TAX	Not expect	BOI TAX	BOI TAX	BOI TAX	50-50%
continue subsidy	subsidy	subsidy	Not expect	subsidy	subsidy	Polluter pay discount	Polluter pay discount

Technology Assistant							
no technology problem	√	√	√	√	√	√	√
Stakeholder Participation							
government involve	√	√	-	√	-	√	-
communities involve	-	-	-	-	-	-	-

Note: √ represent answer yes

#### 4.2.2 Factor 2: Initiator

According to on site survey and in-depth interview, it is found that all implementing factories did not initiate the project by themselves, but having an initiator; 3 out of 6 implementing factories were initiated by industrial estates and 1 out of 6 was initiated by the manager, another 1 out of 6 was initiated by consultant, and another one was initiated by environmental office. Therefore, initiator is considered as a more crucial factor for symbiosis implementation.

#### 4.2.3 Factor 3: Information on Waste Generation

According to on site survey and in-depth interview, all 7 factories agree that information on waste generation in each factory is extremely important for symbiosis implementation, but also confidential and can only be revealed if quantity is distorted or they have contract with each other

#### 4.2.4 Factor 4: Financial Mechanism

According to on site survey and in-depth interview, it is found that 6 out of 7 factories need financial supports or incentives like BOI Tax exemption at the initial project, and also the continuing subsidy during project operation. However, one of them 7 factories does not expect incentive from government. Therefore, financial mechanism is considered as one important factor for symbiosis implementation

#### 4.2.5 Factor 5: Technology Assistant

According to on site survey and in-depth interview, it is found that all of 7 factories have no problem in regards to technology, in other words, technology is not a barrier for symbiosis implementation. Therefore, technology assistant is not an important factor for symbiosis implementation in MTPIE.

#### 4.2.6 Factor 6: Public Participation

According to on site survey and in-depth interview, all of 7 factories agree that stakeholder participation, especially community participation, is not an important factor for symbiosis implementation. However, 3 of them found that government participation is still important for symbiosis implementation.

### 5. Concluding remarks

The only different between implementing and non-implementing factory is policy on zero discharge, zero landfill, and willingness to adjust process. This is the first effective factor for symbiosis implementation.

The symbiosis will not be implemented without initiator. Monthly meeting among executive or managers of all factories addressed by estate owners is extremely important for information exchange. Government agency should involve in the monthly meeting and participate as part of initiator to help solving regulation issues or obstruction of the symbiosis implementation.

Financial mechanism, both incentives at the initial project and the continuing subsidy, is necessary for all factory respondents; while public participation and technology assistant are not significantly important factors for the symbiosis implementation. Hence, a model for effective implementation of industrial symbiosis in industrial estate is proposed as shown in Figure 3.

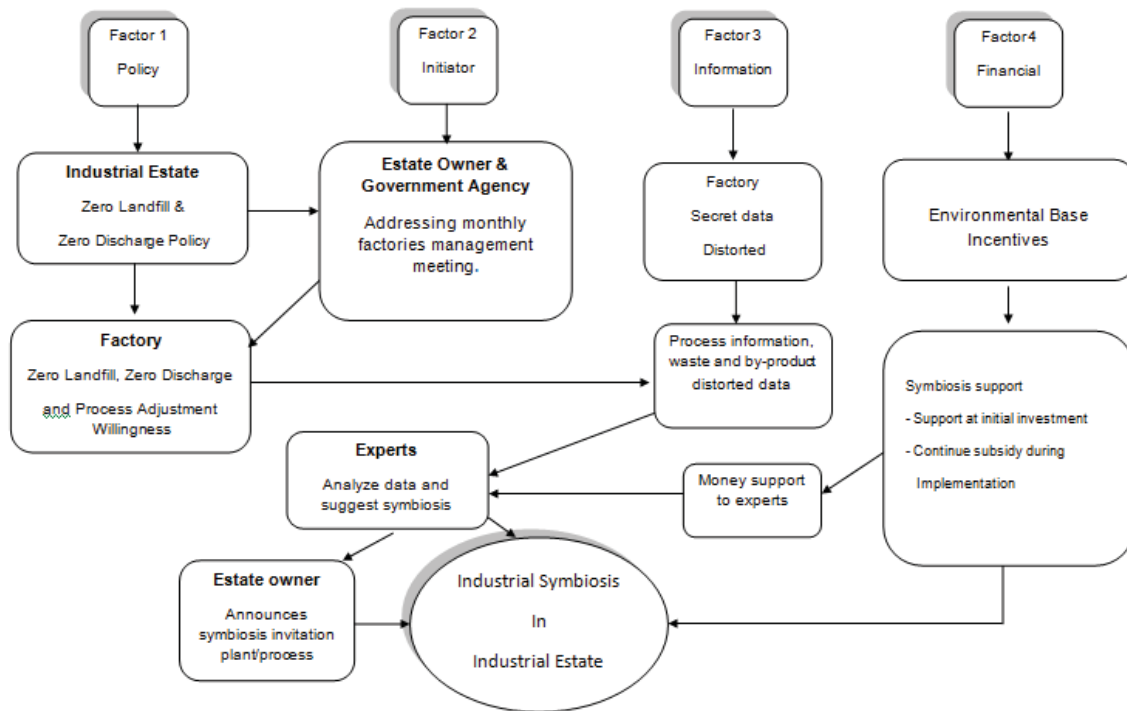


Figure 3: Conceptual model for effective implementation of industrial symbiosis

## References

- Ayres, R.U., & Ayres L.W. (2002). *A handbook of industrial ecology*. Cheltenham: Edward Elgar Ltd.
- Calow, P. (1998). *The encyclopedia of ecology and environmental management*. Oxford: Blackwell Science.
- Barrie T. (1992). *The Blackwell encyclopedia of industrial archaeology*, Oxford.
- Charmondusit, K., & Keartpakpraek, K. (2010). *Eco-efficiency evaluation of the petroleum and petrochemical group in the Map Ta Phut*. Proceedings from The International Conference on Environmental Research and Technology (ICERT08), 28-30 May 2008, Penang, Malaysia.
- Chertow MR. (2000). *Industrial symbiosis: literature and taxonomy*. *Annual Review of Energy and Environment*, 25, 313–37.
- Chertow MR. (2004). *Industrial symbiosis*. *Encyclopaedia of Energy*, 3, 1-9.
- Cohen-Rosenthal, E. (1996). *Designing eco-industrial parks: The US experience*. *UNEP industry and environment*, October-December, 14-18.
- Co'te', R.P., & Smolenaars T. (1997). *Supporting pillars for industrial ecosystems*. *Journal of Cleaner Production*, 1–2, 67–74.
- Cristina, S., Xavier, G., & Teresa, V. (2007). *Material flow analysis adapted to a industrial park*, *Journal of Cleaner Production*, 15, 1706–1715.
- David, G., & Pauline, D. (2007). *Reflections on implementing industrial ecology through eco-industrial park development*. *Journal of Cleaner Production*, 15, 1683-1695.
- Heeres, R.R., Vermeulen, W.J.V., & de Walle, F.B. (2004). *Eco-industrial park initiatives in the USA and the Netherlands: first lessons*. *Journal of Cleaner Production* 12, 985- 995
- EFMA (2000), *Production of NPK fertilizers by the mixed acid route*. *European Fertilizer Manufacturers' Association Booklet*, 8, 8.
- Ernest A. Lowe. (1997). *Creating by-product resource exchanges: strategies for eco-industrial park*. *Journal of Cleaner Production*, 5 (1-2), 51-65.
- Ewa Liwarska-Bizukojc, Marcin Bizukojc, Andrzej Marcinkowski, & Andrzej Doniec (2009). *The conceptual model of an eco-industrial park based upon ecological relationships*. *Journal of Cleaner Production* 17, 732–741.
- Eurostat (2001). *Economy-wide material flow accounts and derived indicators. A methodological guide*. Luxembourg: Office for Official Publications of the European Communities.
- Frosch, R.A., & Gallopoulos, N.E. (1989). *Strategy for manufacturing*. *Scientific American*, 261(3), 94–102.
- Graedel, T.E., & Allenby, B.R. (2003). *Industrial ecology*. 2nd ed. New Jersey: Prentice Hall.
- Hung-Suck, P., Eldon R.R., Soo-Mi, C., & Anthony S.F. C. *Strategies for sustainable development of industrial park in Ulsan, South Korea—From spontaneous evolution to systematic expansion of industrial symbiosis*. *Journal of Environmental Management* 87, 1–13.
- Heeres, R., Vermeulen, W., & de Walle, F., *Eco-industrial park initiatives in the USA and the Netherlands: first lessons*. (2004). *Journal of Cleaner Production*, 12, 985-95.

- Lilian, B., Elabras, V., & Alessandra, M. (2009). *Eco-industrial park development in Rio de Janeiro, Brazil: a tool for sustainable development*. *Journal of Cleaner Production* 17, 653–661.
- Lowe, E. (2001). *Handbook for development of eco-industrial parks, indigo development, USA*. Retrieved from: <http://indigodev.com>
- Magnus, K., & Anna, W. (2008). *Using an optimization model to evaluate the economic benefits of industrial symbiosis in the forest industry*. *Journal of Cleaner Production* 16, 1536-1544.
- Kaosa-ard M., & Rayanakorn K. (2009). *Economic tool for environment management Policy knowledge*. Logdesingwork.
- Kaewtap, K., & Kutiyoos, P. (1998). *Economic tool for environment management*. *Environmental Journal*, 7, 1-19.
- Olli, S. (2007). *Eco-efficiency and industrial symbiosis – a counterfactual analysis of a mining community*. *Journal of Cleaner Production* 15, 1696-1705.
- Roberts, B.H. (2004). *The application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: an Australian case study*. *Journal of Cleaner Production* 12, 997–1010.
- Sokka, L., Pakarinen, S., & Melanen, M. (2009). *Industrial symbiosis contributing to more sustainable energy use – an example from forest industry in Kymenlaakso, Finland*. *Journal of Cleaner Production*.
- Suavanee V. (2002). *Environmental management by eco-industrial estate principle*. Master's Dissertation. Inter-Departmental Program in Environmental Management, Graduate School, Chulalongkorn University.
- United Nation Division for Sustainable Development (2001). *Environmental management accounting principle and procedures*. New York: United Nations.
- Wang, C., Zhang, G., & Wang, W (2009). *Research on industrial symbiosis supporting system of Eco-industrial Park*. *Chinese Journal of Population, Research and Environment*, 7 (3), 61.
- World commission on environment and development, *our common future* (1987). Oxford University Press, Oxford.
- Welford, R. (1995). *Environmental strategy and sustainable development. The Corporate Challenge for the 21st Century*. Routledge, London.
- Zengwei, Y., & Lei, S. (2009). *Improving enterprise competitive advantage with industrial symbiosis: case study of a smeltery in China*. *Journal of Cleaner Production* 17, 1295–1302.
- Electronic media Department of Pollution control, available from [www.pcd.go.th](http://www.pcd.go.th), 10/09/2010
- Economic instruments for environment management available from <http://www.idis.ru.ac.th/report/index.php?topic=5972.0> 29/06/2012

