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PLANNING ECO-INDUSTRIAL PARKS: AN ANALYSIS OF DUTCH PLANNING METHODS

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In theory, eco-industrial parks can make significant improvements in the environment. In that light, this article analyses six planning methods currently in use in the Netherlands. The most salient findings are that these methods lack an explicit vision of sustainability, they do not give due consideration to symbiotic or utility-sharing options, they do not sufficiently engage the companies involved in the development and their policy instruments have a limited environmental impact. The planning methods prove to have many shortcomings: the definition of sustainability is unclear; there are no quantitative standards; information on symbiosis and utility sharing is inadequate; the economic and organizational implications are largely ignored and the environmental impact is insufficiently monitored. However, eco-industrial parks can only have greater environmental benefits through symbiosis and utility sharing. Therefore, location- and company-specific factors have to be taken into consideration. Copyright © 2003 John Wiley & Sons, Ltd and ERP Environment.

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INTRODUCTION

There are several means to induce companies to operate in an environmentally friendly way. The 'classical' approach is geared to individual firms, which involves forms of government intervention by means of coercion (applying classical and new forms of regulation), economic incentives (green taxation) and stimulation of application of business environmental management systems (Vermeulen, 2002). In addition to this, at least three other approaches, worked out over the past decade, deal with companies collectively.

The first variant formulates environmental goals for a whole branch of industry. The companies can share in the environmental effort and allocate the tasks in the most efficient way among themselves (including cost sharing), or competition between companies in sectors is created (benchmarking). Voluntary

agreements with sectors of industries are another form (Glasbergen, 1999, 2000).

The second variant takes the production chain as its organizing principle. In life cycle management the whole chain – from extraction of resources to treatment of waste – is held responsible for the environmental pressure of a product. The most effective and efficient solutions are sought within the network of the production chain (van der Kolk *et al.*, 1995; Vermeulen *et al.*, 1995; de Walle, 1996).

The third variant, known as the eco-industrial park approach, stimulates companies located in an industrial park to jointly diminish the environmental pressure generated by their activities. This is a recent variant and is still being worked out. Its aim is to build up relations between independent companies in the same geographical area in order to improve the environment. Because it is an integrative approach, it could be seen as a supplementary procedure within chain management. Furthermore, its regional orientation creates new opportunities to optimize the material cycle (de Walle, 1996; Den Hond, 1999).

The objective of this article is to review the development of the eco-industrial park, which we define as a clearly delimited territory where, by means of cooperation, firms adjust their activities with respect to one another in order to diminish the total environmental impact without affecting the economic vitality of the individual companies. Eco-industrial parks can only be developed through a collective learning process. This applies to the companies that are engaged in the development as well as to the local governmental organizations that are involved. To work out a collective plan of action, companies and government authorities need to harmonize their activities. Companies that had once operated in relative anonymity alongside one another now need to build up mutual trust, a major departure from current practice. The prospect of collective action requires companies to gain insight into the wide range of environmentally beneficial options and their economic consequences.

As several theorists point out, the development of eco-industrial parks leads to significant improvements in the collective environmental performance of companies (Lowe, 1997a; Côté and Cohen-Rosenthal, 1998). However, the empirical foundations of this movement are weak since there is little quantitative data available. Designing eco-industrial parks is one of the concrete applications of industrial ecology (Boons and Baas, 1999), as illustrated by the industrial park in Kalundborg, where symbioses (exchanges of resources and energy flows between the companies) have been attained. In this Danish city various industries and even farms exchange material and energy flows that otherwise would remain as waste, thus forming a complex system of links (symbioses) between at least nine different types of economic activity. Examples are exchange of scrubber sludge between a power station and a wallboard plant, or treated sludge between a pharmaceutical plant and neighbouring farms. Other exchanges include waste heat or steam from a power station. In more extensive discussions of this example it is being claimed that such eco-industrial parks can generate both economic and environmental gains (Ehrenfeld and Gertler, 1997; Gertler, 1995; Cossgriff Dunn and Steinemann, 1998). Closing of material cycles at industrial parks can be achieved by constructing symbiosis (as discussed above). The collective environmental performance of an industrial park can further be enhanced with various utility sharing options (such as joint exploitation of waste water treatment plants, combined heat and power or a collectively owned wind mill).

The exchange of material flows between firms is not entirely new; especially in the chemical industry economic complexes have already existed for a long time. The difference here is that these complexes exist within relatively homogeneous classes of industry linked through their flows of products and

by-products, whereas in examples of eco-industrial parks such as Kalundborg new unexpected combinations between heterogeneous classes of industry occur.

The case history of Kalundborg is interesting in that it has developed spontaneously (Ehrenfeld and Gertler, 1997, p. 73). It has triggered efforts elsewhere to achieve such results through a planned process of policy making, often organized by local authorities responsible for urban planning (development of greenfields and revitalization of brownfields). In such cases, consultancy agencies play a major role in developing eco-industrial parks in the Netherlands. These agencies originate in diverse areas of expertise: development and management of conventional industrial parks; environmental consultancy; spatial planning and process management. Their origins are reflected in the diversity of planning methods they have put into practice. In general, they formulate directives for a practical approach to support companies and governments in their development process. By articulating these planning methods, they provide information about the environmental options and perform an important steering task in the ongoing collaboration. With these methods they make an important contribution to the process of cooperation; they supply information about possible options. In so doing, the consultants play two key roles: besides connecting theory to practice, they serve as intermediaries between government and the business community. In the first role, they are expected to translate their theoretical knowledge about industrial ecology into guidelines for everyday practice. In the second role, they mediate between the government (the initiator) and individual companies, which are expected to cooperate within the eco-industrial park.

Which kinds of eco-industrial park will actually be developed depends largely on the perspective of the planning method. Therefore, it is important to examine how the planning methods were designed and what choices have been made in the course of their development. A comparative analysis along these lines offers some insight into the current status of these methods and how they can be further elaborated. These assumptions lead us to state the research problem underlying this analysis as follows. *What is the form and content of the current planning methods designed by consultants for the development of eco-industrial parks, to what extent do they fulfil the theoretical claims and what kinds of conclusion can we draw for territorial cooperation between companies?*

To answer these questions, we studied six planning methods currently being used in the Netherlands. All six enjoy national renown, have been reasonably refined, and were formulated by the main consultants in the field (Haverkamp, 2000). After analysing the 'written' material, we drew some tentative conclusions and discussed them with the consultants in semi-structured interviews. In these interviews the methods were clarified in more detail by the designers. The article is organized in the following way. The general characteristics of the methods are described briefly in the first section, while the second presents a framework for assessing these characteristics. The assessment is intended to shed light on several choices that come up in the application of the planning methods and are relevant to sustainability. In the third section, we present our findings and discuss the results. Finally, in the fourth section, we reflect upon current planning methods and consider which developments will take place in the future.

OVERVIEW OF PLANNING METHODS

While the Danish example has grown 'organically', further diffusion of the phenomenon of eco-industrial parks will probably require deliberate strategies by local policy makers. In the Netherlands various planning methods have been developed to realize eco-cooperation on new or existing industrial

parks. These planning methods for eco-industrial parks designed by Dutch consultancy firms perform several functions. In the first place, they structure the process by breaking it down into phases and deciding which actors will be involved at any given point. In the second place, they structure the search for options and set selection criteria. Thus, the methods used in the planning stage will have a strong influence on the achievement of the sustainability goals. In a sense, every planning method harbours an unspecified result within itself. The following subsections describe the general features of the methods elaborated by six Dutch consultancy agencies.

The 'Eco-classification system'

The 'eco-classification system' is a measuring stick used to determine the sustainability of a master plan for an eco-industrial park by comparing it to a point of reference. The standards are set by the participating actors and the consultant (*Ecoclassificatiesysteem*; Grontmij, 1998). Together, they then draw comparisons along the lines of various environmental themes. These themes reflect national and provincial policies and are selected in conjunction with local government authorities. They fall into two groups: themes focused on how an industrial park influences its surroundings; and themes focused on the construction of the park itself. The industrial park is then compared with the frame of reference for every environmental theme. When the situation (effect) proves to be the least desirable one in the scheme, the park receives -3 points for that theme. When the situation is equal to the reference standard, the score is 0. And when the park achieves the most desirable situation in the scheme, it gets a score of $+3$. The situations ranked between those extremes are considered more or less desirable. Since the concept of the eco-industrial park has not been operationalized, though, it remains unclear what kinds of physical change would have to take place in order to achieve the ideal situation. The only expectation that is formulated within this method is that an eco-industrial park should function in harmony with its environment.

An 'environmental grading system'

Three packages of options are formulated within the 'environmental grading system' (*Milieupuntensysteem*; Zandvoort O&A, 1997, 1998). These packages can be put into practice when the municipality starts selling building plots (for greenfield development). The first package responds to the municipal obligations to make the park environmentally friendly. These involve, among other things, the infrastructure for traffic and energy flows and the design of public space. The second package is assembled for the establishing firms. It stipulates all mandatory criteria that a company has to meet to be allowed to locate at the industrial park: for example, obligatory purchase of sustainable energy, optimal re-use of waste water, and application of a transportation management system. The third package includes additional rules for individual firms, such as the adoption of product and process innovations, though these are not obligatory. The third package is supposed to stimulate the companies to carry out environmental measures. They receive a discount on the land price when the measures have been carried out. Companies are required to take part in a park management organization when they sign the land contract. Besides managing the industrial park, the management organization is supposed to look for new means to improve the environment. What the planning method does not elaborate on is how the internal cooperation with the park management organization is to be arranged.

The 'sustainability scan'

The purpose of the 'sustainability scan' (*Duurzaamheidsscan*; BECO, 2000) is to survey the potential for sustainable development at brownfields. This assessment method measures the chances for development by looking

at the carrying capacity among the companies and the municipality for each option. Within the 'sustainability scan', the potential of 36 different options is assessed. Several of these options – such as energy contracts, maintenance and security – are generally applicable and may be utilized at every industrial park, regardless of which industries are represented there. The maximum environmental benefit of these options is limited. Options with a higher environmental impact can only be applied when more information is available about the industrial firms and the larger companies. The consultancy agency takes into account the firms' carrying capacity and their willingness to take action. The consultant gathers information and interviews the actors. The data are translated into chances, possibilities, degree of willingness to act and carrying capacity for each measure with potential. The likelihood of attaining an option is assessed in terms of (i) the applicability of technical measures, (ii) organizational feasibility, (iii) the potential as estimated by the actors themselves and (iv) their willingness to take action.

The 'helping hand'

The main thrust of the 'helping hand' (*Handreiking*; KPMG, 1998) is that companies can reduce their impact on the environment by cooperating at the local level. The cooperation of companies at industrial parks can contribute to economic development without increasing environmental degradation. The options that can be attained at industrial parks can be divided into two categories: company processes and spatial planning. The 'helping hand' is in the first place designed to inspire initiators. Although tools are offered for developing sustainability, indicators and ambitions, the realization is explicitly placed in the hands of the participators. The 'helping hand' is primarily a process-planning method. It emphasizes the importance of cooperation and mutual trust between companies, the municipalities and other actors (public utilities, property developers, investors etc.). The collaborative process is the critical factor. The interested parties are encouraged to join forces by giving extra attention to communication, decision points, steering the process and the roles of each of the actors. The aim of this planning method is to develop enough carrying capacity within five steps (initiation, orientation, decision-making, design and implementation).

The 'roadmap' and 'quickscan'

The 'roadmap' (Grontmij, 1997) was designed as a means to develop an eco-industrial park that fits into the landscape, has a high standard of facilities, is geared to a flexible use of space and leaves room for technical developments. Together with the 'roadmap', the 'quickscan' was developed to make a qualitative assessment of an industrial park. The 'roadmap' is a means to design the development process. The inspiration for the definition of sustainability and the accompanying options used in the 'roadmap' was drawn from the field of industrial ecology. Therefore, the options are often cyclical and aimed at exchanges between companies. Various spatial planning options such as optimizing spatial quality and taking care of the ecological surroundings are also vital to this planning method. The 'roadmap' also incorporates eligibility criteria for individual firms. Only those firms that apply the 'best available technology' are welcome at an eco-industrial park, though how this criterion is applied in practice remains unclear. Companies are expected to contribute actively to the sustainable development of the industrial park. The quality of the industrial park is dependent on the considerations of the municipality, as set forth in the 'roadmap'. The municipality is responsible for regional, economic and environmental policy, for the planning design, for the sale of plots and for maintenance. Once the building lots have been sold, however, these activities are to be taken over by the companies. The establishment of a park management

organization has to ensure that the companies will also remain involved at a later stage. 'Quickscan' is a measuring device to assess the potential of the facilities that can be established at the site. As they can be built in different phases, 'quickscan' can help determine the possibilities for development by providing a set of economic, environmental, technical, organizational and legal criteria. The assessment takes the form of an 'expert guess', making it less of a technical than a subjective estimate.

The 'development vision'

The 'development vision' (BRO, 1997, 1998a, 1998b) uses spatial planning steering instruments, such as a local land-use plan, to develop greenfield sites as eco-industrial parks. Existing traffic infrastructure, water systems, energy systems and nature development are integrated in the planning design. The necessary knowledge originates either with the municipality or with the consultants themselves; companies are not expected to provide information. While cooperation with the municipality is intensive, hardly any other actors are involved in the development process. Yet the companies bear joint responsibility for carrying out the relevant options. Because of the spatial perspective inherent in this method, special attention is given to the spatial options. In total, 26 options are incorporated in the 'development vision'. Three ambition levels are formulated for each one – reducing energy or water use, for instance – and it is up to the municipality to say which level will be implemented. Accordingly, the companies have to keep up their end of the bargain or they will not be allowed to buy a plot. All the criteria set for companies and their physical plant are specified in the local land-use plan. One example is the minimum building height, which forces the firms to make more efficient use of the plots. The companies are obligated to meet the criteria before they are allowed to buy a building lot at the industrial park.

When we consider these profiles, we see a wide variety of planning methods. Each one has its own approach to the development of eco-industrial parks. Some are aimed specifically at brownfield development, others at greenfield, though this is no hard and fast criterion. There are some obvious differences among the methods: for example, the distinction between a process-minded and content-minded approach; the extent and nature of the commitment of the actors in the process and the content of different kinds of option and the way that content is made concrete. Further on in this article, we distinguish between an objective approach and an approach that is directed towards a subjective consensus: a difference between the role of the consultant and the input of steering instruments such as land-use policy or a park management organization.

THE ASSESSMENT FRAMEWORK

A thorough analysis and assessment of the planning methods can only be done within a theoretical framework. Our framework gives special attention to a certain feature of each planning method, namely the ambition level, which indicates what kinds of industrial park will be developed and what kinds of goal will be aimed for. We assume that the ambition level will be determined by four factors: the definition of sustainability that is applied (implicitly or explicitly); the kinds of option that are taken into consideration; the planning design of the process to obtain cooperation and the steering instruments that are used to develop an eco-industrial park. Each of these factors is translated into assessment criteria.

The concept of sustainability

The definition of sustainability is one of the factors determining which options will be developed. The concept of sustainability must first be clarified in order to set unambiguous

goals and directions for the development. It must be clear what is expected of an eco-industrial park and which explicit criteria have to be met in order to assess sustainability.

A discernible amount of environmental improvement must be achieved if we are to justifiably call any industrial park sustainable. When we impose the rigorous standards of industrial ecology, we can only call an eco-industrial park sustainable when sustainable symbioses in relation to the environment are evident. Industrial ecology propagates an economy that develops towards a cyclical system of energy and materials in which the only energy input is the sun and all materials are continuously being recycled (Deppe *et al*., 2000; Gertler, 1995). By reasoning that the closing of material and energy cycles is the highest conceivable environmental goal, we go along with the industrial ecologists to some extent.

This leads to the first assessment criterion: in what way is the concept of sustainability elaborated and does it discuss application of symbiosis as a means to reduce environmental pressure at eco-industrial parks?

Eco-cooperation options

There are various means to reduce environmental pressure at eco-industrial parks. These are called eco-cooperation options to emphasize the need for cooperation in order to attain that goal. The options fall into three categories: symbiosis, utility sharing and the spatial planning of public space. Each of the six planning methods also provides options for use by the individual firms with respect to their internal operations. These are not considered relevant to the present analysis, however, which is focused on concerted efforts undertaken jointly by multiple firms.

The first category is symbiosis, which implies exchanges between companies. The theory of industrial ecology regards this option as the most important path to eco-cooperation at eco-industrial parks (Frosch, 1995). Symbiosis can arise through exchanges where one company's waste is another's resource; or symbiosis may be achieved as a cascade of energy or water (de Walle, 1996). These options can yield a high level of environmental benefits by reducing waste, input of raw materials, energy input and water consumption. In addition, these options yield economic benefits by lowering the cost of waste treatment, levies, materials, water or energy. A disadvantage of coupling production processes is the ensuing interdependence and the complicated organizational processes this engenders. Companies need a clear picture of the preconditions and benefits of the options before they will be willing to take part in a cooperative approach. Moreover, it is important for the companies to trust each other before undertaking any concerted action.

The second category covers all kinds of utility sharing. Some examples are the collective procurement of energy, collective waste treatment and collective transport facilities. Cooperation between the companies is less intensive when the aim is utility sharing than when the goal is the creation of symbioses. When cultivating utility sharing, there is little chance of making direct links between internal production processes; therefore, the degree of interdependence achieved is considerably smaller than with symbiosis. Most of the environmental improvements resulting from this eco-cooperation option come from greater efficiency. Consequently, the maximum amount of environmental benefit is lower than when symbiosis is achieved.

The third category is the cooperation that takes place when companies decide to collectively improve the spatial and visual features of the industrial park. This involves bringing design elements such as green space, the water system, efficient use of space etc. into the plan. The maximum amount of environmental benefit from such options is considerably lower than from utility sharing or symbioses, largely because of the low savings on energy, water

and resources. Currently, the spatial planning of industrial parks is in the hands of the local government. When companies take control, however, a new kind of organization will be needed. In that case, companies will be investing collectively in improvements to their local environment. Even though production processes will not have to be coupled to achieve spatial improvements, mutual organizational and financial interdependence will still arise.

The success of any given planning method will depend on which options it puts forward. All methods require knowledge about the local situation, but different information is needed to achieve symbioses than to improve the spatial and visual features of the industrial park. For symbioses in particular, very detailed and company-specific information is required (Cohen-Rosenthal *et al*., 1996). When considering the options for utility sharing, one needs to know how much capacity is needed by each of the participating companies and how much the infrastructure will cost. Generally speaking, many of the options concerning the spatial and visual features could be implemented at any industrial park regardless of the kinds of company located there. This is also true for the individual options that can be found in some of the planning methods. The application of eco-cooperation processes can give companies an added impulse to improve their environmental performance beyond the level to which they are legally bound.

This discussion gives us a second assessment criterion: to what extent is application of the three type of options (symbiosis, utility sharing and spatial planning of public space) promoted as described in the planning method?

Organization of the process

The course of the development process is determined by the organizational structure. The decision-making process, information gathering and the selection of which actors will be involved all influence the level of ambition. The actors with a direct interest, decision-making power and influence on the development process are mainly the municipality and the (future) occupants of the industrial park. How they will be able to influence the outcome of the development process can be determined in the planning method. Other actors may also be involved: the local chamber of commerce, public service corporations, the board of public works, the environmental movement, and the neighbourhood, for instance. The process of developing an eco-industrial park can be set up as an interactive process, but the form of that process may vary widely. Interactivity can be determined by the extent of commitment that the companies have with (re)developing the industrial park and the choice for sustainability options. At one extreme, the consultant acts as an expert in defining the eco-cooperation options; at the other extreme, the options are laid out in a process of negotiation and consultation among the most important actors.

The third assessment criterion will therefore be to what extent the firms at an industrial park are involved in the planning process.

Steering instruments

Hardly any new steering instruments have been designed specifically for the development of eco-industrial parks. At present, a whole range of spatial planning instruments – such as local land-use plans, long leases and land policy (at greenfields) – are available to the consultant. If the area is municipally owned and rented out, contract can include rules on eco-cooperation. Life cycle analysis and environmental impact analysis are instruments that can be used to identify and assess the options. A park management organization is a steering instrument that has been in use in Anglo-Saxon countries. Since privately owned industrial parks are commonplace there, park management organizations have been established to manage and maintain public space (Buck Consultants International/BRO, 1999). In the current situation, local governments

carry out the management and maintenance tasks at industrial parks in the Netherlands. But taking a broader perspective on the phenomenon of park management, it is apparent that these organizations can perform a wider range of functions. Their primary function is to unite different kinds of actor in the tasks of managing and maintaining public space. Many aspects of utility sharing, such as the operation and maintenance of a water treatment plant or a B-water network, could be included among their responsibilities. The second function is to continuously improve the environmental performance at an industrial park (Schlarb, 2001; Gertler, 1995). The third function is the collective procurement and sale of energy, facilities etc. (Côté *et al*., 1994). The last function has a social character and resembles the function of an entrepreneurial society or social club. Participants can get to know each other and exchange ideas and experiences in an informal atmosphere (Côté *et al*., 1994).

In practice, park management has different kinds of outcome. The initiative to implement a park management organization is usually taken by the developer of the park. In the case of the Netherlands, the developer would be the local government. Public service corporations, chambers of commerce and educational and research institutes can also be drawn in to support the organization (Lowe, 1997b). Besides the top-down procedure, whereby the local government establishes a park management organization, the process can also start from the bottom up, as when companies take the initiative and start cooperating on their own. The disadvantage of the latter situation is that companies cannot be forced to participate, though local governments can make participation mandatory at greenfield sites.

This leads us to our fourth assessment criterion: to what extent and what type of policy instruments (planning instruments, contracts, park management organizations) are suggested, as described in the planning methods?

ANALYSIS OF THE PLANNING METHODS

The most salient results of our analysis of the planning methods on the basis of our four assessment criteria as discussed above, are summed up in the following four points.

- The vision of sustainability is not explicit.
- The categories 'symbiosis' and 'utility sharing' are not sufficiently considered.
- Companies are not sufficiently involved in the development process.
- Steering instruments can only enforce options with a limited environmental benefit.

The vision of sustainability is not explicit

The planning methods pay little attention to the operationalization, definition and fulfilment of the sustainability goals. Although some of the methods do outline what is regarded as sustainability, none of them translate sustainability into an ambition level or link it to the consequences for the options that should be implemented. The definition of an eco-industrial park is often kept as open-ended and broad as possible. The kinds of consequences or implications that should be attached to the development of an eco-industrial park are not explicated.

The planning methods state very few collective environmental goals. In contrast, since the environmental goals for individual companies are easier to enforce and monitor, company-specific goals are stipulated in the methods. Because of this bias, it is hard to see a connection between sustainability and the ultimate objectives for the park.

Clear indicators of sustainability are not found in any of the methods. Thus, eco-cooperation options cannot be assessed in terms of their environmental benefits. Instead, two methods assess the carrying capacity of the actors and the feasibility of the options. Only one method is concerned exclusively with the environmental effects of an eco-industrial park. This method entails a qualitative assessment,

comparing industrial parks with reference situations. None of the methods apply a quantitative environmental effect assessment for eco-industrial parks.

The categories 'symbiosis' and 'utility sharing' are not sufficiently considered

Table 1 shows the themes and the eco-cooperation options addressed in the six planning methods (columns a – f), the options mentioned in the governmental policy documents (column y) (Ministerie van Economische Zaken, 1997), and the options that were found in the industrial ecology literature (column x) (Frosch, 1995; Côté and Cohen-Rosenthal, 1998; Ehrenfeld and Gertler, 1997; Lowe, 1997a). The industrial ecology literature devotes most attention to the application of symbiosis. Utility-sharing options are also discussed somewhat, but the spatial planning and individual options are hardly

Table 1. Themes and options addressed in the planning methods

Themes	Options	a. Eco-classification system	b. Environmental grading g system	c. Sustainability scan	d. Helping hand	e. Roadmap & quickscan	f. Development vision	x. Industrial ecology	y. Dutch policy documents
Symbiosis	Materials	–	×	×	×	×	–	×	×
	Energy	–	–	×	×	×	–	×	×
	Water	–	×	×	×	×	–	×	×
Utility sharing	Materials	–	–	×	×	×	×	×	×
	Energy	×	×	×	×	×	×	×	×
	Water	×	–	×	×	×	×	×	×
	Infrastructure	–	–	×	×	×	–	–	×
	Compact city	–	–	–	×	–	–	–	×
	Greenery	–	–	–	×	–	×	–	–
Spatial structure	Materials	–	×	×	×	–	×	×	–
	Energy	–	–	×	–	–	–	×	–
	Water	×	×	×	×	×	×	–	–
	Infrastructure	×	×	×	×	×	×	–	×
	Compact city	–	×	×	×	–	×	–	×
	Greenery	×	×	–	–	×	×	–	–
	Annoyance	×	×	×	–	×	×	–	–
Individual/internal	Materials	×	×	×	–	×	×	–	–
	Energy	×	×	–	–	–	×	–	–
	Water	×	×	–	–	×	–	–	–
	Infrastructure	×	×	–	–	–	×	–	–
	Compact city	–	×	–	–	–	×	–	–
	Greenery	–	×	–	–	–	×	–	–
	Annoyance	×	×	–	–	×	×	–	–

mentioned. The government policy document presents a similar picture, though it does include a few other aspects (e.g. the 'compact city' notion).

The six planning methods may roughly be divided into two groups. Three methods give little attention to symbiosis and utility sharing (a, b and f), emphasizing the options at the individual level and spatial planning instead. The other three methods (c, d and e) are more interested in the application of symbiosis and utility sharing and less in the options at the individual level and spatial planning. In fact, the second group of planning methods is closer to the train of thought found in the industrial ecology literature and in government policy.

Although three planning methods include symbioses and utility-sharing options, it remains unclear how these options can be achieved. Industrial park management is often promoted as a means to achieve the goal of utility sharing; none of the methods provide a concrete operation and maintenance plan, however. Even after interviewing the consultants, it was still unclear how the symbioses and utility-sharing options could be achieved in practice. While all of the planning methods contain a large amount of common knowledge about eco-cooperation, what they all lack is company-specific information. Indeed, very little attention is paid to how and which company-specific information should be gathered. Therefore, companies and local governments will probably be unable to make informed decisions about utility-sharing and symbiotic options.

We may conclude that the options presented in the planning methods are mainly those with a relatively low environmental impact. These are not the same as the ones we found in the industrial ecology literature or in government policy documents. Consequently, it seems unrealistic to expect the goal of ongoing environmental improvement, as mentioned in the introduction, to actually be attained.

Companies are not sufficiently involved in the development process

The development process has been worked out in two different ways. On the one hand, it is a process that is set up like a conference meeting where companies confer with local government authorities. On the other hand, the process is more one sided; the municipality determines the developmental process by approving a master plan and using steering instruments to enforce it. These differences are shown in Table 2.

In the first variant, consultation takes place between the local government and the companies themselves or an association representing them (Table 2, 'joint initiative'). In three of the six methods, the development process is defined as a process of cooperation. The consultations equip the process by organizing consultation rounds, setting an agenda and inviting actors to take part. The consultants also propose options, thereby stimulating the

Table 2. Process design in the planning methods

	Eco-classification system	Environmental grading system	Sustainability scan	Helping hand	Roadmap & quickscan	Development vision
Process initiative						
– Top down (local government/consultants)	×	×	–	–	×	×
– Bottom up (companies)	–	–	–	–	–	–
– Joint initiative (local government with companies)	–	–	×	×	×	–
Role in identifying EIP options						
– Municipality	×	×	×	×	×	×
– Consultants (commissioned by municipally)	×	×	×	×	×	–
– Companies	–	–	×	×	–	–

carrying capacity and the building of mutual trust. Initially, they propose easily attainable options with a low environmental impact. The oral interviews revealed that symbiosis and utility sharing would be considered later in the process. The consultants expect that mutual trust and the carrying capacity will increase once a number of options have been achieved. Then, in the longer term, symbioses and utility sharing can be cultivated. This process of increasing action to implement options with a higher environmentally impact over time has been likened to a domino effect.

Looking at the second variant, we notice that no discussion takes place between the municipality and the companies. The choices to introduce eco-cooperation options are made by the municipality, which ratifies the master plan and the development of the eco-industrial park. This process has all the features of top-down steering (Table 2, 'top down'). The consultancy agency advises the municipality about the achievable options and the accompanying instruments. The environmental impact is likely to be limited because of the partial steering capacity of the local government. The options most likely to be achieved concern spatial aspects, spatial quality and individual company aspects; the reason is that local government authorities have tools to implement these options. The planning methods that are aimed at the use of municipal steering instruments also tend to be used for greenfield development. This can be explained by the extended possibilities for enforcement at greenfields. Consultancy agencies make a detailed plan for the development of an eco-industrial park in which they clearly describe what kinds of obligation have to be fulfilled by each of the actors. The likelihood of achieving symbioses is small, since companies cannot be forced to cooperate.

A variant whereby an association of companies takes control of the development is theoretically an option, yet it is not a serious element of any one of the methods (the sustainability scan).

Steering instruments can only enforce options with a limited environmental benefit

Spatial steering instruments in particular are applied to enforce sustainability. Existing instruments – for instance, a local land-use plan, an image quality plan,[1] or rules stipulated in the contract – are the usual tools to implement municipal policies (Table 3). Four planning methods suggest using park management as a steering instrument. Park management is mainly relegated to an organization that inherits the management and maintenance tasks from the local municipality. Furthermore, the consultants indicate that park management can also be used for the introduction of utility sharing, but the planning methods were much less specific about these options. Nor was it clear how park management would be organized.

How the steering instruments will be used is stated more clearly in the planning methods. Companies can be forced or stimulated to improve the quality of the spatial environment. When developing greenfield sites, companies

Table 3. Steering instruments suggested in the six planning methods

	Eco-classification system	Environmental grading system	Sustainability scan	Helping hand	Roadmap & quickscan	Development vision
Kinds of instrument for implementation						
– Park management organization	–	×	–	×	×	×
– Spatial structure	–	×	–	–	×	×
– Communication	–	–	–	–	–	–

[1] An image quality plan is a local land-use plan that addresses the visual quality of the spatial environment. A local (land-use) plan indicates how an area will be used; an image quality plan indicates how it will look.

can be obliged to participate actively in the park management organization. When brownfield sites are under reconstruction, participation cannot be made obligatory; it is only voluntary.

When we consider the above findings, we can conclude that the planning methods have several deficiencies.

- First of all, the planning methods do not clearly explain the relation between the characteristics of the different types of eco-cooperation option and the extent to which they will contribute to achieving sustainability at an industrial park. The planning methods even lack clearly defined environmental targets and an operational concept of what an eco-industrial park should be. This implicitly corresponds to a lower ambition level.
- Second, none of the analysed methods provide a system to quantitatively measure environmental impacts of proposed options, thus making informed decision making difficult.
- Third, the planning methods offer insufficient information to the companies and governments about the application and introduction of symbioses and utility sharing. As a result, these types of option, which may lead to interrelationships between independent companies, will not be examined closely.
- Fourth, in the information provided little attention is devoted to the economic and organizational consequences, which are of importance to the companies. Possible barriers, and solutions to those problems, that could be of concern to the decision-makers, are not discussed in the planning methods.
- Finally, we conclude that, for the options on which enough information is made available in the planning methods, little attention is given to expected environmental impacts of these options.

When we assess the six planning methods with respect to their ambition level, we observe a qualitative improvement of the developed industrial parks, but the *environmental* performance is only minimally upgraded. Generally speaking, we can say that the planning methods emphasize spatial planning measures. The concept of sustainability is hardly elaborated and certainly does not receive the central position it warrants. Consequently, the planning methods aim at a lower environmental performance than what may be expected on the basis of the theoretical claims derived from the literature on industrial ecology and the Dutch governmental programmes.

REFLECTIONS

In light of the above analysis, we can conclude that current planning methods take a pragmatic approach to developing eco-industrial parks. Although spatial planning options play a minor part in industrial ecology, the planning methods give it the greatest emphasis. When we take a closer look at the planning methods, we can discern two schools of thought on how to establish an eco-industrial park. We distinguish two different methods of approach, which, although implicitly, are applied by the consultants to realize eco-industrial parks.

In the *first approach*, companies are brought together in order to carry out eco-cooperation options through consultation and cooperation. The underlying assumption is that the companies themselves are the best equipped to identify and assess their options. Cooperation at an early stage would therefore guarantee, or at least facilitate, the development of eco-industrial parks. It is not to be expected that a process involving all of the companies at an industrial park will necessarily generate symbioses. Symbioses are exchanges that usually take place between two companies. These options demand big investments, exert strong influence on the management of a firm and require company-specific information, yet that

information is often confidential and will not be released if many companies, and possibly other actors, are involved in the process.

In the *second approach*, consultants act as external experts; their task is to instruct the local municipality while identifying and assessing the options. The municipality decides which measures can be enforced and which instruments have to be used to reach their goals. One of the problems is that consultants give advice about spatial planning options, a natural consequence of the expertise they already possess – while they know little about the generation of symbioses, the spatial planning process is an open book for them. This situation may be explained by the difficulty of steering cooperation processes and is complicated by the fact that it is unknown which companies are going to settle at greenfield sites.

The limited ambitions of these planning methods can be explained by reliance on a domino effect. This implies that easy options are to be implemented first and increasingly difficult ones (with a higher environmental impact) later. The consultants see this mechanism as a means to develop eco-industrial parks, whereas in our opinion it remains uncertain whether a domino effect will really come into play. After all, when companies make a decision about the third category of eco-cooperation options (spatial planning), they will take a different approach than when the decision concerns options in the second or first category (utility sharing/symbioses), which would influence each firm's internal management. Much greater uncertainties are caused by the interdependencies that are established within symbiotic and utility-sharing relationships. As yet, no cases have come to our attention demonstrating that the domino effect is actually working.

To reach a synthesis, we need to draw the best elements from each of the six planning methods. Although it is possible to assemble a better planning method in this way, the chances of achieving symbioses and utility sharing will hardly increase. This is because none of the planning methods take location and company-specific factors into account. The implementation of symbiosis and utility sharing is a meticulous process and is difficult to plan. In that light, we can offer some practical proposals, which take a different perspective on developing eco-industrial parks than the current planning methods.

The first proposal relates to the importance of distance with respect to symbioses and utility sharing. Since transport costs go down with distance, options for symbiosis along these lines are more easily achieved when companies are located close together. Thus, costs for transport and energy loss can be kept to a minimum. Influencing the location choice of companies may be used as an instrument to increase the possibilities, and profitability, of symbioses and utility sharing.

The second proposal refers to company-specific characteristics. One company may be more suitable to the application of symbioses and utility-sharing options than another. The extent to which a company is connected with its region can be a decisive factor for the attainment of eco-cooperation options. Since the application of symbiosis or utility sharing connects a company more firmly to one specific location, the flexibility of that company diminishes. This is no extra handicap when a company is already embedded in that location or region, but otherwise it may be detrimental to its competitiveness. Some companies are totally embedded in a regional production network and may thus be able to profit from the agglomeration advantages that arise in such a network. The possibilities of attaining symbioses and utility sharing can also be looked upon as agglomeration advantages. By establishing specialized industrial parks for housing a regional production network, uncertainties and costs can be diminished.

A third proposal relates to the possibilities for exchanges among large industrial firms. Supposedly, larger industrial firms are better equipped to achieve symbioses and utility sharing. This hypothesis is based on the

assumption that these companies have large and stable waste flows. Moreover, large companies are less inclined to move, since relocation costs increase with company size and their production processes are more likely to be embedded in local production networks. The larger industrial firms may function as anchor companies that are actively searching for new possibilities for re-use of waste and energy. Subsequently, they can search for the right companies to accommodate their waste flows (Schlarb, 2001; Heeres, 1999).

Location and company-specific factors are scarcely taken into account by current planning methods. More research is required to elucidate the location choice of companies, the part that anchor companies could play, internal management deliberations and the organization of the cooperation process. From these analyses, we might be able to distil more useful strategies for the development of eco-industrial parks, with an emphasis on the options of symbiosis and utility sharing.

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