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IMPLEMENTATION AND MAINTENANCE OF ECOPARK CO-OPERATION

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PREFACE

This report has been made to define a theoretical framework for Industrial Symbiosis between industrial companies - in a Local Agenda 21 context.

It has been written by dr. ing. Johan Thoresen - Oestfold Research Foundation - as part of the Norwegian Productivity 2005 Industrial Ecology-programme at NTNU, Trondheim.

The described framework forms the methodological basis for a case project carried out by the author in ora ecopark in fredrikstad, norway and is an example of the close co-operation between ntnu and oestfold research foundation.

SUMMARY

An expanded framework for the industrial ecology concept (IE-concept) and its implementation has been developed in this report. The concept builds on theory and perspectives proposed by other scientists, mainly Tibbs (1992); Ehrenfeldt (1994); Jelinsky et al. (1992) and Lafferty et al. (1997). The expanded concept framework may be represented by the following aspects:

Exploitation of company-internal potentials for sustainable development through:

- Improving metabolic pathways.
- Dematerialising output.
- Internal loop-closing.
- Improving patterns of energy use.
- Understanding and adjusting product functionality to real customer needs.
- Securing a balance between environmental impacts from the company and the carrying capacity of relevant recipients.

Exploitation of potentials through IE-networks through:

- Loop-closing between companies.
- Upgrading of waste materials or substances.
- Systematic use of local/regional resources and infrastructure.
- Common service systems (e.g. purchasing, maintenance, personnel transportation, education/training etc.)

Support and regulation from national and local government through:

- Regulatory approaches, economic instruments and macro-policies.
- Introduction of IE principles and practices in county and municipal planning.

Linking local interests through action co-ordinating structures:

- Active stakeholder participation and co-ordination through LA 21 initiatives with participation from e.g. industry, municipality/county, research institutions and households.

A set of social and organisational principles and processes have been identified as necessary to make the IE-concept work between independent actors in a region:

- The creation of arenas for information, communication and feed-back within the region, between companies in the IE-network and within the individual companies.

- Systematic use of feed-back information loops to spread results and progress reports from IE-networks to involved or interested parties.
- Permanent involvement by companies requires identification.
- A learning-by-doing should be used.
- A sense of part-responsibility of each IE-network participant is needed for successful network results.
- External facilitators should be used for initiation and maintenance of the IE-network co-operation process.

A 5-step social and organisational learning process is proposed in the report, which is regarded as necessary to reach a satisfactory degree of success and permanence of ecopark or IE-network co-operation.

Management support and priority setting has been found to be essential to start and maintain a well functioning IE-network over time. In addition, the 'facilitator' is expected to introduce

both visions and methodological practices for the network on the one hand and help bring about practical achievements from the network on the other.

Finally, the following issues have been identified from literature as possible drivers and barriers to successful IE-network practices; economic issues, inter-company issues, intra-company issues, resource and technology issues, industry vs. local government issues and public opinion issues.

Trondheim/Fredrikstad, Norway, December 2000

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1 INDUSTRIAL ECOLOGY – A THEORETICAL FOUNDATION

The term industrial ecology (IE) was first used in 1971 by a Japanese research group developing an industrial policy for the Ministry of Trade and Industry (Erkman, 1997). During the past two decades scientists have introduced a large set of definitions of IE, with widely differing content. However, according to Erkman (1997) there seems to be agreement on three key elements of IE between scientists :

- IE is a systemic, comprehensive, integrated view of all components of industrial economy and their relations with the Biosphere
- IE emphasizes the complex patterns of material flows within and outside the industrial system
- IE considers technological dynamics, i.e. long term evolution of clusters of key technologies as a crucial element in the transition from the actual non-sustainable system to a viable industrial system.

IE is a concept wider than the frequently used term 'Industrial Metabolism'[1], which basically considers materials and energy flows through the industrial system viewed in a life cycle perspective. IE also comprises the understanding of how the industrial system works, how it is regulated, its interactions with the Biosphere and how it could be restructured to make it comparable/compatible with the way natural systems work.

A definition by Graedel and Allenby (1994) may be useful for the understanding of the IE concept:

> *IE is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. The concept requires that an industrial system be viewed not in isolation from its surrounding systems, but in concert with them. It is a system view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to product, to waste product, and to ultimate disposal. Factors to be optimized include resources, energy and capital.*

[1] Industrial metabolism implies the understanding and description of materials- and energy pathways in industry.

To turn IE into an operational concept, Tibbs (1992) has developed a practical framework, which later has been complemented by Ehrenfeldt (1994). Seven elements have been developed to specify the IE-concept:

Improving the metabolic pathways of industrial processes and materials use.
Implies the understanding and description of materials- and energy pathways, carrying out Pollution Prevention- and Toxic Use Reduction-programs, end-of-pipe pollution control and waste management.

Creating loop-closing industrial systems.
Implies re-manufacturing, reuse and recycling of waste energy, materials and product-/transport packaging, integrated industrial communities (‘industrial symbiosis’) and recovering and designing industrial by-products as feed stocks.

Dematerializing industrial output.
Implies selling customer functionality, light-weighting, re-manufacturing and recycling.

Systematizing patterns of energy use.
Implies minimizing energy consumption, energy cascading, de-carbonization, development and use of renewable sources for energy production and commuting through communication.

Balancing industrial input and output to natural ecosystem capacity.
Implies developing and spreading knowledge of sustainability levels or carrying capacities of local, regional and global recipients. Also systematic actions to use clean technologies, substituting quality for quantity, introduction of the ‘precautionary principle’ and risk assessments, sustainable practices in agricultural, silvicultural and maricultural activities and population control.

Aligning policy to conform with long-term industrial system evolution.
Implies the introduction of macro-policies (e.g. policy analytic frameworks, extended producer responsibility etc.), regulatory approaches (e.g. product take-back, recycled content mandates etc.) and economic instruments (e.g. internalising environmental costs, deposit redemption, product liability etc.).

Creating new action-coordinating structures, communicative linkages, and information.

Implies changes in the structure that constitute the primary producing and consuming sectors of societies. Also building environment into core competence of everyday business practice, creating an environmental ethic, extended organizational roles (e.g. product stewardship), public disclosure and cooperative alliances (e.g. information exchanges, supplier relationships) and supplying ecology information to the customer.

Some perspectives on IE-initiatives have proven useful (van Berkel, Willems and Lafleur, 1997):

IE is *proactive*, not reactive. IE is initiated and promoted by industry because it is in their own interest and the interest of those surrounding systems with which they interact, not because it is imposed by one or more external factors.

IE is *designed on*, not *added on*. This characteristic recognizes that many aspects of material flows are defined by decisions taken very early in the design process and that optimization of IE requires every product- and process designer and every manufacturing engineer to view industrial ecology with the same intensity that is brought to bear on product quality or manufacturability.

IE is *flexible*, not *rigid*. Many aspects of the process may need to change as new manufacturing processes become possible, new limitations arise from scientific and ecological studies, new opportunities arise as markets evolve etc.

IE is *encompassing*, not *insular*. In the modern international world, IE calls for approaches that not only cross industrial sectors, but cross national and cultural barriers as well.

There are different approaches to IE. However, these are not mutually exclusive, but emphasizes different aspects of the industrial society that can be influenced in order to reach an environmentally compatible situation. Common for them all is to assess how companies can move from implementation of relatively obvious and incremental environmental improvements towards comparatively radical environmental innovations.

One approach to IE is materials specific, analysing the way material flows through the industrial society in order to identify, evaluate and implement improvement opportunities.

A second approach is product specific, analysing the ways in which component material flows of a selected product may be modified or redirected to optimise the product-environment interaction in a life cycle context.

A third approach is regionally focussed, aiming to optimise the exchange of materials and energy between industries at the local level (“ecoparks”) or include all material, energy, and information transfer between industries, consumers, inhabitants, and local natural resources ("islands of sustainability" or "industrial symbiosis").

A final approach is actor-specific, involving industries, government and consumers investigating the opportunities facing different actors in the industrial society to change material and product flows in an environmentally compatible direction (Jelinsky et al., 1992).

The IE-focus is concerned with material- and energy flows. Every action by living organisms generates waste energy that is in a degraded, less useful form. Some of this energy may be used to drive other processes and organisms. But with each successive action, the energy is degraded or dispersed further until it is no longer useful. Here the entropy can be thought of as a measure of disorder, where the state of a system with energy dispersed is higher in entropy than a state with energy concentrated.

In a similar way it may be argued that the difference between a degraded or dissipated state of material and a valuable state of the same material is simply a matter of differences in entropy or degree of dispersion between the two material states.

There are two ways which can turn a degraded material or degraded energy into a more valuable state: *one* to find a process that can use the material or energy in its degraded state or *two* to refine or upgrade the material or energy and have it recycled in a closed system. In an ideal system, both these approaches are combined (Lowenthal et al., 1998).

The success of IE-initiatives is strongly dependent on organizations' understanding and skills in involving own personnel, neighbouring companies and other local external stakeholders in exploiting local potential for environmental co-operation and improvement.

2 LINKS BETWEEN IE AND LOCAL AGENDA 21 INITIATIVES

An agreement of principles for international environmental action in the 21. century was reached during the United Nations' conference on environment and development in Rio de Janeiro in 1992 (the Local Agenda 21 or LA 21). With its local improvement perspective based on co-operation between industry, municipalities, research institutions and households, these principles have a wider scope than the isolated ecopark-concept. LA 21 initiatives may comprise the following issues to satisfy the intentions expressed in chapter 28 of the Rio-convention (Lafferty and Eckerberg, 1997):

- Evaluating environmental effects in relation to basic economical and political priorities.
- Relating local priorities, decisions and action to their global effects.
- Integrating an environment- and development perspective across professional sectors in planning, decision making and implementation.
- Ensuring that all important societal actors are involved in defining and implementing improvement action directed at the environment and societal development.
- Ensuring that local problems and development potential are addressed within a broad ecological and regional framework in a multi-generational perspective.

Practical co-operation between authorities, industry/commerce and households are too seldom based on holistic analyses of current environmental conditions and the mutual importance of these conditions for regional development towards sustainability. The consequences may be that the results of LA 21-action and instruments can be addressed to improve environmental aspects that aggregates to only a minor share of the region's total influence on the local-/regional-, cross-national and global environment.

A starting point for local development may therefore be that environmental problems and development potential are viewed in concert with the potentials of the whole region, across municipal borders and across professional sectors and stakeholder areas of interest. Furthermore, that environmental improvement actions are prioritized according to their ability to influence the development towards a sustainable society both on a local/regional, national and global level.

Most current and earlier LA 21 projects have tended to be very narrow in perspective, disregarding possible actions based on a holistic view within and between adjacent regions with massive links of co-operation for resource exploitation, regional services or common interests in infrastructure (SFT, 1996; SFT, 1997 and Ramsdal, 1997). Regional analyses (Thoresen, 1998) suggest that sustainable use of local/regional resources and regional infrastructure may play an important role in our efforts to reach a sustainable society. For this reason, it is our view that the IE-concept should be expanded to comprise the systematic introduction of LA 21 co-operation and evaluation of potential benefits from the use of local/regional resources and infrastructure.

The implementation of IE and LA 21 working principles involve inter-personal as well as inter- and intra-organisational communication and understanding. The success of IE-networks is therefore dependent on organizational learning principles and practices.

3 ORGANISATIONAL LEARNING AS DRIVERS FOR IE-NETWORKS

Morgan (1997) mentions several possible models for behaviour in organizations.

The *population ecology model* implies that the individual company is imprisoned in a given form and will not be able to survive if demands from the environment are considerably changed and if these demands require other characteristics than those possessed by the company. *New organizations will emerge and the ones best adapted to the natural and business environment will grow and be successful, until the environment after an interval of time presents new demands which a previously successful company may or may not be able to fulfil.*

The contingency model as outlined by Burrell and Morgan (1979), Lawrence and Lorsch (1967) and Burns and Stalker (1961) implies that companies must make their own company-specific adjustments to the environment. There exists no general solution for the organization of skills and competence within a company. An optimum solution is dependent on the actual conditions and situations the individual company must adjust to. There may even be several solutions leading to the desired goals ('equifinality'). According to Burns and Stalker, a stable and unchanging environment may give rise to closely controlled systems (mechanistic structures), while an unstable and rapidly changing environment may give rise to highly adaptable systems (organic structures). When the environment is uncertain, turbulent and rapidly changing, the need for differentiation in skills, knowledge and ways of acting inside the company increases (Lawrence and Lorsch, 1967). *The organization must adapt to environmental changes through learning.*

The *autopoiesis model*. Maturana and Varela (1980) argue that living systems are organisationally closed, autonomous systems that make reference only to themselves and changes occur in circular patterns of interaction within the system. This makes systems able to self-create or self-renew. Maturana and Varela state that such a system's interaction with its 'environment'(or surroundings) is a reflection and part of its own organization. It interacts with its environment in a way that facilitates its own self-production, i.e. its environment is really a part of itself. Applied to the business world, this implies that companies or organisations may attempt to achieve a form of self-referential closure in relation to its environment, while at the same time treating their environment as extensions of their own identity. So, companies or organizations in the autopoietic state continuously shape and reshape themselves and the environment they are a part of. The individual organization is an integrating part of the larger system, and its internal adaptation must be understood as a part of the process of adaptation and change for this larger system. *This implies that new forms of cooperation and working practices will develop within the larger system, from which the company and its individual employees will learn new skills, gain new knowledge and gain understanding of their own roles.*

The mentioned organisation models points at different qualities which the dynamic and successful organization or system needs to possess. These qualities may be further sub-divided into the following abilities and skills (Morgan, 1997):

- *Learning to learn*. The learning organisation possesses the ability to actively influence and create its own future (generative learning), where learning to learn implies a continuous challenge and adjustment of one's own goals and values.
- *Minimizing critical specifications*. Employees at all levels should be given the opportunity and authority to make decisions within their own area of responsibility. This invites creativity and understanding of one's own role in the organization.
- Differentiated skills, knowledge and practices. To be successful within its environment, a system must be as differentiated in skills, knowledge and practices as this environment.
- Surplus of functional abilities at each level. A management system should be designed and implemented and a culture developed where relevant specialized functions are available at all organization levels , e.g. functions of control, memory bank, initiator, transfer of stimuli and responses and translation of information.
- All operational- and most maintenance- and development tasks should be solved at the lowest possible organization level. Consequently, such resources and competence should be available at low levels.
- Employees at all levels should be prepared to take on both leading activities (goalsetting, planning, coordinating, implementing and follow-up) as well as their normal operational functions.

The management system should also take into consideration that a high uncertainty and high potential environment should be responded to by the development of organisational and individual creativity, while at the same time minimizing the use of formal working procedures (Jay Galbraith, 1977). Creativity in the solution of problems or exploitation of development potential may be increased by a high level of delegation to the persons/groups in question and their acceptance of responsibility for the task at hand (Thoresen, 1998b). A creative environment may also be created by allowing persons or groups to select, formulate and prioritise their own improvement action (Horowitz, 1990).

The proper functioning of an organizational system or cluster of systems is strongly dependent on dynamic feedback loops between actors (Argyris, 1990; Morgan, 1997; Senge, 1990). In the early phases of environmental understanding by company management, industrial ecology to its fullest extent will not normally be regarded as a practical company policy, but rather as a vision. The reason is that a high degree of interaction with other industrial systems may seem unrealistic at the present time, since this puts high demands on the permanency of such arrangements. In the industrial world, uncertainty and demand for short-term profitability is prevailing, rather than the need for binding, long-term arrangements.

4 EXPANDED FRAMEWORK FOR THE INDUSTRIAL ECOLOGY CONCEPT

Both national authorities and industry tend to introduce and implement regulation and improvement activities that lack a comprehensive and holistic view of industrial systems in a life cycle perspective and programs to utilize their improvement potential within their own system and in cooperation with adjacent systems. The IE concept as promoted by Tibbs and Ehrenfeldt, represents a good basis for a holistic working model both for the development of comprehensive regulation and company-internal planning and decisions.

However, one major difficulty is that dominant ideas in the economy tend to work in an opposite direction of IE, e.g. ideas that favour opening of material cycles rather than closing them, marketers' desire for built-in obsolescence etc. The strong focus on short-term profitability and future business uncertainty for each individual company implies that environmental improvement activities are sought within the company rather than through developing long-term physical link-ups and cooperation with outside companies.

Current industrial approaches show far too low ambitions on the part of industrial managers to cope with environmental questions in all relevant decision situations within the company. This may also be due to limited environmental knowledge in general and limited understanding of the life cycle consequences of their own processes and products in particular. To make the IE concept operational, it therefore seems necessary to integrate environmental issues into company processes for planning, development and decision making on a strategic, tactical and operational level.

Probably the right way for the company to go about this problem is to introduce IE-principles into its environmental policy as a first step. This ultimately may lead to improved knowledge and understanding for managers and employees of environmental problems, threats and potential within the company and the potential in closer contacts with its surroundings. This new knowledge and understanding may in turn cause management to open up for cooperation and even physical link-ups with outside companies and a more open communication with customers and external stakeholders[2]. *To be successful, the implementation of IE principles must comply with company goals, i.e. short and long term profitability.*

[2] External stakeholders : e.g. authorities, finance institutions, insurance companies, customers, suppliers, Non Government Organizations (NGOs) etc.

4.1 Working principles and structure for IE-initiatives through local networks

With basis in the theoretical and empirical findings from the above chapters, the following expanded IE-framework may be defined, to construct the necessary link-ups between companies (Tibbs, 1992; Ehrenfeldt, 1994; Jelinsky et al., 1992; Lafferty et al., 1997 and Thoresen, 1998).

Exploitation of company-internal potentials for sustainable development through:

- Improving metabolic pathways.
- Dematerialising output.
- Internal loop-closing.
- Improving patterns of energy use.
- Understanding and adjusting product functionality to real customer needs.
- Securing a balance between environmental impacts from the company and the carrying capacity of relevant recipients.

Exploitation of potentials in IE-networks through:

- Loop-closing between companies.
- Upgrading of waste materials or substances.
- Systematic use of local/regional resources and infrastructure.
- Common service systems (e.g. purchasing, maintenance, personnel transportation, education/training etc.)

Support and regulation from national and local government through:

- Regulatory approaches, economic instruments and macro-policies.
- Introduction of IE principles and practices in county and municipal planning.

Linking local interests through action coordinating structures:

- Active stakeholder participation and co-ordination through LA 21 initiatives with participation from e.g. industry, municipality/county, research institutions and households.

As a practical tool for environmental improvement, the IE-concept may be regarded as a natural continuation of the Cleaner Technology concept and the lifecycle perspective. The different perspectives for environmental improvement are shown in fig. 4.1. The left part illustrates that the introduction of the Cleaner Technology concept (A), where one solely looks at improvement potential (reduction of resource use, pollution and waste) for the individual manufacturer. The use of this method normally leads to some reduction potential, but these are not large enough to satisfy future demands for improvement (cf. Factor X requirements[3], Kyoto convention requirements[4] etc.). Other methods have been developed where one looks at environmental impacts from product use all along the product lifecycle (Life Cycle Assessments or LCA). This concept (cf. fig. 4.1 – B) introduces a largely improved perspective for improvement than solely to focus on environmental impacts from individual production processes. The LCA methodology has shown that the most serious environmental problems associated with product manufacturing and use may be due to consequences of raw material selection, transports, the consumers' way of using or consuming type product, end treatment of product waste etc. The improvement potential revealed by using an LCA-perspective has normally revealed a much larger improvement potential than by isolated use of the Cleaner technology method. However, not even a systematic use of a product lifecycle perspective yields sufficient improvement potential to satisfy the radical Factor X requirements.

The Industrial Ecology (IE) concept (cf. fig. 4.1 – C) has therefore been introduced as a continuation of the lifecycle perspective. This method implies that one focuses on a company's interactions with other companies across product chains (value chains). The objective is to map and exploit potential for material and immaterial interactions between individual value chain actors at the different points along in the chain which represent the largest impacts on the environment.

[3] von Weizaker et al. (1997)
[4] A United Nation convention for reduction of climate gas emissions worldwide held in Kyoto in 1997.

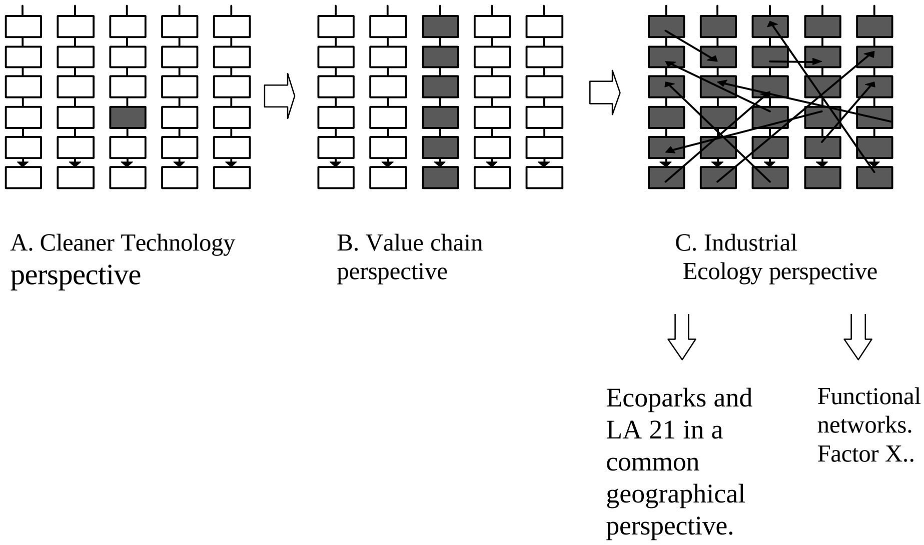

Fig. 4.1 The concepts of Cleaner Technology-, Lifecycle- and the Industrial Ecology concepts

The IE-perspective may be materialized through ecoparks, where value chain actors representing different value chains may cooperate in a network with a common purpose (e.g. maximizing materials- or energy efficiencies etc.). The concept also comprises the potential for cooperation and communication between industrial companies, local/regional government, households and regional research institutions. In this local dialogue, the potential from using regional resources, regional infrastructure and proper regulation or incentives from local government plays an important part (cf. LA 21 principles).

One important aspect of the IE-concept is that it challenges the functional user needs to product performance. Which are the basic requirements of the consumer/user of the product? Can these requirements be satisfied by products or services which have lower resource requirements or give reduced environmental impacts through their life cycles? Can a systematic exchange of "waste"-products, waste heat or common exploitation of resources between adjacent companies in an ecopark lead to reduced, total environmental impacts from the ecopark as a whole?

One has to be very careful in selecting the right method or process to initiate material- or immaterial interactions between companies in the IE-network. Therefore, the following principles are success factors.

4.2 Working principles for involvement, identification, information and communication in IE-networks

Industrial networks must exist on a voluntary basis. This implies that network-participation is a working form that must be profitable (i.e. leading to new solutions either for increasing income, reducing costs and risk or increasing asset utilisation) or competence building (i.e. competence synergies may expand individual competence for participants which in turn leads to improved solutions).

Network success rest with its ability to introduce new perspectives in handling problems and exploiting potentials within and between participating companies.

Many recently designed networks expect a more proactive role among participants. Under predictable market circumstances some networks may be of permanent nature (stable networks), while others in a rapidly changing market situation (dynamic networks) may be pulled together for a given run and then disassembled (Miles and Snow, 1992). Common for them all is the requirement on each company to share necessary information within the network.

The practical organisation of arenas for information sharing and common problem solving create identification. This in turn may lead to effective and permanent working relationships within the network, which are essential for success.

Some vital aspects for the development of effective relationships between network companies and between individual working group participants are listed below:

- The creation of arenas for information, communication and feed-back through e.g. steering group participation, partnering sessions, intra-company thematic working groups on selected topics, person-to-person dialogue.
- Systematic use of feed-back information loops to spread results from working groups to involved companies and organizations.
- Identification through involvement e.g. by developing common service facilities, web-pages, use of local media and development of common ecopark grounds.
- Learning-by-doing. Active participation is required in mapping, problem solving and exploitation of potentials in the individual companies and in the project groups.
- Focusing on part-responsibility of each group participant for successful group results.

- Involvement of external resources for introduction of working concepts and as drivers for initiation and maintenance of the ecopark co-operation process.

Some perspectives on Hybrid arrangements[5] as strategic alliances developed by Borys and Jemison (1989) and Rackham, Friedman and Ruff (1996) may be essential building stones for setting up an IE-network:

1. The development of a common vision or purpose for the network as a whole and for possible thematic sub-groups within the network (Vision).
2. A minimum amount of mutual trust and willingness to share ideas among network partners (Intimacy).
3. The potential for adding real productivity and value to all network partners (Impact).

Trust is a key success factor. The so-called “knowledge based trust” (Kramer and Tyler, 1996) develops over time, largely as a function of the parties having a history of interaction that makes them realise that the other parties’ behaviour is predictable and trustworthy.

Furthermore, trust (“identification based trust”) exists because the parties effectively understand and appreciate the other parties’ desires and needs.

A common outside threat or a desire to exploit common potential may often be the rationale for networking between organisations. When hybrids or networks are formed, they have a special need for institutional leadership during formation. This leadership allows them to develop common purpose and understanding (Selznik, 1957). In a better way than any of the busy network partners, this type of leader or ‘facilitator’ may be able to bring about both visions and methodological practices for the network on the one hand and practical achievements from the network on the other. In practice, this implies the roles of the theorist, initiator, arranger, central communicator and a person who ‘keeps track’. However, experience (Mueller, 1991) has shown that such ‘facilitators’ need to possess some important characteristics:

- Ability to get the job done.
- Having sufficient knowledge of the businesses and problems at hand.
- Being able to move back and forth between a visionary and methodological level and a more ‘down-and-dirty’ detail level.
- Encouraging a ‘one objective’ network rather than focusing on a set of sometimes contradictory, individual company objectives.

[5] Hybrid arrangement: An organisational arrangement that use resources and/or governance structures from more than one existing organisation (Borys and Jemison, 1989).

During start-ups, networks should be assigned a focus or broad purpose rather that a specific goal. The work to achieve specific goals may be handled later by processes other than networking, i.e. special task forces, projects or organisational programmes within the network or inside the individual company.

The stability of networks is a critical success factor, where systematic feedback to management of the individual companies may be fruitful (Mueller, 1991). This may be done at some pre-set target events where information about ideas, findings, solutions or experience is transferred. If the networks are not expected to last for an extended period, participants may not engage in the sorts of behaviour that generates trust and legitimate authority. Contrary to traditional organisations which achieves stability by instituting rules, procedures and roles that create stability and dependability among their members, voluntary networks must rely on their ability to create additional value (economic- or environmental value, satisfaction of idealism etc.) between its members on a continuous basis (Borys and Jemison, 1989).

When two or more companies enter into a network, the objective normally will be that the combined efforts will yield results which the companies on their own may not be able to realize. One should bear in mind that when network co-operation has lasted for some time, some changes in the modes of co-operation usually will be needed. Good personal relations are required and these in turn must be voluntary and based on mutual trust. To be successful on a permanent basis, there must be a dynamic aspect involved in the way networks co-operate. If not, there is a danger that the network may disintegrate (Haugland, 1996). These aspects may introduce organisational challenges, which many companies find hard to handle. One way to handle this problem is to start the network co-operation with modest ambitions and let relations and degree of integration develop over time.

To facilitate necessary changes within or between companies, it is essential to gain top management support and priority setting of improvement actions within the individual company or between companies. Furthermore, it is necessary to increase environmental understanding for key personnel at different operational levels where practical improvement action is planned and implemented. To make the necessary decisions and implement necessary actions for these categories of management and other employees, it is essential to create broad environmental understanding and acceptance of individual responsibility for environmental impacts from the company. The two curves in fig. 4.2 are meant to represent the aggregation of environmental understanding and acceptance of responsibility over time.

The left and upper curve shows the development of environmental understanding for environmental key personnel over time, while the other shows the development of understanding for top management and operative key personnel. No improvement action will take place unless environmental key personnel succeeds to help implant relevant environmental knowledge and understanding among these two groups. Furthermore, a certain critical level of understanding is required before these two groups will make the desired decisions or implement operational improvement action. There will be a time lag between the point in time where environmental key personnel reaches this critical level and when the two other groups reaches their critical levels. For the proactive company, this time gap should be minimised. Systematic co-operation in IE-networks may be an instrument to minimise the time gap.

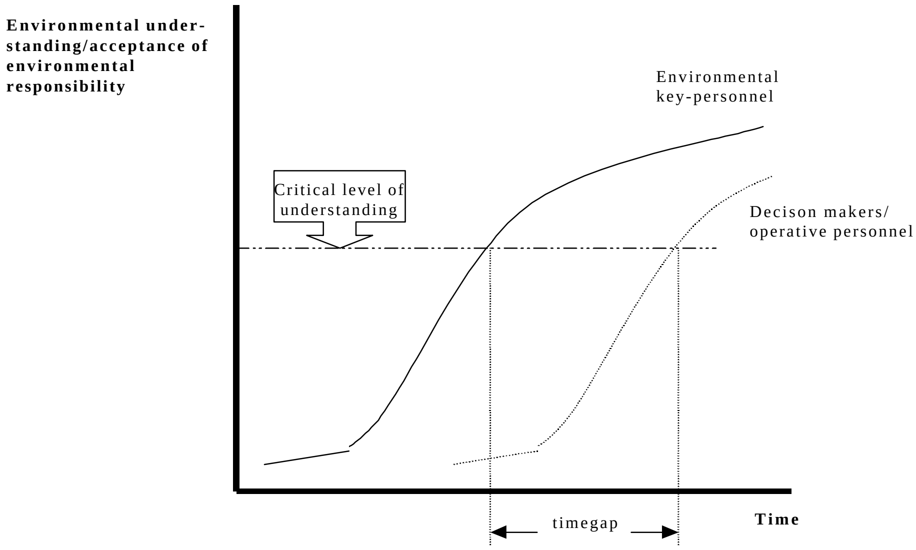

Fig. 4.2 The development of environmental understanding and acceptance of responsibility for personnel at different organization levels

The introduction of IE-networks between companies is a learning process for the personnel and companies involved. Permanent and successful co-operation within the networks will not be secured before top management and key personnel in the individual companies identify themselves and their actions with the development of the whole network. A model for this learning process has been developed (see fig. 4.3).

The process of company integration in this learning process is considered to have five different steps, as fig. 4.3 shows. Total time period to ascend all five steps will decrease with the quality of activities carried out in each step.

Information activities and campaigns towards the community must be put in focus during the whole learning process. The reason is that the community cannot accept the presence of industrial processes with ecological characteristics they cannot perceive (assymetric information). Simple and to-the-point information on ecological characteristics of new or adjusted processes will be an essential challenge for industry (re-phrasing of Haury, 1999).

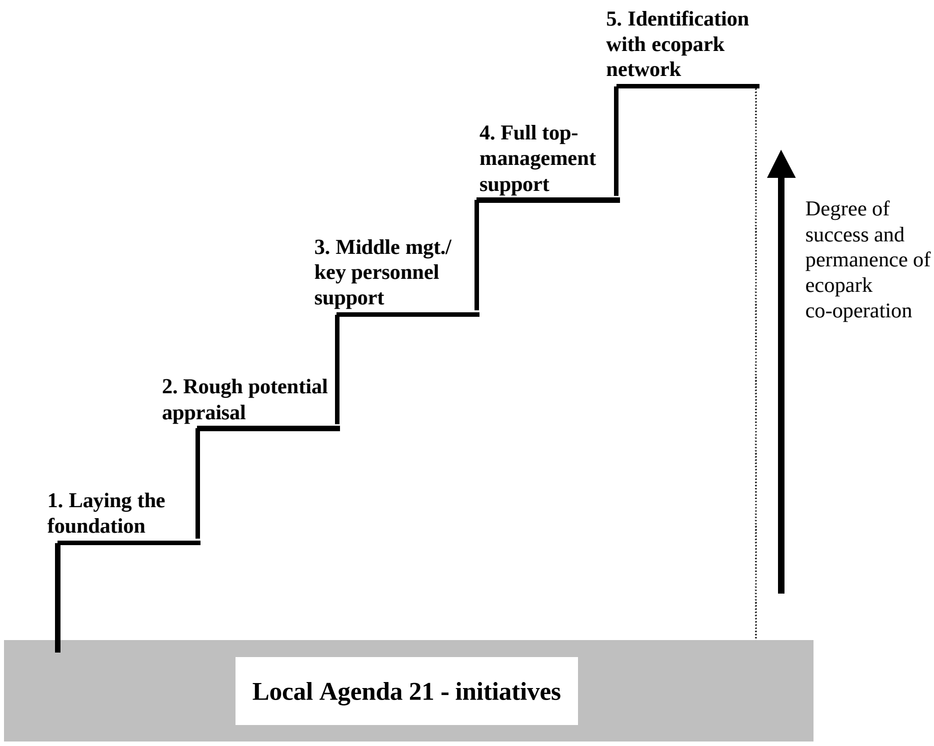

Fig. 4.3 Illustration of the learning process within IE-networks of companies

The five-step learning process is defined according to participatory action learning and research principles. These principles imply that network participants are actively engaged and accept responsibility for the various development steps. The researcher's role is as a facilitator and advocate for and supporter of change. The process may be described in the following way:

Step 1 - Laying the foundation. This foundation may be based on local/regional understanding and interest to initiate and maintain a pressure towards sustainable development for all actors in society (industry, agriculture/forestry, municipalities and households) both locally and within the region/county. These initiatives may very well be integrated in the LA 21-work within municipalities. In regions where all actors are reasonably well acquainted with local LA 21 principles and practices, the 5-step learning process for IE-networks may have a flying start. Since local dialogue, communication and improvement initiatives have a strong impact on environmental improvement viewed in a holistic perspective, ongoing community and local government involvement should be integral to the process. For this reason, LA 21 initiatives may serve as a suitable foundation all through the 5-step process.

The foundation may also be based on research interest and initiatives from regional research institutions, as well as the desire from company management to be prepared for future political directives aimed at a sustainable development or pressure from the public.

A partnering session or initial kick-off meeting between representatives from the local municipality, industry and research institutions may be a practical tool to start up an IE-network learning process. In this session, key personnel from each company are assigned for active participation in the IE-network.

Step 2 - Rough appraisal of improvement potential (Baseline study). The experience is that most companies have scarce personnel resources and do not readily take part in activities outside the company, unless such participation can give a short to medium term rise in profitability or potential for needed competence development. Therefore it is necessary to make a rough appraisal or baseline study of inter-company environmental improvement potential, community involvement, regulatory issues and other key information to understand local conditions. From these baseline studies, companies can judge if the improvement potential for their own companies is sufficiently high to call for network participation.

Such appraisals may be carried out e.g. by research institutions. To increase the environmental understanding of environmental key personnel in each individual company, the appraisal should be carried out in close co-operation with such personnel from participating companies.

Results from these network appraisals may well be presented in a second partnering session with participants from top or middle management in the participating companies. The agenda of the session should be focused on environmental issues of common interest and organisation of an IE-network with the task to bring out the presented improvement potential.

Experience has shown the need for *an external resource or "facilitator"* with the role to initiate the early activities in forming the IE-networks and for driving, planning and maintaining later activities within or between participating companies. The role of this facilitator should – depending on the situation and step on the learning ladder - change back and forth between the conceptual role of supplying appraisal and network methodology , organise and maintain the learning processes in each step of the ladder etc. and a more operational role in discussing operational problems and help exploit improvement potential within each company or between network companies.

Both the role of the "facilitator" and the key environmental issues for separate network-group co-operation should be decided in the second partnering session.

Step 3 - Middle management/key personnel support. This may be secured through a phase of company internal mapping of volumes and quality of material-, water- and energy streams of interest to the IE-network (waste heat, waste material, potential for loop-closing internally or within network, transportation needs and potential for product design changes, common solutions for transportation etc.).

It is suggested that company internal mapping be organised as a project lead by each company's environmental key person, where relevant personnel at different organisational levels participate according to their knowledge of products and processes.

Environmental key personnel also participate in IE-network groups organised by issue (e.g. waste, energy etc.) where synergies are created between professionals with different knowledge and experience. All participate in a discussion of improvement solutions based on the mapping results – both within each company and within the network.

One of the company representatives is chosen to take on the responsibility for the actual results coming out of the group work and for releasing competence synergies between group participants. The role of the external "facilitator" is to secure that the learning process develops according to intentions and to make practical arrangements connected to the group discussions. Again, the change back and forth between a conceptual and an operational role is essential for success. However, definitions of areas of interest for mapping and improvement and plans for implementation should be left to network-group participants.

The degree of active participation and acceptance of responsibility by each network-group participant is vital for further network success.

Step 4 - Full top management support. Management support may be secured through a close communication with top management, to present and discuss findings and development potential for the individual company and for the network. This may be achieved by management participation in steering groups for company internal mapping and idea generation projects or by means of presentation meetings at important milestones in the projects. Presentations should be made simple, to-the-point and translated into rough, economic potential (cost-/income consequences and possible investment needs).

A continuous focus on environmental development issues (inter-company or intra-company) can be introduced by developing relevant eco-efficiency indicators and using these systematically in the companies' management systems (e.g. for annual budgeting of environmental goals and follow-up).

Step 5 – Identification with the ecopark network. Partnering sessions with top management participation are essential, where meeting frequency is adjusted to the communication needs to secure continuous pressure on network co-operation and improvement results. Important discussion points for these sessions will be to develop a clear vision and identification of future areas of common activity for the IE-network, follow-up of inter-company improvement actions and –potential and of eco-efficiency indicators describing network performance on selected environmental issues. Issues for further development focus should be decided and so should the organisation of network activities and the successive transfer of "push-pull" initiatives from the "facilitator" to network participants. Sessions with fewer participants may also be desirable, since implementation of some of the development opportunities may not involve all companies.

Continuous identification with the IE-network from all companies require the development of areas of common interest (positive presentation in media, common web pages for PR and information, common service functions within the ecopark, area development, business development based on waste material or waste heat etc.). Eco-efficiency awards for good performers may prove successful to encourage identification, and so may eco-conferences and workshops arranged on a regional or national level with participation from industry, local municipalities, local public or their interest organisations and research institutions.

Common eco-efficiency development goals on a company bases and aggregated for the whole network may also prove successful.

Regional development towards sustainability may well start up in one geographic area with basis in an IE pilot-network. Successes and experience from this pilot-network may be spread as "waves in water", originating from the development of environmental understanding for a set of key persons from different companies, cf. fig. 4.4.

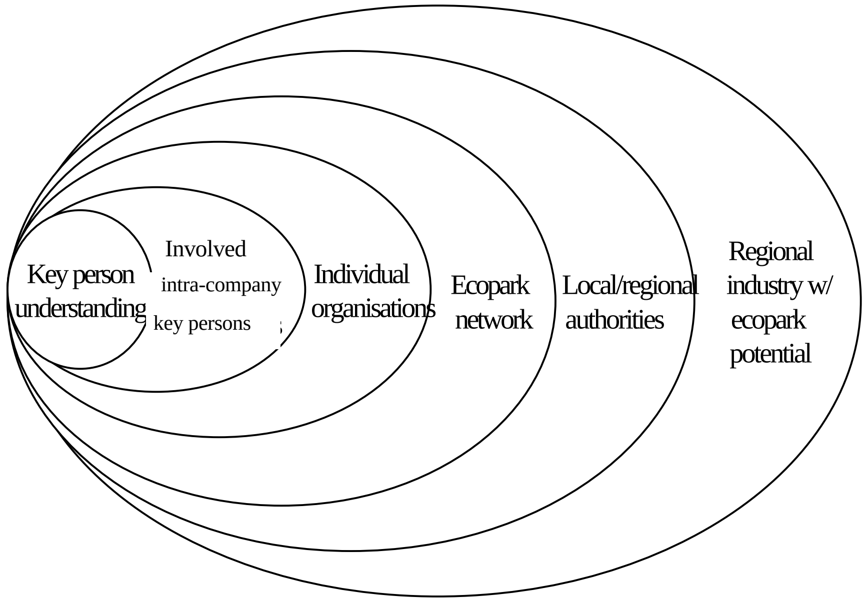

Fig. 4.4 The spreading of regional understanding of potentials from IE-network co-operation

Fig. 4.4 indicates that the understanding of regional IE-network potential starts with developing an understanding among a limited set of key persons from some proactive companies, who opens up for dialogue in intra-company IE-networks. This understanding is in turn spread to each of the participants' companies and then to the whole company network. If local/regional authorities have not been involved at an earlier stage, they should now be involved to introduce necessary incentives or a regulation framework to enhance network co-operation. Success-stories are then used by industry associations or authorities to involve other regional industry with IE-network potential. Research institutions may be the agents to spread and exchange experience within international scientific arenas.

5 INTERNATIONAL ECOPARK INITIATIVES

The evolution of IE has been far from linear and its use in industrial systems has not at all been comprehensive according to the framework suggested by Tibbs (1992) and Ehrenfeldt (1994). Global, industrial approaches at the moment seem to have taken two directions
(Erkman, 1997):

- Moving from 'case by case waste exchange programs' to waste-energy and/or -materials exchange in 'eco-industrial parks' or 'islands of sustainability' where exchange of waste energy and/or -materials takes place within regions.
- Optimisation of resources. Two main strategies seem to be followed; one is the de-materialization strategy to increase resource productivity both on product level and at global infrastructure level and *two* following de-carbonisation strategies to move the carbon content of energy sources from high to none.

There are over 12.000 industrial estates around the world, but only some thirty estates have been developed into eco-industrial parks (EIPs) in the USA, Japan, Germany, France, Italy and Denmark. These EIPs are at various stages of development. Several parks are already well developed, but most are still in the planning and feasibility stages. The initiatives range from forming already existing, co-located industries into IE-networks to the planning and developing new IE-networks from scratch.

In the USA, the President's Council on Sustainable Development (PCSD) has formed an active task force on EIPs as one element of building as sustainable development. Based on recommendations from PCSD, the Environmental Protection Agency (EPA) and the Department of Energy (DOE) have been assigned the task of exploring possibilities for EIPs. Many of these initiatives are based on "brownfield[6]" redevelopment.

"Virtual" EIPs also have developed, being formed by a network of companies, which are not physically located in the same park. These networks of companies can still with success share materials and services, which are not dependent on co-location in the same industrial park.

Studies of international literature reveals several examples of poor and successful IE-networks and the most important ones are mentioned below.

[6] "Brownfields" are abandoned, usually urban sites with actual or perceived contamination, where prospective buyers or lenders are reluctant to redevelop the sites because of potential future environmental liability associated with the sites.

The most prominent of these is the Kalundborg “Industrial Symbiosis[7]-network” in Denmark.

The Kalundborg “Industrial Symbiosis” network:
This is one of the favorite cases discussed between industrial ecologists. It is an industrial network which has not been planned, but one which has developed over time between widely different companies located near each other. Originally the motivation for network cooperation was the desire to reduce waste materials by seeking profitable uses for these. However, gradually both managers and town residents found that the network project generated very substantial environmental benefits through the inter-company transactions. There is no formal organisation established, no common board or budget, rather … “we do what pairs of us think is a good idea”. However, the symbiosis partners have established an information centre – the Symbiosis Institute– to satisfy the international demand for information and to develop the symbiosis idea further .

The following figures show environmental savings due to material- and energy interactions between the participating companies:

Reduced consumption	- 19.000 tons of oil / year
	- 30.000 tons of coal / year
	- 600.000 m3 of water / year
Reduced emissions	- 130.000 tons CO_2 / year
	- 3.700 tons SO_2 / year
Reduced waste volume:	- 135 tons of fly ash / year
	- 2.800 tons of sulphur / year
	- 80.000 tons of gypsum / year
	- 800 tons of sludge-nitrogen / year

http://www.symbiosis.dk/c2.htm

[7] Industrial symbiosis can be defined as a cooperation between different industries by which the presence of each increases the viability/profitability of the other(s), and by which the demands of society for resource savings and environmental protection are considered (Lowe, 1995).

Other examples of ecopark initiatives are the following:

The Burnside Industrial Park in Nova Scotia, Canada.
Here a research team from the school for Resource and Environmental Studies at Dalhousie University has aimed to develop principles, guidelines and strategies to enable an existing collection of plants to become an industrial ecosystem. 1200 small and medium-sized businesses are located within the same site.

The guidelines are intended to generate action that may apply to new industrial parks as well as to retrofitting old ones.

An eco-efficiency centre has been created through a partnership between Dalhousie University, Halifax Regional Municipality, Nova Scotia Power Inc. and the governments of Nova Scotia and Canada. The objective behind this centre is to help improve the ecological effectiveness and economic efficiency of Burnside Industrial Park businesses in Halifax, Nova Scotia. In practice, the centre works to improve the efficiency of individual companies on the one hand, while on the other hand encouraging an ecosystemic perspective in the ecopark as a whole. One major role is to support cooperation between businesses where appropriate.

http://www.mgmt.dal.ca/res/research/indprkpb.htm

Eco-Industrial Parks (EIPs) in Rochester, New York, Baltimore and Maryland.
Cornell University's Work and Environment Initiative (WEI) has developed a three-step development concept for EIPs, including the development of closed-loop production systems linked to a core resource technology. The concept emphasises a network model of economic and industrial development in which smaller companies collaborate to achieve marketing advantage and develop joint products. Different types of workshops and conferences for network-participants are essential instruments to create interest and innovative strategies for future link-ups between companies.

The projects try to combine environmental and energy efficiencies with high-performance business practices (Lowe, 1995).

The Work and Environment Initiative (WEI) is part of The Cornell Center for the Environment. WEI's goal is to examine new ways to improve environmental performance at work and to increase green employment opportunities.

http://www.cfe.cornell.edu/wei/cupersp.html

Industrial partnerships in the Sarnia-Lambton area of Southern Ontario, Canada.
Case studies in the area have been carried out to document successful formation of partnerships, identify economic, regulatory and other barriers to forming partnerships and establish principles for developing networks in other industrialised areas.

Five different cases comprise a power/steam cogeneration project, a flue gas de-sulphurisation project, an energy distribution project (Bruce Energy Centre), an energy from waste project and finally sintering project of industrial waste.

The cooperation between the companies has been initiated by an industry association which includes the major firms in the area.

Nisbeth et al. (1998).

A number of drivers and barriers for successful IE-network performance have been suggested through these case studies and from other literature (Nisbeth et al., 1992; Lowe, 1995 ; Borys and Jamieson, 1989, Selznic, 1957 and Rackham et al., 1996). This information is shown in more detail in the following table.

Table 5.1 Barriers and drivers for successful IE-network perofrmance

Barriers to successful IE-network performance	**Drivers** for successful IE-network performance
Economic issues: • Lack of funding.	*Economic issues*: • Economic benefits for all network partners is the main driver. • Relatively small capital investment needs.
Intra-company issues: • Too strict product specifications. • Reluctance of industry to use by-products as raw material. • Corporate executives use "commands" instead of influence or incentives to intervene in local operations. • The transformation to ecoparks are presently often intersecting with the massive restructuring of corporations, massive cost cutting, staff cutting, mergers and divestitures.	*Intra-company issues:* • Corporate policies are desirable, secondary drivers. • Excess production capacity • Low or manageable risk. • Poor environmental/health image of individual companies. • Need for an economical source of material/energy input (e.g. steam). • Rising raw material- or energy costs. • Desire to reduce fixed costs
Inter-company issues: • Reconciliation of risk profiles between network partners. • Lack of trust between network partners. • Multiple participation. • Different attitudes to risk. • Different goals have to be reconciled. • Division of capital investments/cost between participants • Just resource input and just cost and benefit sharing is difficult. • Difficulty increases where network participants represent different business sectors or if some participants are small. • Readjusting operations and economics if one party drops out of network. • Over-utilisation of networks, leading to undesirable dependence on a limited number of contacts	*Inter-company issues*: • A common purpose. • The need for a champion's strong personal commitment to sustainable development. • The need for a 'facilitator' or 'driving factor' to initiate and maintain an IE-focus within the network. • Common development of competence. • Open communication within the network.
Inter-company issues (contd.): • Network-expertise may become too narrow. • High expectations for co-operation can limit creativity. • Too much focus on real and perceived problems.	*Resource and technology issues*: • In-place industrial infrastructure. • Available space. • Available processing technology. • Corporate process-/rawmaterial competence. • Scarce supply of raw material or energy.
Industry vs. local government issues: • Difficulty in sharing vision between industry and regulatory and political bodies. • Lack of political support.	*Resource and technology issues (contd.):* • Desire to maintain a critical industrial mass through a pooled situation.
Public opinion issues: • Environmentalists' resistance. • Community resistance.	*Industry vs. local government issues:* • Relevant regulation. • Support from local/regional government.

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