IIIEE Master's Theses 2003:10

Industrial Symbiosis: A Closer Look on Organisational Factors

A study based on the Industrial Symbiosis project in Landskrona, Sweden

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Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, October 2003

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Published in 2003 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
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Printed by KFS AB, Lund.

ISSN 1401-9191

Acknowledgements

I would like to express my gratitude to all people who allowed me in some way or another to write this thesis and thus explore the realm of Industrial Ecology and help society to take one more, tiny little step in the direction of sustainable development.

First of all, I would like to thank my main supervisor and friend, Murat Mirata, who notably helped me find my way back to the path when I had lost sight of it, and who I spent lots of good times with, even when relentlessly commuting with the bus and train between Lund and Landskrona, or biking under the rain of the Swedish summer to interview companies.

I also would like to thank Mikael Backman, my second supervisor, without whom the Industrial Symbiosis project in Landskrona probably never would have happened. I hope I will one day be able to convince both company managers and civil servants in the same way as he has done with the companies in Landskrona.

Thank you to Benoît Duret, from Auxilia, who gave me very useful insights into the reality of Eco-Industrial Developments in North America and on Industrial Symbiosis in general, during a record-long phone discussion of four hours.

A big thank you also to Noel Brings Jacobsen, from Øresund Environment, who has provided me with insights on the Industrial Symbiosis network in Kalundborg, for which he has been working for several years as a project manager.

I would like to thank the Swedish Business Development Agency, NUTEK, that financed the project in Landskrona, as well as all the companies involved in the project. It fills me with optimism for the future, when I see company managers showing that they care and are ready to explore new paths towards more sustainable entrepreneurship.

Thank you also to the Municipality of Landskrona and more especially to Claes Nilsson from the Office for Trade and Industry (*Utvecklingsstiftelsen*) and to Högni Hansson and Charlotta Barthelson from the Environmental Department. I was especially proud to meet and discuss with Högni, who has been one of the characters in Sweden making the single-biggest contribution to preserving this beautiful country's environment. I hope that my own work will have somewhat helped to make Industrial Symbiosis cross the Öresund, and that soon Sweden will count several Landskrona.

It has been a long summer sitting inside when outside the sun was shining, and I therefore also want to thank my friends from batch 8 and all IIIEE staff who stayed in Lund during the summer for their involuntary support.

Thank you to the IIIEE and especially to Lars Hansson for a great Master programme and what will probably remain one the best years in my life.

Finally, of course, I would like to thank my parents who have, through the year, supported me financially and with their love, and who have certainly contributed in many ways in triggering my love of nature and my will to work to preserve and improve our environment and our quality of life.

Thank you all.

Abstract

Private companies, more and more, address their environmental impact through increasingly sophisticated internal environmental work. The concept of Industrial Ecology (IE) and its local/regional application, Industrial Symbiosis (IS), indicate that there is potential for further improvements in the environmental performance of companies at their interorganisational interfaces. Besides improving their environmental performance, companies may also achieve competitive advantage through IS networking. Despite these benefits, the number of IS networks is still limited. This may, to some extent, be due to the fact that although IE literature has extensively analysed the technical aspects of IS networking, softer organisational issues are not sufficiently understood and taken into consideration.

This study, based on action research methodology, analyses organisational factors influencing the outcome of IS networking. It is based on an IS project launched in May 2003 as a Swedish pilot project in the Municipality of Landskrona (Sweden), with the support of the Swedish Business Development Agency (NUTEK). The project involves 19 companies and the Municipality of Landskrona. The analysis of the factors influencing the companies' decision to engage in IS networking and the actual outcome of networking builds upon a review of IE, management and organisational literature. These factors are tested in the context of the Landskrona project, notably in order to outline factors that appear to be specific to a Swedish context.

The main factors outlined as influencing the companies' decision to engage in IS networking are institutional pressure, access to critical resources, increased efficiency and costs savings, and interorganisational learning. More specific to Landskrona, and possibly to Sweden, is the perceived need by companies for increased local networking in general. The major organisational factors influencing the outcome of IS networking are alignment with business reality, environmental maturity and commitment of the actors, existing institutional platforms and linkages, communication and trust, coordination and public/private partnerships.

Keywords: industrial ecology, industrial symbiosis, networking, organisational theory

Executive Summary

Private companies more and more address their environmental impact through increasingly sophisticated internal environmental work. The concept of Industrial Ecology (IE), and its local/regional application Industrial Symbiosis (IS), on the other hand, indicate that there are potentials for further improvements of the environmental performance of companies at the interorganisational interfaces.

Besides improving their environmental performance, companies may also achieve competitive advantages through IS networking. Despite these benefits, the number of IS networks is still limited. This may to some extent be due to the fact that although IE literature has extensively analysed the technical aspects of IS networking, softer organisational issues are not sufficiently understood and taken into consideration.

This thesis therefore examined the following main research questions:

- ***What are the organisational factors that have major influence on the development and operation of Industrial Symbiosis networks?***
- ***How can the coordination bodies help provide the right set of organisational factors to facilitate networking?***

In order to answer these questions, the author chose an action research methodology, analysing a specific IS project in its early stage of development. In order to draw lessons and implications for IS networking in general, the study of this case was framed in relation to IE, management and organisational theory, through a literature review of these fields. Management and organisational literature were reviewed because IE has not sufficiently addressed the organisational factors having an influence on IS networking, and these fields can inform it on these factors. Existing IS network projects were also reviewed to assess past experience with these organisational factors.

To answer the first research question, the author also analysed the main factors influencing companies' decision to engage in IS networking. The main outlined factors are institutional pressure, access to critical resources, increased efficiency and costs savings, and interorganisational learning. The three last factors correspond to the objective of gaining competitive advantages through IS networking. However, it appears that the potential of IS networking to provide companies with competitive advantages should not be exaggerated. The main motivation for companies to engage in IS networking remains institutional pressure.

Major organisational factors influencing the outcome of IS networking are identified to be alignment with business reality, environmental awareness and maturity of the actors, existing institutional platforms and linkages, communication and trust, commitment of the actors to the network, coordination and public/private partnerships and the existence or lack of a vision for the network.

IS networking is not fully aligned with business reality. This implies that to be attractive for companies it has to provide them with clear economic benefits. It also needs to provide them with safeguards to protect them from potential risks connected with IS networking.

IS networking requires a sufficient level of environmental awareness and maturity of the actors involved. Indeed, it should not replace proper internal environmental work, but be its continuation.

It is very important for IS networking to fully take into consideration and take advantage of the pre-existing institutional platforms and linkages. These platforms and linkages allow for a high degree of trust, mental proximity and communication, which are also essential factors for IS networking. These factors notably allow for reduced transaction costs and improved information sharing.

Possibly the most important factor in IS networking is the fact of having highly committed actors. Indeed, IS networking is an evolutionary process that takes time. It is thus vital to ensure a sustained strong commitment of the actors of a network.

Especially when the pre-existing institutional platforms and linkages are weak or inexistent, an important factor is the coordination of IS networks. IS networks require a committed, credible and skilled coordination body. This coordination body can help providing the right set of organisational factors by facilitating communication and face-to-face contacts between the members of a network. It can also reduce transaction costs by centralising information in the network and by helping to identify potential synergies.

Finally, IS networking usually implies public/private partnerships. Local/regional public bodies can provide IS networks with valuable, notably financial, support, and have themselves an interest in the development of IS networking. They can also play an important role, in, together with private actors, defining a vision for IS networks, including environmental objectives. Agreeing on the final objectives of IS networking allows for more consistent measures to be taken on the short-term.

The IS project in Landskrona, Sweden, was launched in May 2003 as a Swedish pilot project, with the support of the Swedish Business Development Agency (NUTEK). As of July 2003, the project involved 19 companies and the Municipality of Landskrona, through its Technical Department, its Environmental Department and its Office for Trade and Industry. The author was involved in the actual coordination of the project.

There are clear potential areas for synergies in Landskrona. The main ones are the exchange of heat, notably involving the District Heating (DH) system of the Municipality of Landskrona, the development and exchange of alternative fuels, the exchange of chemicals and water. Other major areas are transportation and logistics and common purchasing. Also regarding the exchange of more intangible resources there appear to be clear opportunities.

The factors outlined by the literature review were tested in the context of the Landskrona project, notably in order to outline factors that appear to be specific to a Swedish context. Observations in Landskrona confirm the importance of the factors described above.

More specific for Landskrona and possibly for Sweden is the perceived need by companies for increased local networking in general. This will of companies to increase contacts with the local environment appears to be favourable to the development of IS networking.

Besides the fact that the coordination body plays a central role in providing the right set of organisational factors into place, this thesis has a number of other implications. As institutional pressure remains a central factor motivating companies' decision to engage in IS networking, regulation and policy should be designed to encourage more directly companies to engage in IS networking. Furthermore, as IS networking requires a high degree of environmental maturity, in many instances, the priority remains to raise environmental awareness and encourage sound internal environmental work.

Regarding the IS project in Landskrona, a number of recommendations are made for the future development of the project. There is a need to better define the role of the public bodies involved in the project, and to involve more the whole Municipality of Landskrona into the project. The coordination body should also strive at making as quickly as possible the actors of the network become autonomous in working with the network.

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1. Introduction

This thesis analyses organisational factors influencing the formation and the outcome of Industrial Symbiosis (IS) networks. It is based on an IS project in the Municipality of Landskrona[1], Sweden, initiated by the International Institute for Industrial Environmental Economics (IIIEE) at Lund University.

1.1 Background

Industries increasingly try to address environmental aspects of their operations. The focus has first been on internal production processes, but the scope of action has gradually been expanded to other activities of a company. Growing efforts have also been made to address environmental aspects connected to the produced products, or provided services, throughout their life cycle, i.e. also beyond the gates of the company. Significant improvements have thus been achieved, with the spreading of tools such as Environmental Management Systems (EMS) and Life Cycle Analyses (LCA). These improvements have to a great extent been made possible through the gradual acknowledgement by company managers that improvements of a company's environmental performance do not exclusively and necessarily imply costs, but may actually also lead to savings and, in time, increased revenues.

However, these improvements have traditionally been approached from an almost exclusively internal perspective, focusing on a company's own activities and products, in isolation from its immediate environment. Moving to the next level of environmental performance may require going also to the next level of organisational configuration by examining interorganisational issues. In terms of improving their business performance, companies already have identified and made use of the potentials located at the interorganisational interfaces, for example by building strategic partnerships and creating alliances around core competencies (Cohen-Rosenthal, 2000).

The exploration of potentials for further improvements of companies' environmental performance through the analysis of their interactions with their environment, i.e. other companies and the local community, has given birth to a concept and discipline of its own: Industrial Ecology (IE). One of the aims of IE is to develop industrial ecosystems that exhibit cyclical resource-use patterns analogous to those observed in mature biological systems (Connelly & Koshland, 2001).

One way of achieving this objective is through Industrial Symbiosis (IS) networking, which is a local/regional application of IE and can be seen as a special or hybrid type of industrial network. It is based on the exchange of materials, energy and other resources, resulting both in economic benefits for the actors involved and in an improvement of their overall environmental performance. "The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity." (Chertow, 2000).

[1] See Appendix 4 for a list of the companies involved in the project.

1.2 Research problem

Although IE and IS are still emerging disciplines, much research has been done on the technical possibilities for increased resource-use efficiency. This research has focused on material and energy flows, and there appear to be clear opportunities for overall improvements in the environmental performance of involved industries. However, the number of operational IS networks is rather limited. This may to some extent be due to the lack of awareness of company managers on the benefits connected with IS. However, deeper reasons may be that IS networking is not sufficiently aligned with the business reality of private companies and that the organisational factors influencing the outcome of IS networking have not been fully understood and taken into consideration. Indeed, IS, as IE, appears fundamentally to be a social and organisational construct, and an intervention at the organisational and social level (Cohen-Rosenthal, 2000).

Even when there is clear potential for improvement through IS, and material or energy exchanges are clearly feasible technically, IS projects may fail because of the unwillingness or incapacity of the involved companies to collaborate effectively. This incapacity is often due to "softer" issues related to management, strategy, and business constraints. Indeed, as IS initiatives cross company boundaries, they necessitate the coordination of the activities of several economic actors, which traditionally do not collaborate with each other (Boons & Baas, 1997). Thus, for example, the relationship formation that is implied by IS networking, may lead to a loss of decision-making latitude and discretion, a consequence for which company managers traditionally have a particular aversion, as it may lead to a loss of autonomy and control over their own operations, and consequently a loss of operational flexibility.

Thus, there is a need to further explore organisational dynamics among networking companies, by approaching IS from an organisational and a strategic management point of view.

1.3 Objectives and research questions

The main objective of this thesis is to make a contribution to the field of Industrial Ecology in terms of facilitating the development of IS networks, by describing and analysing the initial phase of an action research project on IS networking involving 19 private companies and 3 public bodies in Landskrona, Sweden. The second objective is to directly contribute to this project by providing insights about the perceptions of the involved companies of the project and recommendations on future developments. This may contribute to providing an understanding of the specific requirements of IS developments in a Swedish context.

The two main research questions for this thesis are the following:

- ***What are the organisational factors that have major influence on the development and operation of Industrial Symbiosis networks?***
- ***How can the coordination bodies help provide the right set of organisational factors to facilitate networking?***

Additional subsidiary research questions have been identified in order to establish a flow of logic to answer the two main research questions:

1. What major factors influence companies' decisions to participate in IS networks, and how?

2. What conditions have to be fulfilled to ensure and maintain the active participation of private companies in IS networks?

3. How can coordination agents help provide such conditions?

4. What is the situation in Landskrona, and how could it be improved?

5. What are the conditions that are specific to IS networking in a Swedish context?

1.4 Methodology

From a methodology perspective, the analysis of the initial phase of the development of the IS project in Landskrona allows this research to make an original contribution to research on IS, in the sense that the literature on IS seldom analyses projects at such an early stage. Most studies of projects are made after their completion, making it more difficult to analyse the initial motivations of companies for joining IS projects as well as their perception of IS and their expectations from such projects.

This research is based on a post-positivistic approach and constitutes an action research. Action research is a process by which change and understanding can be pursued at the same time (Dick, 2003). The action research methodology was deemed an appropriate approach for this research because participant observation seemed the best way of gathering data, given the early stages of both the academic literature and practice on IS networking. It was deemed important that the theory be applied to an existing IS project, in order to ensure that the ideas are practical and rooted in reality.

There are no universal laws governing cause and effect in IS and no two projects are identical. It appears to be more than anything else the people involved who make IS networking happen and the way they do it is complex and, again, not governed by universal laws. Although there is some sense of direction, the final end of IS projects is usually not well defined, and the actors of IS need guidance for the steps they should take. Thus when doing research on IS, it may be desirable to be part of the process in order to be able to understand it and reflect on it. The factors described above also motivate the choice that was made of using qualitative rather than quantitative data.

This research directly participates to reaching the core objective of the project in Landskrona, which is to apply the concept of IS to a Swedish case. The author has been involved in the actual development of the IS project, notably through the series of interviews that have contributed to furthering the reflection of both the project team of the IIIEE and of the companies themselves on potential synergies and on required adjustments in the organisation of the network. Thus, this research does contribute to guiding the future evolution of the studied case.

Two main levels of research were utilised to answer the research questions of this thesis. The first level of research consisted mostly in desktop research and interviews with experts, and can be broken down in two sub-levels. First, a literature review was made of the fields of IE, strategic management, organisational theory, and networking and cluster theory, in order to establish a conceptual base for the work. This allowed outlining relevant organisational

factors, notably by adapting factors described in management literature to IS networking. This literature review was thus not a mere review but already included an element of analysis regarding what factors are relevant and how they do apply to IS networking. Secondly, existing IS network projects were reviewed to assess past experience with the organisational factors of networking.

The second level of research consisted in analysing the specific case of the IS project in Landskrona, through direct field observations, interviews, document analysis and group interactions. This allowed outlining common elements with previous projects, confirming factors outlined by literature and highlighting factors present in Landskrona but that have not been described by literature or in previous projects, being thus specific either to Landskrona or to the Swedish context.

Regarding the literature review, although IE literature has partially addressed organisational issues, it was deemed useful to also review the bodies of literature mentioned above. These bodies of literature have not all been applied in a systematic way to the environmental field, and they may provide the fields of IE and IS with useful inputs on organisational factors. However, given the high number of relevant fields, this literature review is clearly not extensive.

In order to assess lessons from existing IS network projects on the organisational factors of networking, besides a review of the literature describing these projects, interviews were made with two practitioners of IS (see Appendix 1). One of them, after a one-month long study visit to North America, has been making an assessment of North American experiences of IS networking. North America has in the last decade experienced the largest number of IS projects. The purpose of this interview was mainly to obtain an updated picture of these North American cases that are often referred to by the IE literature. Indeed, in practice these cases appear as not being always as successful as depicted in the literature.

The second IS practitioner has been working for several years as a project manager at the Industrial Symbiosis Centre in Kalundborg (Denmark). As with the other IS practitioner, the main purpose of this interview was to receive an up-to-date picture of the IS network in Kalundborg, which is generally considered as the most successful and mature case of IS networking. Furthermore, this interview also provided useful feedback on the organisational factors influencing the outcome of IS networking.

For the specific analysis of the IS project in Landskrona, general information on the companies involved in the project and more specific information on their environmental performance and work were collected. For 8 of the companies, initial reviews and more thorough Strategic Environmental Management reports written by students of the Master's Programme of the IIIEE were available. Additional information was provided by the webpages of the companies and through interviews.

Semi-structured interviews were conducted with all 20 involved companies[2] (see Appendix 1 for a list of interviewees). A set of questions was established to ensure that all main issues were covered during the interviews. This set of indicative questions, which was elaborated in an iterative process of successive reviewing between the author and his supervisors, is presented in Appendix 2. It focused on the motivations of the companies for joining the

[2] See Appendix 4 for a list of the involved companies.

project, on the degree of interaction with other companies before the project, on potential areas for collaboration and on limitations and barriers to collaboration.

This choice of semi-structured interviews can be motivated by the varying initial knowledge the author had of the activities of the companies, by the differing degree of advancement of each company in the exploration of potential collaboration areas as well as by the diverse nature of the companies involved in the project. This motivates also the use of qualitative rather than quantitative data. The choice of semi-structured interviews also allowed making the interviews more dynamic. Interviewees were the persons in charge of the IS project within the companies. In 8 cases this was the company's Managing Director (MD). In the 12 other cases this person was the company's production, technical, safety, quality or environmental (in 4 cases) manager or a combination of these, the company's MD being also present in 3 of these 12 cases (see Appendix 1). Interviews lasted on average 90 minutes.

Interviews were also made with the other actors of the network, namely the Environmental Department (*Miljöförvaltning*) and the Office for Trade and Industry (*Utvecklingsstiftelsen*) of the Municipality of Landskrona. The purpose of these interviews was mainly to develop an understanding respectively of the role these actors could play and of the role they were willing to play in the IS network. These interviews also served the purpose of developing a picture of the economic and environmental background and history of Landskrona, and helped putting into perspective the statements of the companies involved in the project.

The findings of the interviews of the actors involved in the project were compiled and classified into categories that corresponded to the main research fields of the literature review. This allowed to compare and contrast the motivations of companies for joining IS networks and the organisational factors influencing the outcome of IS networking extracted from the literature with the motivations and factors observed in the specific case of Landskrona.

1.5 Scope and limitations

This thesis focuses primarily on the IS project started in May 2003 in Landskrona (Sweden). The geographical boundary of the study thus corresponds to the Municipality of Landskrona. Although the findings of the study may be applicable to other regions of the world, as it is the case for any IS network, the project in Landskrona has very specific characteristics, even in a Swedish context.

The second main limitation is the fact that the project is still in its initial phase, the involved companies having had only a limited number of formal meetings within the framework of the project. Therefore, potential areas for collaboration may not yet have been uncovered and explored, while the technical and economic feasibility of those already discussed have not been fully assessed. This makes it also more difficult to analyse organisational and managerial issues, as the interviewed company managers could not refer to past experiences but had to reflect on issues they may be confronted with. Thus it is unclear to what extent they would in a given situation actually act as they claimed they would during interviews.

Another limitation is the fact that this study analyses the motivations of companies for engaging in IS networking mostly by analysing the motivations of companies who have decided to engage in IS networking. To study factors influencing the decision of companies to join IS networks, it would have been useful to also analyse the reasons why approached companies refused to join the project.

Regarding the literature review on networking and Interorganisational Relationships (IR), a limitation is the fact that the majority of this literature is based on networking around the main products and the core competencies of the involved companies. Indeed, IS networking is fundamentally different from these types of network, in the sense that it focuses on the exchange of by-products and wastes. Thus there are intrinsic limitations to the extent to which findings from the networking and IR literature can be directly transferred and applied to IS networking.

Finally, it should be noted that the main focus of this research is on IS networking between companies. It analyses organisational factors mainly from a company perspective. Thus, issues such as the role of public bodies, the integration of IS networking into the agenda and policies of these public bodies and the involvement of the community into IS networking, although very important, are not studied in depth. The role of public bodies is mainly seen from a project facilitation perspective, although the role and interest of public bodies in IS networking could and should go far beyond such a mere facilitation role.

1.6 Outline of the thesis

The structure of this thesis is divided into 5 main sections. Section 1 is the introduction to the thesis. It introduces the research, presenting its background, the research problem and main research questions, the methodology as well as the scope and limitations of the research. The methodological approach of this thesis is action research. Section 1 discusses the justification for using this methodology, as well as the type of data collected and the phases of the research. Thus, it introduces the logic used to answer the research questions of this thesis.

Section 2 consists of a literature review. The fields of IE, strategic management, organisational theory, and networking and cluster theory are reviewed in order to establish a conceptual base for the work. The purpose is to outline the main organisational factors that influence the development of IS networking and the operations within IS networks. This literature review also reviews existing IS network projects to assess past experience with these organisational factors.

Section 3 consists of an introduction to the IS project in Landskrona and describes the main features of the project and already discovered potential areas of collaboration. Section 4 consists of the analysis and interpretation of the main organisational factors observed in Landskrona. These factors are compared with the ones outlined in section 2. The purpose is to test these factors, and outline factors that appear to be specific to Landskrona and to a Swedish context.

Section 5 consists of the conclusions of the research. The main research questions are answered and the implications of the research for practice and theory are discussed. This section also presents suggestions for further research and recommendations for future developments in the IS project in Landskrona.

2. Industrial Symbiosis (IS) and Interorganisational Relationships (IR) – A literature review

This section consists of a literature review and has three main objectives. The first objective is to define Industrial Symbiosis (IS) networking. The second objective is to analyse the main factors that may influence the decision of private companies to engage in IS networking. Finally, the third objective is to analyse factors that may influence the outcome of IS networking.

As discussed in section 1.4 above on methodology, a literature review on how companies approach IS networking and on the organisational factors influencing the outcome of IS networking should not be limited to a review of the literature on IS or Industrial Ecology (IE). Indeed, although IE literature has partially addressed organisational aspects of IS, it does notably not sufficiently address why companies do or do not engage in IS networking.

Management and organisational theories such as the resource dependence theory, transaction costs economics, and network and cluster theories on the other hand deal with Interorganisational Relationships (IR), which IS literally is, and can inform IS on crucial areas. Therefore, relevant literature on IRs and on networking has also been reviewed in order to reach the three objectives described above.

2.1 Defining Industrial Symbiosis Networking

Before analysing organisational factors influencing the outcome of IS networks, it is important to define what is meant by IS networking. This is done in three steps. First, the concept of IE is discussed, as IS can be considered as a local/regional application of it. Secondly, the concept of IS is described. Finally, as the term "IS networking" indicates, IS builds on a specific type of networking. Therefore, general features of networks, together with more specific characteristics of IS networks are analysed, in order to provide an understanding of what IS networking implies.

2.1.1 Industrial Ecology

The concept of Industrial Ecology (IE) became popular in the late 1980s with the article by Frosch and Gallopoulos, "Strategies for Manufacturing" (1989), in which the authors present the concept of an "industrial ecosystem". Robert Ayres (1989) has developed a similar concept under the appellation "industrial metabolism". An industrial ecosystem is the transformation of the traditional model of industrial activity, in which individual manufacturers take in raw materials and generate products to be sold, plus waste to be disposed of, into a more integrated system in which the consumption of energy and materials is optimised and the effluents of one process serve as the raw material for another process (Frosch & Gallopoulos, 1989). Thus, developing such industrial ecosystems that exhibit cyclical resource-use patterns analogous to those observed in mature biological systems (Connelly & Koshland, 2001), where most essential nutrients are fully recycled driven solely by energy from the sun (Korhonen, Wihersaari, Savolainen, 1999) is among IE's objectives.

Despite its value, this analogy between industrial and natural ecosystems has been criticised and certainly has limitations. Indeed, an important difference between a biological and an industrial ecosystem is the fact that in nature, evolution towards greater efficiency is a

spontaneous process, while it needs intentional action in an industrial ecosystem. In other words, achieving IE objectives requires the management of the relations between the organisations involved (Boons & Baas, 1997). Thus, IE can be defined as an interorganisational phenomenon (Boons & Baas, 1997), and a central aspect of it are connections: not only materials and energy connections, but also organisational and human connections (Cohen-Rosenthal, 2000).

The overarching objective of IE is to achieve sustainable production and consumption patterns, and thus, ultimately, sustainable development. As of 1992, according to Holmberg and Sandbrook (1992), 70 definitions of sustainable development were current. However, a commonly accepted definition of sustainable development is the one developed in 1987 by the Brundtland Report *Our Common Future*[3] (WCED, 1987, p.43) with its economic, social and environmental dimensions. Besides this definition, a vision of sustainability that reaches growing consensus is the framework supplied by The Natural Step (TNS). This framework sets the following four "system conditions for sustainability" (Holmberg, Robèrt, Eriksson, 1996; Robèrt, Daly, Hawken & Holmberg, 1997; Robèrt, 2000):

- Substances from the earth's crust must not systematically increase in the ecosphere.
- Substances produced by society must not systematically increase in the ecosphere.
- The physical basis for the productivity and diversity of Nature must not be systematically deteriorated.
- Resources must be used efficiently and fairly with respect to meeting human needs.

Within the TNS framework, an important condition on the way towards sustainability is that no intermediary step blocks further evolution towards the final objectives. Besides these general objectives, according to O'Rourke, Connelly and Koshland (1996) the main operational objectives of IE can be summarised as follows:

- Increased resource efficiency;
- Reduced emissions and waste;
- Closing of material cycles;
- Increased use of renewable materials and energy; and
- Dematerialisation.

The concrete application of IE has taken two main paths: a product and/or material-based systems perspective; and a geographically defined local/regional industrial ecosystem approach (Korhonen, 2002).

2.1.2 Industrial Symbiosis

The concept of Industrial Symbiosis (IS) can be seen as a geographical, local/regional application of IE. As IE, IS is based on a biological analogy. The term "symbiosis" refers to the biological term designating relationships in nature, in which at least two otherwise unrelated species exchange materials, energy, or information in a mutually beneficial manner,

[3] Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

thus taking advantage of synergies[4]. More specifically, IS refers to a type of symbiosis known as mutualism (Miller, 2002, p.187). Marian Chertow, in her taxonomy of IS (Chertow, 2000, p.313), has defined the concept of IS in the following way:

> *"Industrial symbiosis, as part of the emerging field of industrial ecology, demands resolute attention to the flow of materials and energy through local and regional economies. Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity."*

The two main dimensions of IS are economic benefits for the actors involved and an improvement of their overall environmental performance. As an attempt to achieve the operational objectives of IE at a local/regional level, the final objective of IS can be considered to be the achievement of a sustainable local community. Thus, although IS primarily focuses on linking industries, it can and should also involve the local community, for example by integrating municipalities into the symbiotic exchanges (Burström & Korhonen, 2000). IS may thus also aim at contributing to regional self-sufficiency. These dimensions of IS, although very important, are however not studied in further detail in this thesis.

As seen in the definition by Chertow quoted above, the main focus of IS is, traditionally, the exchange of tangible resources such as materials and energy. This may be due to the fact that industries collaborate more naturally around such resources. However, IS should not be limited to the exchange of tangible resources. More intangible resources, such as knowledge, managerial and human resources, can also be exchanged, in what can be called "soft symbiosis" (Brings Jacobsen, 2003). Just as for tangible resources, actors can split costs and share benefits. "Soft symbiosis" may especially be considered once all "low-hanging fruits" in terms of the exchange of tangible resources have been picked.

The concept of IS was made popular through numerous studies, notably by Ehrenfeld and Gertler (1997), of the case of the city and industrial district of Kalundborg in Denmark, where IS developments started in the 1960s. Desrochers (2000) has shown that cycling of by-products has occurred throughout human history. However, Kalundborg is often considered as the first comprehensive IS network that developed through a conscious and concerted involvement of its members.

Several different terms that imply similar systems are used in the literature and in various existing projects to designate concepts very similar to IS. Especially in North America, practitioners and scholars refer to Eco-Industrial Development (EID), as "the application of industrial ecology principles to industrial development and regional economic development" (Friend, 2002, p.8).

EID has two main applications: Eco-Industrial Parks (EIP) and Eco-Industrial Networks (EIN). The main difference between EIPs and EINs is that EIPs are concentrated to industrial parks or industrial estates, while in EINs, the actors of the network are spread over a larger area, a municipality or a region. Thus, in EIPs there is a much higher degree of geographic proximity, and, most of the time, some sort of coordination of the tenants. On the other hand, EINs are considered to provide increased possibilities for synergies, as they allow for a greater diversity of actors. Regarding EIPs, a distinction should be made between

[4] Interactions of discrete agencies (as industrial firms), agents (as drugs), or conditions such that the total effect is greater than the sum of the individual effects (Synergy or synergism, EB Online, 2003).

EIPs that build upon an existing industrial park or industrial estate, thus with existing companies, and EIPs that are designed and developed "from scratch".

Despite such differences, IS can be considered to capture all these concepts and applications of IE. The main distinction appears to be in terms of the geographical scope of the linkages. This makes the findings and experiences from the literature on these other concepts applicable to IS. Chertow has outlined five types of what she calls "eco-industrial park models" (Chertow, 2000), that actually can be considered as corresponding to different types of IS. These take place:

- through waste exchanges (Type 1);
- within a facility, firm (Type 2);
- among firms collocated in a defined eco-industrial park (Type 3);
- among local firms that are not collocated (Type 4); and
- among firms organised "virtually" across a broader region (Type 5).

The focus of this research is mainly on type 4, as it is closest to the type of network under development in Landskrona (see section 3.1).

2.1.3 Networking

The essence of IS is that it is based on developing functional linkages among industrial activities. Thus, IS fundamentally is a type of network, consisting mainly of private companies, and IS networks can be seen as a special, or hybrid type of industrial network. Networks themselves, on the other hand, can be seen as a specific type of Interorganisational Relationship (IR). IRs are "the relatively enduring transactions, flows, and linkages that occur among or between an organisation and one or more organisations in its environment" (Oliver, 1990)[5]. An IR is regarded as an alternative to a market or an organisational hierarchy (Barringer & Harrison, 2000). IRs can notably help companies create value by combining resources, and sharing knowledge (Barringer & Harrison, 2000), two central aspects of IS networking.

Other authors refer to Inter-Firm Collaboration (IFC). Gertler (1995) outlines four broad categories of IFC, which vary in terms of their levels of trust and interdependence:

- informal and unorganised cooperation among two or more firms around a very specific problem;
- formal and organised cooperation among several firms within a membership-based organisation, with very limited inter-dependence, and where the primary unifying factor may be geography, sector, or end markets;
- formal and organised cooperation (but not necessarily "legally defined") among a smaller set of firms, with some significant degree of interdependence, and with quite specific shared interests; and
- value-adding partnerships between customers and groups of suppliers working on better meeting customer needs.

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[5] The main types of IR outlined in the IR literature are joint ventures, networks, consortia, alliances, trade associations, and interlocking directorates (Barringer & Harrison, 2000). Although IS networking can be seen as a type of IR, it does not fully correspond to any of these types of IR.

Networks correspond mainly to the third category. Networks can be defined as constellations of companies that organise through the establishment of social, rather than legally binding, contracts (Barringer & Harrison, 2000). There is a qualitative difference in network versus transactional relationships such as traditional customer-supplier relations (Powell, 1990). Networks are an organisational phenomenon by which distinct companies interact in collaborative ways in order to solve problems or achieve results they could not achieve by acting individually (Gertler, 1995). This corresponds to the concept of synergy, which is, as seen in section 2.1.2, a central element of IS. The fundamental objective of such networks is usually to increase the competitiveness of the involved companies. Geographic concentration is a prevailing characteristic of networking, but networks may also be developed by non-collocated companies (Gertler, 1995). Networks usually imply a rather high degree of information sharing and exchange between the actors involved, as compared with traditional transactional relationships.

Chisholm (1998, p.6; as cited in Cohen-Rosenthal, 2000, p.256) has outlined four network principles:

> *"First, interorganizational networks operate largely as abstract conceptual systems that enable members to perceive and understand in new ways. Developing shared understanding makes it possible for members to create ways of organizing to deal with these complex problems.*
>
> *Second, networks differ from mere interorganizational relationships: Networks improve the ability of organizations to deal with ill-defined, complex problems or issues that individual members cannot handle alone. Network activity is oriented to the shared vision, purpose, and goals that bind members together...*
>
> *Third, loose coupling of members is another feature of these systems: Members represent diverse organizations that are physically dispersed and meet to conduct activities required to carry out the higher-level system purpose....*
>
> *Fourth, network organizations are self-regulating: Members, not a centralized source of power, are responsible for developing a vision, mission and goals and for initiating and managing work activities. Members share their understanding of issues and devise ways to relate to each other in carrying out the work necessary to bring about a shared vision of the future."*

Gertler (1995) distinguishes four different types of networks:

- co-production networks of firms where firms cooperate in manufacturing components, assemblies, or finished goods;
- co-marketing networks of firms that jointly market their products in ways that give them access to and power in high value markets;
- learning networks of firms who collectively seek to learn about and manage complex issues related to competitiveness;
- resource networks of firms who pool or share resources in developing a joint solution to a common problem, such as waste management.

IS networks mainly fall into the two last categories. They can to some extent be seen as a hybrid of conventional network structures that includes rather strictly defined IRs. Indeed, IS networking implies a considerable number of collaborations involving physical structures/entities, which need to be governed under more formal contracts (see section 2.3.1.4 below). Besides traditional business networks such as co-production networks, types of networks that appear to be more similar to IS networks are industrial, or so-called flexible manufacturing networks as first described in Piore and Sabel's "The Second Industrial Divide" (1984) and clusters, as defined by Porter (1998). Elements from the literature on these networks and clusters may thus also apply to IS networking and are therefore used in the analysis of IS networking throughout section 2.

An important difference between these networks and IS networks appears to be the fact that these other types of networks usually connect businesses active within the same sector, while IS networks usually try to build upon a variety of different sectors and activities. Indeed, the idea is that, as within a biological ecosystem, a high level of diversity increases the possibilities of symbiotic linkages. Another major difference between IS networks and other types of networks is the fact that other types of networks are based on the main products and the core competencies of the involved companies. IS networks on the other hand usually focus on the exchange of by-products and wastes, which are seldom major elements in corporate agendas. As mentioned in section 1.5 above, this fundamental difference may limit somewhat the transferability of the findings from other types of networks to IS networking.

2.2 Factors influencing companies' decision to engage in Industrial Symbiosis Networking

As seen in section 2.1.3, IS networking can be seen as a specific type of Interorganisational Relationship (IR). This section reviews primarily strategic management and IR literature in order to understand what factors may influence private companies' decision to engage in IS networking. Indeed, these bodies of literature have analysed what factors motivate companies' choice to engage in collaborations with each other.

The literature on IRs is rather fragmented. Its review focuses mainly on two papers, one by Oliver (1990) and one by Barringer and Harrison (2000). This is motivated by the fact that in these two papers, the authors have tried to collect and integrate this fragmented IR literature.

According to Oliver (1990), it can be assumed that companies consciously enter into relations with other companies for specific reasons within the constraints of a variety of conditions that limit or influence their choices. There appear to be two main reasons for companies to engage in IS networking. The first reason is external institutional pressure (section 2.2.1). The factors analysed in sections 2.2.2, 2.2.3 and 2.2.4 correspond more to the second reason, which is of more internal nature. This second reason is the attempt by companies to obtain competitive advantages through IS networking, and corresponds to a strategic choice perspective (Barringer, Harrison, 2000).

Although each of the factors described in the sections below may be a separate and sufficient cause for companies to engage in IS networking, the decision by companies to engage in IS networking is most probably a combination of all these factors. The respective importance of these various factors may also vary in time, notably according to the evolution of the network.

2.2.1 Institutional pressure

An important factor that may influence the decision of companies to engage in IS networking is related to institutional pressures. Institutional theory suggests that institutional environments impose pressures on companies to appear legitimate and conform to prevailing social norms (DiMaggio & Powell, 1983). Following Oliver's (1990) determinants of IRs, institutional pressure may have two dimensions: necessity and legitimacy.

According to the necessity determinant, a company may establish linkages or exchanges with other organisations in order to meet necessary legal or regulatory requirements. In this sense,

mandates from higher authorities, such as government agencies, may provide the impetus for IRs that otherwise might not have occurred voluntarily (Oliver, 1990).

In IS networking, institutional pressure materialises mainly through environmental regulation. Environmental regulation has been the clear driver for the development of symbiotic exchanges in Kalundborg (Ehrenfeld & Gertler, 1997; Brings Jacobsen, 2003). In the absence of ever-stricter environmental regulation, companies could and probably would have acted completely differently. Thus, for example, gypsum exists as a by-product of coal power plants only because environmental regulation requires desulphurisation of the flue gases of coal power plants. Once there is a by-product, companies look for the most efficient way to dispose of it (Brings Jacobsen, 2003) notably by engaging in Inter-Firm Collaboration (IFC).

Fundamentally, environmental regulation still provides a major drive for companies to improve their environmental performance. While doing so, it may also be the cause of considering interorganisational performance improvement potentials. IS networking may thus require appropriate legislation to become attractive for private companies. Examples of such legislation are regulations on landfill tax, or on differentiated taxes for different energy carriers.

IS networking can, as discussed in section 2.3.2 below, be seen as a more complex type of environmental management and as the continuation of internal environmental work (Sinding, 2000; Brings Jacobsen, 2003). Sinding (2000) underlines that in general, companies engage in voluntary activities because they perceive a more or less well defined threat of less appealing alternative forms of regulation. Thus, they act in order to pre-empt such regulation.

Legitimacy refers to a more general need by companies to justify their activities or outputs. Here, the institutional environment of companies can be broadened to the concept of stakeholders and even to society as a whole, companies trying to preserve their "license to operate". Thus, a company's decision to engage in IS networking may be due to its will to demonstrate or improve its reputation, image, prestige, or compliance with prevailing norms in its institutional environment, as has been shown to be the case for IRs in general (Oliver, 1990).

A small firm can increase its visibility through partnerships with larger, better-established companies. Furthermore, IS networking can be seen as an evidence of the will of companies both to be more open towards the local community and to reduce their environmental burden. Companies are more likely to engage in IRs as a consequence of such considerations in a context of explicit institutional and public criticism (Oliver, 1990). This appears to also apply for IS networking.

One strategy for companies to comply with existing explicit/implicit norms is to imitate or mimic other industries. This idea corresponds to the concept of mimetic isomorphism (Sinding, 2002). Thus, in the case of IS networking, a company may decide to join a network because neighbouring companies have already done so.

Finally, as discussed in section 2.3.6.2 below, local/regional (and national) public bodies may assist in putting the right institutional pressures into place and thus favour the development of IS networking. This is especially the case if these bodies are themselves involved in or are the initiators of IS networks.

2.2.2 Access to critical resources

The second main reason that may motivate companies to engage in IS networking is to gain competitive advantages in this way. By definition, firms must do something specialised or unique to develop a competitive advantage (Dyer & Singh, 1998). Scholars have taken different perspectives to explain how companies may develop competitive advantages. One of these is the so-called resource-based view (RBV) of the company, which places the main focus on the resources that are within the company to explain sources of competitive advantages (Barney, 1991).

However, both the resource dependency theory (Pfeffer & Salancik 1978) and the relational view of the firm (Dyer & Singh 1998) indicate that a company's critical resources may extend beyond firm boundaries. According to the resource dependency theory "organisations must engage in exchanges with their environment to obtain resources" (Barringer & Harrison, 2000). The need to acquire these resources thus creates dependencies between companies and other organisations.

To manage these dependencies, companies may try to acquire control over critical resources in an effort to decrease their dependence on other organisations. Companies may for example form IRs to gain access to resources such as capital, employees with specialized skills, intimate knowledge of a market, or a modern production facility (Barringer & Harrison, 2000). Regarding IS networking, resource dependence poses two questions: what kind of resources may companies want to gain access to as part of an IS network, and how critical are the resources that are exchanged in IS networks for the involved companies?

So far, the main focus of IS networking has usually been on wastes and by-products. Often, rather than trying to gain access to a critical resource, companies may engage in IS networking in order to find an output for a waste or by-product. Traditionally, this is not seen as an element of the core business of companies (Brings Jacobsen, 2003). Thus, the resources IS networking currently focuses upon are usually not perceived as critical resources. In this sense, resource dependence could actually indicate that companies are not sufficiently interested in IS networking.

However, companies can have an interest in collaborating on "non-core business" activities, as this may constitute an efficient alternative to the outsourcing of these activities. This was documented to be the case in the INES project[6] in the Netherlands (Boons & Baas, 1997). Furthermore, although by-products are often not seen as critical resources, companies seem to increasingly acknowledge that more attention should be given to these flows.

More importantly, it appears that IS networking may very well provide companies with critical resources and that by-products can be such critical resources. Thus, in the case of Kalundborg, the gypsum provided by the coal power plant can be seen as a critical resource for the company manufacturing plasterboard (Brings Jacobsen, 2003). It appears that by-products may be more likely to be critical resources for their buyer than for their seller.

However, even for the seller, for example in the case of waste heat produced by a power plant, this by-product can become a valuable resource if there are customers willing to buy it. Thus, Dye and Singh (1998) indicate that a company's ability to generate rents from its

[6] See appendix 3 for a description of this project.

resources may require that these resources be utilised in conjunction with the complementary resources of another company. In the case of heat, for example, this heat is only a valuable resource if there is a local need for it and a customer willing to pay for it. Thus, companies who combine resources in unique ways, notably through IS networking, may realise an advantage over competing companies who are unable or unwilling to do so.

Dyer and Singh's relational view further indicates that critical resources may be embedded in inter-firm routines and processes. They outline relation-specific assets as potential sources of interorganisational competitive advantages (Dyer & Singh, 1998). They refer to Williamson (1985), who has defined the following three types of asset specificity: site specificity, physical specificity, and human asset specificity. Site specificity refers to the situation whereby successive production stages that are immobile in nature are located close to one another. Physical asset specificity refers to transaction-specific capital investments that tailor processes to particular exchange partners. Human asset specificity refers to transaction-specific know-how accumulated by transactors through long-standing relationships.

IS networking thus may clearly imply site-specificity, notably making it possible to reduce transportation and coordination costs. IS networking appears to also imply human-specific assets, as the members of the network develop experience in working together and accumulate specialised information, language and know-how. This allows them to communicate efficiently and effectively, which reduces communication errors (Dyer & Singh, 1998). These advantages only materialise if companies are aware of their options and sufficiently willing to make relation/transaction-specific investments. This underlines the importance of commitment of the companies to the network, as discussed in section 2.3.5 below.

Thus, companies may decide to engage in IS networking either because someone in the region has a resource that is critical for the company, or because certain assets can only become a resource if considered in reference to other local/regional activities. Although these resources are seldom core resources, they can clearly add value to the companies engaging in networking.

2.2.3 Costs savings and efficiency

Besides the access to critical resources, another way companies may try to achieve a competitive advantage by engaging in IS networking, is through the increased efficiency and the resulting saved costs that IS networking may induce.

First, IS networking may imply direct savings for companies in the sense that it may allow them to obtain cheaper prices for their raw materials and inputs. Indeed, wastes and by-products supplied by collaborating companies within an IS network are likely to be cheaper than virgin raw materials. This is also valid for energy, as a company that has waste heat, may be willing to sell it cheaper than the market price priced by conventional energy suppliers.

Besides these direct savings, according to Oliver (1990), the formation of an IR may be prompted by what she calls the efficiency determinant. This corresponds to a company's attempt to improve its internal input/output ratio. Some incentives for establishing IRs for the purposes of improving efficiency may be the company's anticipation of increases in return on assets or reductions in unit costs or waste. IRs can also allow collaborating companies to achieve economies of scales (Powell, 1990).

This efficiency factor appears to be clearly relevant in the case of IS networking. Increased efficiency, in the form of resource-efficiency is indeed at the core of IS. Although this is not systematically the case, increased resource-efficiency may lead to significant financial savings. Such savings are then not only a result of an optimised use of resources, but also of reduced waste management costs.

Efficiency motives for engaging in IS networking may however only prevail if IS networking, from a transaction cost perspective, represents the efficient mid-range solution between organisational hierarchy and the market (Oliver, 1990). Transaction costs economics (TCE) (Williamson, 1985) focuses on how a company should organise its boundary-spanning activities so as to minimise the sum of its production and transaction costs (Barringer & Harrison, 2000).

Transaction cost economisation is regarded among the main factors that determine whether transactions will be carried out within organisations, in intermediate structures (IRs), or in the market. The movement from market-mediated transactions to formal interorganisational arrangements may thus occur as a result of an organisation's attempt to economise on the cost of transactions (Oliver, 1990).

In IS networking, typical transaction costs include regulatory, discovery, contracting and monitoring costs (Ehrenfeld & Gertler, 1997). It is unclear whether companies may choose to engage in IS networking because it allows them to reduce their transaction costs. According to Porter (1998), clusters may contribute to lowering transaction costs, notably through sourcing locally instead of from distant suppliers.

This may also be the case for IS networking. Furthermore, as seen in section 2.2.2 above, the human specific assets that IS networking may help companies develop, may contribute to lowering transaction costs. IS networking allows companies to develop longer-term and closer relationships, and this may also gradually lead to reduced transaction costs.

However, it appears that the transaction costs implied by IS networking may actually be rather significant, and can influence the development of IS networks adversely. As discussed in section 2.3.1.4 below, IS networking may notably require sophisticated contracts. However, in Kalundborg, while some contracts are very sophisticated, others are mere "gentlemen's agreements" (Brings Jacobsen, 2003). This appears to mainly depend on how crucial the resource is. Furthermore, as discussed in section 2.3.4 below, factors such as the development of trust between the partners of a network may contribute to reducing these transaction costs.

In order to be attractive for private companies, it is thus important for IS networks to develop a governance structure that minimises transaction costs (Williamson, 1985). This explains why, as discussed in section 2.3.6 below, IS networks usually involve a facilitation and coordination agent. Indeed, this agent helps companies reduce their transaction costs, notably by identifying possible synergies. Without this external help, because of the high transaction costs, many companies would be much more reluctant to engage in IS networking.

2.2.4 Interorganisational learning

Another factor that may influence companies' decision to engage in IS networking appears to be interorganisational learning. Superior knowledge allows companies to enhance their

competitive position. Companies may thus form IRs to learn from their partners (Barringer & Harrison, 2000). Indeed, it appears that companies often learn by collaborating with other organisations (Powell, Koput, Smith-Doerr, 1996). The acquisition of new technical skills or technological capabilities is actually one of the most widely cited motives by companies for IR formation (Barringer & Harrison, 2000). Knowledge can be divided into two types: information and know-how (Grant, 1996). Know-how is more difficult to transfer than information, but is more likely to result in advantages that are sustainable (Dyer & Singh, 1998).

Interorganisational learning may be a motivation for companies to join IS networking, which, as seen in section 2.1.2 above, does not only imply exchanges of tangible resources, but also intangible issues such as the sharing of experience and knowledge. This will however depend on the willingness of companies to share information and knowledge. Indeed, as discussed in section 2.3.1.2 below, certain companies may be reluctant to share knowledge, because they perceive a risk of disclosing proprietary information.

An important variable that helps determine how much a company can learn through interorganisational relationships is its absorptive capacity. Absorptive capacity corresponds to a company's ability "to recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990). A company's ability to learn is based on prior preparation, which is linked to such things as the quality of the company's employees, its knowledge base, the quality of its management information systems, its organisational culture, and the presence of learning incentives.

Dyer and Singh (1998) refer to partner-specific absorptive capacity to describe the absorptive capacity of partners in a specific relationship. It is a function of the extent to which these partners have developed interaction routines that maximise the frequency and intensity of interactions. It is enhanced as individuals within the partner companies get to know each other well enough to know who knows what and where critical expertise resides within each firm (Dyer & Singh, 1998). This underlines the importance of face-to-face communication and interaction in IS networking, as is discussed in section 2.3.4 below.

Although the acquisition of new knowledge and skills is certainly part of the IS networking "package", according to Brings Jacobsen (2003) interorganisational learning does not appear to be the main driver for IS networking. The main drivers are really regulation and direct economic benefits.

2.2.5 Other factors

Although IS networking may provide companies with competitive advantages, this potential should not be exaggerated. Indeed, fundamentally, by-product exchange makes seldom a major contribution to the economy of companies. The main driver appears thus to be institutional pressure. A number of other factors may however also have an influence on the decision of companies to engage in IS networking.

According to Oliver (1990), environmental uncertainty may prompt companies to engage in IRs in order to achieve more stability and predictability in their relationships. This may allow for more orderly and reliable patterns of resource flows and exchanges (Oliver, 1990). Thus, IS networking may help companies to develop long-term relationships with suppliers and service providers. IS networks may provide increased stability, provided they are not too large and difficult to manage. Furthermore, IRs can allow companies to share the risks and

costs of activities that are beyond the scope of the capabilities of a single company (Powell, 1990). Thus, IS networks may allow companies to share the costs of investments they would not make individually.

Finally, Oliver (1990) outlines two opposed determinants that may influencing the decision of companies to engage in IRs. According to the asymmetry determinant, IRs may be prompted may the potential for a company to exert power or control over another company or its resources (Oliver, 1990). On the other hand, the reciprocity determinant emphasises cooperation, collaboration and coordination among organisations, rather than domination, power and control. Potential partners to an exchange anticipate that the benefits of forming a linkage exceed the disadvantages, particularly the loss of decision-making latitude and the cost of managing the linkage. Both relate to the resource dependency theory, but reciprocity tends to indicate that resource dependence may not necessarily imply a struggle for power and control.

IS networking appears fundamentally to be a reciprocity-based IR, being characterised by balance between the involved companies. Indeed, in theory, the reciprocity determinant comes closest to the definition of IS and mutualism (see section 2.1.2 above) and seems to be the primary motivation for companies for joining IS networks. However, there are certainly also elements of power struggle between the members of an IS network. Thus, for example, as seen in section 2.2.2 above, by-products may be more likely to be critical resources for their buyer than for their seller. This may imply a certain power imbalance between these two actors, the seller possibly taking advantage of this imbalance during transactions. The fact of exerting such power does however not appear as a direct motivation for companies to engage in IS networking.

2.3 Organisational factors influencing the outcome of networking

Companies are often overly optimistic about the benefits of developing IRs, and many IRs fall short of meeting the expectations of their participants or fail for other reasons. Thus, the failure rate for IR is actually rather high (Barringer & Harrison, 2000). This section analyses major organisational that may influence the outcome of IS networking.

2.3.1 Alignment with business reality

Although IS may involve other organisations, such as public bodies, the central actors of any IS network clearly are private companies. Furthermore, although they engage in IS networking, these companies continue competing on traditional markets. Thus, they are confronted with the same constraints and pressures as competitors that operate in more traditional ways. Therefore, a central factor influencing the outcome of IS networking is how well it is aligned with the economic reality businesses are confronted with.

It appears that IS networking is not fully aligned with business reality. First, it does not fully correspond to a traditional way of making business. Second, it brings a number of risk factors along with it. This implies that companies will only join IS networks and maintain their commitment if they perceive clear benefits that outweigh the potential disadvantages of IS networking, and if mechanisms are available that minimise the potential risks connected with IS networking.

2.3.1.1 IS networking: an unconventional way of making business

As seen in sections 2.1.2 and 2.2 above, besides improvements of the overall environmental performance of the involved actors, a central element of IS networking is to provide companies with competitive advantages. From this perspective, IS networking appears to be aligned with the business objectives of private companies. Thus, in 1992, a survey of businesses in Canada indicated that 92% of business people support opportunities to make use of their waste for productive and environmentally acceptable activities, 90% were willing to participate in cooperative waste reduction mechanisms and 90% want more information on efficiency and waste minimisation possibilities (Crawford & Côté, 2002).

Yet, despite this stated interest, it appears that the actual practices of business may get in the way of IS networking, notably through the ruts of established pathways and organisational inertia (Cohen-Rosenthal, 2000), or so called structural inertia (Hannan & Freeman, 1984). According to the concept of structural inertia, organisations are reluctant to change, and thus tend to rely on highly reproducible organisational structures (Sinding, 2000).

As Milton Friedman (1962) has put it: "the business of business is business". Thus, in order to maintain their competitiveness, companies tend to focus on their core competence and critical resources. As discussed in section 2.2.2 above, it is questionable whether waste materials and heat and other by-products are seen by companies as critical resources. IS networking is thus fundamentally different from other types of networks in the sense that it does not address the normal supply-chain and the main products and services of companies, as for example clusters do. It is not core-business but side-business (Brings Jacobsen, 2003).

Furthermore, it appears that in general, companies do not perceive competitive advantage as directly related to an efficient use of natural resources (Boons & Baas, 1997). Thus, there still appears to be a willingness to accept waste as a normal cost of doing business (Cohen-Rosenthal, 2000). Besides, environmental management savings are still often not systematically and fully accounted. Despite the emergence of the concept of full-cost accounting, many companies are still not being fully aware of the potential savings induced by improved environmental performance and by IS networking.

The lack of awareness of the potential savings induced by environmental management underlines, as discussed in section 2.3.2, the importance for IS networks of recruiting environmentally aware and mature companies. Indeed, these companies are more likely to perceive the potency of gaining competitive advantages through increased resource-use efficiency.

IS networking requires companies to make decisions at a local level. Indeed, as seen in section 2.1.2 above, IS is based on geographic proximity and thus takes advantage of local solutions. This clashes with the general globalisation trend of markets. An increasing number of companies are subsidiaries of large international groups, and decisions are increasingly taken at the group level (Brings Jacobsen, 2003). Corporate structures with issues such as ownership changes, corporate approval processes and management changes make it difficult for companies to take the decisions that IS networking may require.

Such issues may even prevent companies from joining IS networks in the first place. Thus, in the case of the Golden Horseshoe By-Product Synergy Project in Ontario (Canada) (see Appendix 3 for a brief description of the project), companies or representatives of companies who wanted to join the project could not get approvals within their corporation,

because they were small subsidiaries of large groups, or were in a process of takeover or sale (Seth, 2002).

Similarly, according to the stakeholder theory, companies are at the centre of a network of stakeholders (Barringer & Harrison, 2000). They need to give simultaneous attention to the legitimate interests of all relevant stakeholders in the important operational and strategic decisions that they make[7]. IS networking may thus be given a very low priority, if it does not coincide with the interests of the various stakeholders of a company.

IS networking often implies increasing companies' dependence on a smaller number of local suppliers. There appear to be clear benefits connected with the fact of having fewer suppliers and generating close links with them. As seen in section 2.2.2 above, this may notably increase the incentives of these suppliers to share knowledge and make performance-enhancing investments in relation-specific assets (Dyer & Singh, 1998). However, many companies appear to continue following traditional management theory, according to which companies should be eager to increase the number of their suppliers, thereby maximising bargaining power and profits (Porter, 1980).

Another aspect of IS networking that may not be fully aligned with business reality is investments. Most private companies require short payback times for their investments (1-3 years). This may often be difficult to achieve for investments related to symbiotic linkages, as these linkages often imply low value streams. Furthermore, companies may be reluctant to make such investments, because they are often highly collaboration-specific. This implies that they have often little value in alternative uses (Dyer & Singh, 1998).

Even when one company is convinced of the benefit of such investment, it may find it difficult to persuade its partner to make significant collaboration-specific investments (Gulati, 1995). However, making initial collaboration-specific investments may be an important condition to make subsequent specialised investments economically viable. Furthermore, IS network partners may need to make "bundles" of related relation-specific investments in order to realise the full potential of those investments (Dyer & Singh, 1998).

According to Ehrenfeld and Gertler (1997) the exchange of by-products and cascades of energy use is not inherently different from traditional supplier-customer relationships. However, there are clear differences, IS networking implying notably much closer and informal ties, mostly governed by formal contracts. Therefore, IS networking may require specific networking skills, such as those discussed in section 2.2.4 above regarding interorganisational learning. Companies may not always be accustomed to networking and thus lack the necessary skills.

2.3.1.2 Perceived and potential risks

There are various risks that are either true potential risks attached to IS networking, or that are factors that companies perceive as risks that may prevent them from engaging in IS networking.

A traditional concern for companies when engaging in IRs is the risk of disclosing proprietary information (Barringer & Harrison, 2000) and giving away trade secrets. Sharing

[7] This factor can be related to the institutional pressures discussed in section 2.2.1.

of information on areas such as the chemical composition of waste streams and material inputs, energy, etc is however essential for the identification of potential synergies and collaboration within an IS network.

As seen in section 2.1.3 above, a difference between IS networks and most other types of business or industrial networks is the fact that because IS networks seek a high degree of diversity among the members of the network, the involved companies are seldom direct competitors. This thus limits the risk of disclosing information to a partner who is already a competitor or who may eventually become one. Nonetheless, companies appear to be reluctant to disclosing information, even if the information required by IS networking is seldom of strategic nature. The reluctance to share information with other companies, underlines the importance, as discussed in section 2.3.6 below, of the role of an external coordination body in helping identify potential collaboration areas.

Information sharing may also pose a problem in terms of the allocation of property rights, when companies within a network develop new technologies (Gulati, 1995).

Another risk perceived by companies in connection with IS networking is the loss of autonomy and flexibility in their decision-making that joint planning and decision-making may imply. Thus, establishing a partnership with one company may foreclose the possibility of establishing a partnership with another company. In addition, the organisational routines created by a partnership may make it difficult for a company to act independently.

According to Barringer and Harrison (2000) IRs may induce monopoly-type phenomena. This may also be the case for IS networking, if for example, within a network, one company becomes the exclusive provider of a service or product. However, this risk may be bypassed by the other companies by threatening this company of going through external suppliers. On the other hand, this is not always possible, for example in the case of heat exchange. Then however, the mutual dependence between the partners of the exchange may prevent them from acting opportunistically.

A connected concern is the potential power imbalance that may arise if one partner becomes overly dependent on the other (Barringer & Harrison, 2000). This situation increases the potential for opportunistic behaviour on the part of the stronger partner (Gulati, 1995). Such power imbalance may exist in IS networks, when a network is composed of companies of very different size. This may notably be the case in networks involving large anchor tenants (see section 2.3.5.2 below) and much smaller companies.

Another risk is connected to the reliability of supplies. Indeed, in a situation of material exchange, the company selling the material may run the risk that upsets at the buying company's facility interrupt the outflow of the by-products. In such a situation, the by-products would instantly become wastes to the selling company and would need to be disposed of according to the relevant regulatory requirements, implying high costs (Ehrenfeld & Gertler, 1997).

2.3.1.3 Clear economic benefits

The need for short pay-back times, together with the fact that in general IS networking appears not to be fully aligned with business reality, implies that an important condition for IS networking is that private companies perceive clear economic benefits connected with IS networking. Indeed, despite the environmental dimension of IS networking, it appears that

the main motivation for companies to join these networks clearly is increased profitability and competitiveness. Companies may be initially attracted by an IS project only because of pure interest. However, they will only pursue a network if they are able to see its potential to render a tangible and fairly short-term impact on their bottom line (Gertler, 1995). Thus, "for industrial ecology to be successful, it has to demonstrate superior business as well as environmental results" (Cohen-Rosenthal, 2000).

The Golden Horseshoe project (see Appendix 3 for a brief description of the project) failed to attract a significant number of companies, because it was not perceived by companies as adding value over their existing efforts (Seth, 2002). Furthermore, there should be clear benefits for both partners of a symbiotic linkage (Ehrenfeld & Gertler, 1997). Thus, potential connections have to be thoroughly tested for their economic viability (Cohen-Rosenthal, 2000).

In Kalundborg, for example, each connection was negotiated as an independent business deal and was established only if it was expected to be economically beneficial. Benefits are measured either as positive flows by marketing a by-product (or obtaining feedstocks at prices below those for virgin materials) or as savings relative to standard pollution control approaches (Ehrenfeld & Gertler, 1997).

The exchanges within IS networks must provide clear economic benefits, for all partners of the exchanges. This should be the case even when IS networking implies the one-way transfer of a resource such as a specific know-how. The transferring company must also have a clear incentive to devote the resources required to transfer this know-how (Dyer & Singh, 1998).

Besides providing clear economic benefits through the actual exchanges, some projects have also tried to attract companies by providing them with direct financial incentives. Financial incentives can be given to companies to encourage them to work actively to achieve the objectives set by the project. Thus, in the Cape Charles Sustainable Technologies Industrial Park, Virginia (see Appendix 3 for a brief description of the project), involved companies pay 12% lower rents if they comply with the set of codes, covenants and restrictions developed through the public-private management partnership running the project (Schlarb, 2002). Such artificial incentives appear however to be deemed to have limited impact on long-term company commitment to IS networks.

It is also important that before economic benefits can be identified, the actual entry fee into an IS network is not perceived as prohibitive by the companies. This appeared to be a major barrier in the Golden Horseshoe project, which had a large entry fee, as many companies considered that there were no guaranteed returns and were sensitive to the business climate. However, as discussed in section 2.3.5 below, an entry fee, besides covering management costs of an IS network, may contribute to securing the commitment of the involved companies to the project. Thus, a balance should be found between these two considerations.

2.3.1.4 Need for safeguards

Besides the need for clear economic benefits for all collaborating partners, in order to minimise risks, IS networking may require sophisticated contracts. Thus, contract design is an important issue in IS networking (Friend, 2002). A contract is indeed an important control mechanism by which companies protect themselves from a partner's opportunism (Gulati,

1995). In the case of Kalundborg, for example, for most linkages there is a dedicated contract specifying the duties of the parties, volumes, timetables of transport, quality, liability etc. (Sinding, 2000). Thus IS networking may require sophisticated contracts for every single relationship and material or energy flow. The limit of this approach is, as discussed in section 2.2.3 above, that it implies relatively high transaction costs.

Formal control mechanisms such as contracts can be supplemented and sometimes even replaced by informal social controls, which rely on personal trust relations. Such informal self-enforcing mechanisms may actually be more effective than contracts (Dyer & Singh, 1998). Indeed, with self-enforcing mechanisms, contract costs are avoided because the exchange partners trust that payoffs will be divided fairly. This underlines, as discussed in section 2.3.4 below, the importance of the development of trust between the partners of a network. However, as also discussed in section 2.3.4, informal safeguards require substantial time to develop. Informal contracts are probably not likely to take fully over in IS networks. However, it appears that the mechanisms governing IS transactions should combine formal and more informal agreements.

2.3.2 Environmental awareness

Porter and van der Linde (1995) have shown that active environmental work is far from compromising competitiveness. It may actually provide companies with competitive advantages, notably through increased resource-use efficiency. Furthermore, Esty and Porter (1998) have shown that thinking in terms of IE principles may also benefit private companies. However, companies need to be aware of these benefits, and IS networking is thus more likely to appeal to companies who are aware of the benefits of active environmental work.

Recruiting such companies may also secure a higher level of commitment to the network, which is another central condition of successful IS networking, as discussed below in section 2.3.5. Furthermore, IS projects may benefit from further increasing the environmental awareness of involved companies, that may have joined the project more for the economic than for the environmental benefits of IS networking.

A common criticism of IS is that it may actually be counter-productive from an environmental perspective, as it may distract companies from optimising their environmental performance internally, and may sometimes actually contribute to maintaining unsustainable patterns. Thus it can be argued that in the case of Kalundborg, the network contributes to supporting the production of energy through fossil fuels by increasing its efficiency. Although increased efficiency is desirable, this may be seen as slowing down the transition towards renewable sources of energy.

Another example and common criticism of IS is that because it focuses on finding a use for a company's waste, it may represent a disincentive to reducing this waste at source (Chertow, 2000; Cohen-Rosenthal, 2000). However, Chertow (2000) argues that the line between by-product/waste reduction and waste/by-product exchange is rather straightforward to draw, as companies will eliminate or reduce waste as long as it is economically feasible.

Nonetheless, working with companies with a high level of environmental awareness and maturity[8] may help ensuring that interorganisational solutions complete and do not replace proper internal environmental work of the companies. IS projects may thus benefit from focusing on working with such "environmentally mature" companies. In this sense, IS networking can be seen as a sophisticated type of interorganisational environmental management (Sinding, 2000; Brings Jacobsen, 2003). It can be seen as the continuation of internal environmental work.

Evidence of environmental maturity and sound environmental management may be provided by certified Environmental Management Systems (EMS). A formal criteria for recruiting the members of an IS network may thus for example be that participating companies have an EMS certified according to the ISO 14001 standard[9] (Cohen-Rosenthal, 2000), or a similar type of standard. Surely ISO 14001 certification is not the only indicator to judge the maturity of a company's environmental awareness. Nor does ISO 14001 certification guarantee a high level of environmental performance. However, it does imply that a certified company has a number of routines and monitors its different material and energy flows and its environmental aspects. Besides, a certified EMS requires the development of emergency management plans and containment alternatives in case of accidents. Such precautions are very important in the context of symbiotic exchanges between companies within an IS network (Cohen-Rosenthal, 2000).

Furthermore, ISO 14001 requires continuous improvements in the environmental performance of certified companies. Although these improvements may be very incremental and slow, eventually the certified company reaches a point where most "low hanging fruits" have been picked. To maintain its certification the company then needs to start implementing more ambitious steps in its environmental work. At this stage, the improvement potentials offered by becoming part of an IS network can become more attractive to companies. This is also important for the continuous development of IS networks themselves. Cohen-Rosenthal (2000) has underlined the importance of placing a strong emphasis on continuous environmental improvement as a baseline criterion for involvement in Eco-Industrial Networks (EIN).

Furthermore, ISO 14001 requires certified companies to implement training and other measures to raise the environmental awareness and involvement of employees. This is intended to ensure commitment to the environmental work, and may thus also be beneficial for IS networking, as strong commitment is also a central factor of successful networking, as discussed in section 2.3.5 below.

Especially in North America, a number of Eco-Industrial Parks (EIP) put a strong emphasis on EMS, such as the Ecopark in Londonderry, New Hampshire (See Appendix 3 for a brief description of the project), where complying with ISO 14001 is a basic requirement of participating companies as a way to demonstrate "environmental good faith" (Cohen-Rosenthal, 2000). In the Cape Charles Sustainable Technologies Industrial Park (See Appendix 3 for a brief description of the project), companies that demonstrate sound

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[8] Companies that have done comprehensive internal work to improve their environmental performance.

[9] ISO 14001 is the international standard for Environmental Management Systems (EMS) developed by the International Standardisation Organisation (ISO). By ISO 14001 certification is meant that a company's EMS has been certified by an accredited certification body as fulfilling the requirements set by the ISO 14001 standard.

environmental management approach benefit from more favourable treatment (Cohen-Rosenthal, 2000).

2.3.3 Existing institutional platforms and linkages

IS networking appears to be strongly context-based, building on local assets and needs. A "cookie-cutter" approach will not work (Schlarb, 2002), each situation being unique. Thus, important factors influencing the outcome of IS networking are the institutional platforms and the linkages between the actors of an IS network that already exist prior to the development of the network. Existing institutional platforms refer to formal or informal institutions that are already in place before the development of an IS network, such as trade associations, for example. They are institutions that are recognised and seen as credible by the companies and other actors involved in an IS network. Furthermore, they already serve as a natural forum for meetings, interaction and collaboration. Existing linkages, on the other hand, refer to the ties that already exist between the actors of a network, such as a pre-existing sense of community between these actors.

The importance of such factors is shown by famous examples of industrial networks, which, as seen in section 2.1.3 above, have characteristics that are similar to IS networks. This is notably the case of the manufacturing networks of the Italian region of Emilia-Romagna, (Piore & Sabel, 1984). The success in this region was to a great extent attributable to pre-existing factors such as active trade associations and close family and community ties (Ehrenfeld & Gertler, 1997). Indeed, these ties implied a high degree of trust, which is, as discussed in 2.3.4, an important condition for networking.

Another example is the Danish networking experience. In 1989, the Danish Ministry of Trade and Industry launched a programme, called "Strategy '92", in order to establish network collaboration among Small and Medium-sized Enterprises (SME) (Gertler, 1995). The programme proved very successful, Denmark becoming a model of a purposefully created inter-woven economy. However, even in this case, the cultural and institutional underpinnings of the change were already in place (Gertler, 1995).

Finally, the IS network in Kalundborg is a perfect illustration of the importance of pre-existing linkages, as the companies notably already had close ties allowing for a high degree of mental proximity (Ehrenfeld & Gertler, 1997). As seen in section 2.3.4, mental proximity is indeed also a very important factor for networking.

The cases of Kalundborg, the Danish networking experience and Emilia-Romagna are thus similar in the sense that they built upon a unique and favourable context. The development of these networks was the result of a long, evolutionary and to some extent spontaneous process. Their success is thus to a great extent attributable to the presence of favourable conditions. This explains why their direct transferability is questionable, and shows the limits of external intervention to develop such networks (Gertler, 1995). Most of the time the presence of such favourable conditions cannot be compressed in time and is path dependent. Thus, Piore and Sabel (1984; as cited in Boons & Baas, 1997) conclude the following: "The cohesion of the industry [in these regional networks, Boons/Baas] rests on a more fundamental sense of community, of which the various institutional forms of cooperation are more the result than the cause' (Boons & Baas, 1997).

Besides the fact that cases that are considered successful cannot be directly transferred elsewhere, this indicates that it is important to adapt to and build upon the existing

institutional platforms and linkages between the actors in a network. Thus, in the case of an industrial district, often linkages and possibly also a coordinating institution already exist. An example of an existing coordinating institution that was taken advantage of in an IS project is the association Europoort/Botlek Interests in the Rotterdam (Netherlands) Harbour INES Project (Boons & Baas, 1997) (see Appendix 3 for a brief description of the project).

An IS network may thus fail because, although suited institutional platforms do exist, they have not been identified by the IS project team. The availability or absence of existing institutional platforms and linkages may also explain why IS networks may fail, in cases where none of the factors presented above are available in a given area. In such cases, there is no "network" on which an IS can be built (Boons & Baas, 1997).

Fundamentally, it appears to be very important that IS networks take advantage of the local identity and sense of community (Brings Jacobsen, 2003), provided that these factors are available. A strong local identity and sense of community do indeed allow for a high level of trust and mental proximity, two factors that, as discussed in the next section, are very important in IS networking. Thus, for example, the Avedøre project in Denmark (see Appendix 3), despite clear potential synergies, has not so far managed to take off, notably because of a lack of local identity and of sense of community (Brings Jacobsen, 2003). Indeed, this project is located in an industrial district without a proper local community (Anderberg, Krueger Troelsen, Damgaard Nielsen 2003).

It is thus very important that IS project initiators start by making a comprehensive assessment of all dimensions of the situation before the start of the project.

2.3.4 Communication and trust

An important factor influencing the outcome of IS networks is the degree of trust and mental proximity there is between the actors of the network. It appears that when there is not already a high degree of trust and mental proximity between these actors before the development of the network, these elements can be bred by intense communication and face-to-face contact.

In an inter-firm cooperation context, trust can be defined as "a type of expectation that alleviates the fear that one's exchange partner will act opportunistically" (Gulati, 1995). Mental proximity, on the other hand, refers to the fact that the actors of a network share common values. They both play an important role in IS networking. They can reduce the transaction costs associated with partnerships, by allowing for less formal and detailed contracts (Gulati, 1995), and by reducing monitoring costs. As seen in section 2.3.1.4 above, informal social controls that build on trust may supplement and even replace formal controls (Dyer & Singh, 1998). Trust may favour the exchange of ideas and information at a confidential level (Brings Jacobsen, 2003) and in general accelerate the information flows required to develop and maintain partnerships (Gertler, 1995).

Mental proximity is important in the sense that the corporate cultures of collaborating companies need to be compatible enough to facilitate coordinated action (Dyer & Singh, 1998). Culture in this context refers to common practices, values and objectives. If these cultures are too distant, they may clash, causing the failure of a partnership, or at least resulting in frustrations and costly delays (Barringer & Harrison, 2000). This is not only the case between private companies, but also with other actors involved in an IS network, such

as public bodies, as the cultural difference between the public and private sector are usually even bigger.

Inter-firm trust may emerge mainly in two ways. First, Gulati (1995) indicates that it may emerge when companies have repeatedly completed successful transactions in the past. Thus, ongoing interactions can engender trust among partners, as they learn more and more about each other, and inter-firm trust appears to develop on an incremental basis. In this sense, inter-firm trust appears to also be a function of how experienced the partners of an IS network are in general at working in an inter-firm setting (Boons & Baas, 1997).

The second way trust can develop is through social interactions (Brings Jacobsen, 2003). Indeed, fundamentally, trust is an interpersonal phenomenon. Thus, inter-firm trust appears to be based on close personal ties between the individuals in the companies that contracted with each other. Social interactions imply also contacts on a non-professional basis, during free-time, through social activities. The case of Kalundborg is a perfect illustration of this. The town's small size and its relative isolation have made for a tight-knit community in which the employees and managers of the local companies have naturally interacted socially on a regular basis (Ehrenfeld & Gertler, 1997). This also allowed this so-called mental proximity and shared values to emerge.

This indicates that in order to foster the development of trust and mental proximity, there needs to be a high level of communication and interaction between the members of an IS network. Furthermore, it appears that in order to foster the development of personal relationships, it is important that IS networks provide their members with frequent opportunities for face-to-face contact (Sterr, 2000). Experience from other types of networks, notably in Emilia-Romagna also clearly shows the importance of face-to-face contact (Gertler, 1995).

As seen in section 2.2.4 above, a high degree of personal interactions between the partners of a network may also enhance the capacity of companies to exchange information and know-how with each other. Know-how transfers typically involve an iterative process of exchange, and the success of such transfers depends on whether personnel from the collaborating companies have direct, intimate, and extensive face-to-face interactions (Dyer & Singh, 1998).

In Kalundborg, no deliberate institutional mechanism was needed to promote conversations among the potential partners. However, where a high-level of interaction between the members of an IS network is lacking, it is important that the coordinators of an IS network create venues in which participants can develop and foster personal relationships (Gertler, 1995; Sterr, 2000). General network meetings can contribute to this, if they are not too steered by the coordinators of the network, i.e. the members of a network are given the opportunity to express themselves and interact with each other. Fundamentally it appears that it is the local dialogue that makes IS networking happen (Brings Jacobsen, 2003), and a dialogue may only take place if the members of a network interact actively with each other.

2.3.5 Commitment to the network

Another important factor for the development of an IS network appears to be the degree of commitment of the involved companies and other actors to the network. An IS network requires strong commitment from all involved actors. Commitment may, however, also be secured by recruiting so-called champions. These champions are actors who are particularly

committed to the development of the network, and who help gaining the commitment of the other members of the network.

2.3.5.1 General commitment

Although all IS projects have their own specific characteristics, one feature that is common to all is the fact that the planning, design, and implementation of an IS network constitute an evolutionary process that takes time. Many existing projects run over rather short periods of time, seldom more than a couple of years. Their main objective is often to assess the feasibility of IS networking between a number of given actors, and to identify potential collaboration areas. It appears clearly that much more time is required to implement the identified synergies and achieve a functioning and self-sustaining network.

Therefore, it is important to secure the commitment of the involved actors, especially the private companies, not only in the beginning of a project, but also over an extended period of time. Else, there is a risk that an IS network fails, not because of a lack of potential areas for collaboration, but because of fading interest from companies to work towards their implementation. Thus, in the Golden Horseshoe project (see Appendix 3 for a brief description of the project), from 52 companies involved in the meetings, only 5 companies joined the project officially, and from 10 synergies under preliminary investigations, only 1 synergy was implemented (Seth, 2002). Indeed, "knowledge of kinds of waste streams can provide a means to determine potential linkages. But this does not link them; decisions by people do" (Cohen-Rosenthal, 2000, p.245). Committed and energetic participants are critical to the success of IS networks (Seth, 2002).

Commitment is also important once a symbiotic linkage has been implemented. Thus, experience from the Triangle J Council of Government Industrial Ecosystem Development Project, North Carolina (see Appendix for a brief description of the project) shows how easily a successful collaboration can collapse if there is a lack of commitment by the actors involved. In this project, a synergy implemented around the exchange of methanol between a resin company and a wastewater treatment plant became obsolete, to a great extent because the wastewater treatment plant got involved in a scandal around the use of its sludge, and blamed this on the partnership around methanol, although it appears that the synergy had no connection with the scandal (Duret, 2003).

As seen in section 2.3.1.3 above, an important condition for IS networking is that it provides the involved companies with clear economic benefits. One way of securing company commitment may thus be to first focus on the partnerships that provide most tangible and short-term economic benefits, as this may contribute to building up trust and commitment among participants.

Another possible method to ensure commitment of companies to a network is to make companies contribute financially to the project, thereby making them have a financial stake in the project. This has notably been successfully experienced in the German Rhine-Neckar project (see Appendix 3 for a brief description of the project). Such financing conditions may contribute to ensuring strong commitment of the companies in the sense that they lead to considerable expectations among the companies (Sterr, 2000).

However, as discussed in section 2.3.1.3 above, it is also important that this financial contribution is not perceived as prohibitive by the companies. It should also be noted that there is a risk that such financial contributions give companies the feeling that the IS project

is a short-term product-based project rather than a long-term process. Furthermore, financial commitment is not enough, as more than money, crucial resources in IS networking are time and human resources. Thus, it is possibly more important that the actors of an IS network commit to allocating a minimum amount of time and dedicated personnel for working with the network.

In order to ensure commitment of the actors of an IS network, it appears also important that the coordinator of the network follows up significantly meetings and discussions with the members of the network in order to sustain their interest.

Barringer and Harrison (2000) underline the fact that IRs should not be formed and set aside by the top managers of the involved companies, but should receive ongoing managerial scrutiny, oversight, and support. This appears to also be important in the case of IS networking. However, experience from both Kalundborg and other IS networks indicate that it is crucial not to focus exclusively on the commitment and the involvement of top-management level of companies for IS networking (Brings Jacobsen, 2003). First, it appears that other levels within the hierarchy of companies should be targeted, namely the people who are directly responsible for by-product, raw material and environmental management (Seth, 2002).

Furthermore, the "factory floor", i.e. production managers technicians and workers, should also be included into discussions at an early stage, as they are the ones who have the technical solutions and thus are the ones who eventually will make symbiotic linkages work. They should thus be included in the project, for example by forming an "environmental club" with the purpose of solving concrete, basic problems. If only top-management is involved, there is a risk that commitment to the network will fade away after a few months. The key is thus a combination of top-down and bottom-up approach, top-management involvement remaining central for discussions on future evolutions and general commitment of the involved companies. Too many IS projects throughout the world had only top-management involvement (Brings Jacobsen, 2003).

2.3.5.2 Champion and anchor tenants

Besides the collective commitment of all participants to the IS network, it appears to be an advantage for IS networks to have some actors that are particularly committed to the development of the network, so-called champions. Such champions may be useful in the sense that they may contribute to maintaining general commitment to the network. Thus, such champions should have the drive, energy and clout to motivate politicians, citizens, businesses, and other stakeholders to support the development of the network (Schlarb, 2002). It is important that champions are perceived as being credible by the other actors of the network.

Such champions have a direct interest in the development of an IS network, either because they are already specialised in dealing with the wastes and by-products of other companies, or because they produce large streams of by-products themselves. They can thus be large companies or other organisations with diverse raw materials and by-products (Seth, 2002). Large champions can then be related to the so-called "anchor tenant approach" (Chertow, 1998; Korhonen & Snakin, 2001). Chertow (1998) describes this approach in the following way:

"It is the same concept as building a shopping mall around one or more large department stores to anchor the commercial development within. In practice, it involves looking for a starting point that already exists" (Chertow, 1998).

For example, in Kalundborg, at the heart of the system are the Asnaes Power Station, one of the largest power stations in Denmark, the Statoil refinery, and Novo Nordisk which employs an important fraction of the population in Kalundborg (Ehrenfeld & Gertler, 1997).

Anchor tenants may help securing the commitment of other companies, as they need to secure outputs for their large by-product streams. Also the literature on clusters underlines the importance of having big "locomotive" companies that can really push and pull things through, in conjunction with smaller fast local actors (Berggren & Brulin, 2002). The anchor tenant approach confirms the importance of taking advantage of the existing institutional platforms and linkages, as discussed in section 2.3.3 above. Indeed, planners of an IS network should also look at existing potential anchor tenants and champions.

However, although it is useful and beneficial to build IS networks around champions and anchor tenants, they do not appear to be an absolute prerequisite of IS networking (Brings Jacobsen, 2003), provided that there is a sufficient level of general commitment of the actors involved in an IS network.

Furthermore, anchor tenants and champions may in some instances actually counteract the objectives of IS networks. This can be the case, for example, when the anchor tenant or champion has a very strong interest in a particular area and does not give enough attention to other areas. This was notably the case in the IS programme in Humberside, United Kingdom (UK) (see Appendix 3 for a brief description of the project). In that project, the initial project champion had a great interest and stake in a CHP plant. Therefore, its efforts to engage other parties overly concentrated on finding partners who could use the by-product steam (Mirata, 2003). This significantly influenced the diversity of participants, which as seen in section 2.1.3 above is an important aspect of IS networking.

2.3.6 Coordination and public/private partnerships

Two features appear to be common to a vast majority of IS networks. The first feature is that they are managed by a coordinator, which facilitates communication and cooperation within the network. The second feature is the fact that very often IS networks are the result of public/private partnerships.

2.3.6.1 Coordination

A feature that is common to most types of networks is the fact that they are difficult to organize and manage, particularly as the number of actors involved increases (Barringer & Harrison, 2000). A major factor influencing the outcome of IS networking is thus how well a network is managed. Indeed, poor management of an IS network may mask potentially viable linkages (Cohen-Rosenthal, 2000).

As seen in section 2.3.3 above, the existing institutional platforms and linkages are very important factors for IS networking and should be fully taken advantage of. However, when there is not a pre-existing favourable cultural context for exchange, the absence of such a context may to some extent be compensated through institutional mechanisms (Ehrenfeld & Gertler, 1997). Thus, a common feature in the set-up of IS networks is the presence of a

catalysing agent that facilitates and coordinates the network between the companies and other actors involved.

This is a feature common to most types of networks, which can be described as a hub and wheel configuration (Barringer & Harrison, 2000), the coordinator being at the hub of the network. This role could be played by one of the involved companies. However, it is usually played by a body such as an academic institution, or a consultancy company, often in partnership with public bodies or trade associations.

The fact of having one of the involved companies to play this role may have both drawbacks and benefits. A private company may be more committed than the entities mentioned above, and the management might be more effective and efficient. Indeed, the company's own performance more directly depends on the outcome of the networking activities. On the other hand, as discussed in section 2.3.5.2 above regarding anchor tenants and champions, this company may then focus too much on areas it itself has a direct interest in. The main reason why companies involved in a network usually do not themselves coordinate the network is however probably the substantial resources this coordination requires.

Several factors motivate the need for a coordination agent. First, it may be motivated by the lack of familiarity of companies with inter-firm collaboration (IFC), which may especially be the case for smaller businesses (Gertler, 1995). Even when companies are experienced with IFC, a coordination agent is important in introducing the actors of a network to the concept of IS. Introducing this new concept may take time and require careful explanation and lots of examples.

Second, as mentioned in section 2.2.3 above, the coordination agent allows to minimise the transaction costs of IS networks. The coordinator may thus play an important role in facilitating communication between the companies, notably by encouraging face-to-face contacts between them, as discussed in section 2.3.4 above.

The coordination agent may also reduce transaction costs by collecting and centralising information and by helping companies to identify potential synergies and collaboration areas. As seen in section 2.3.1.2 above, IS networking requires a significant level of exchange of information about their various inputs and outputs between the involved actors in order to identify potential areas of collaboration. However, private companies may be reluctant to share all this information with other companies, before they know whether they may benefit from the collaboration within the network or not. Companies appear usually more willing to share relevant information with the coordination agent of the network. Companies perceive that the risk of leakage of proprietary information is then much lower.

Furthermore, networking requires an understanding of the capabilities and whereabouts of potential collaborators (Gertler, 1995). Thus, to find potential partners, companies have to have a rather comprehensive knowledge of the activities of the other companies involved in the network. However, it appears that companies often tend to work in isolation from each other. This may particularly be the case for small companies. The identification of potential partners and synergies requires also substantial resources, mostly in terms of time, which is usually a very scarce resource for private companies (Gertler, 1995).

Minimising transaction costs is not only important in the initial stage of IS networks. Indeed, transaction cost theory indicates that most enduring IRs are not maintained free of cost

(Oliver, 1990). Thus, there may be a need for of continued support of the network by a coordination agent once synergies are up and running.

The Danish networking experience also shows the importance of network coordinators as it to a great extent built on so-called network brokers to catalyse collaboration (Gertler, 1995). According to Rosenfeld (as cited in Gertler, 1995) "brokers are the often indispensable individuals who catalyse and facilitate networks by providing ongoing liaison, trouble-shooting and strategic planning services to the participating firms". Due attention should thus be given to the recruitment and training of these network brokers.

Finally, besides training and competence, it appears to be important that the coordination agent is seen as credible by the actors of the network. Furthermore, he needs to be fully committed to the development of the IS network. If this is not the case, networks are likely to fail. The coordinators should thus be the first champions of the network, or so-called institutional anchor tenants (burström & korhonen, 2000).

2.3.6.2 Public/private partnerships

Almost all documented cases of IS networks have been generated in the presence of public support and/or involve public bodies such as municipalities or regional public bodies (Chertow, 2000). Such bodies may be general local and regional administrative and political authorities with a broad mandate or more specialised bodies. Thus, local and regional economic development agencies, chambers of commerce, environmental bodies and agencies and universities and research institutes are among the bodies whose involvement in IS programmes is desirable.

Some of these bodies, mainly municipalities, can themselves be involved as partners of actual exchanges (Burström & Korhonen, 2000), but most of them may rather be co-initiators and facilitators of IS networks. This can be explained by the fact that these public actors may have an interest in the development of IS networking, both because of its environmental dimension and of its local economic development and social dimensions. The Danish networking experience also tends to confirm the potency of public intervention and support to favour the development of networks (Gertler, 1995).

As seen in section 2.2.1 above, public bodies play an important role in the development of IS networking, in the sense that institutional pressure is a major driver for private companies to engage in IS networking. However, besides this role, which is of indirect nature, public bodies may play a more direct role in the actual development of IS networks. As seen in section 2.3.3 above, it appears to be important to find the best-suited institutional platform for promoting networks, notably by building on the existing institutional platforms.

When there is not an existing network upon which an IS project can build, such as an active local trade association, the most natural existing institutional platforms may actually be public institutions, such as economic development agencies. This may however only be the case if these public bodies are indeed perceived by local companies as a natural locus for inter-firm interaction. Thus, public bodies can play the role of coordination agent, which, as discussed in section 2.3.6.1, is essential for the development of IS networks. They then constitute what Boons and Baas (1997) call authoritative coordination institutions.

Public bodies can support IS networking by providing information to companies about IS networking and offering grants to support network experiments (Gertler, 1995). Thus, as

seen in section 2.3.1.3 above, public bodies may provide financial support in the initial phase of projects. Especially in a context of low level of inter-firm collaboration and the absence of strong trade and industry associations, financial incentives may play an important role (Gertler, 1995).

This financial support should however not be counter-productive. Thus there is a risk that it may support the development of linkages that are intrinsically not viable economically. Indeed, public funding cannot alone sustain an IS network over time, and such artificial linkages appear to be deemed to collapse after a while. Public support may also result in lower levels of commitment from companies, as they may see projects with strong public support as someone else's work.

Referring again to institutional theory (see section 2.2.1 above), public bodies may play a role once the symbiotic linkages that provide clear economic benefits have been implemented in an IS network. Indeed, often, further symbiotic arrangements are potentially available, but they cost more than conventional practices. Political impetus may then be necessary to go further, for example, requiring emission reductions or adjusting prices to make symbiosis economically attractive (Ehrenfeld & Gertler, 1997).

The key to public involvement in IS networks appears to be public/private partnerships, with a close contact between the public bodies, other coordinators of the network and the involved private companies. It appears that public support may also add credibility to the recruitment pitch of IS networks (Seth, 2002).

2.3.7 A vision for the network

An important factor influencing the outcome of IS networking appears to be the existence or the lack of definition by participants of the fundamental purpose and objectives of an IS network. Effective collaboration requires indeed a common understanding by the involved parties of what is to be achieved through the collaboration. First, this implies that the companies involved in an IS network need to know what they want themselves to achieve through the collaboration within the network. Second, they need to understand the motivations of the other involved actors. In fact, as seen in section 2.2 above, companies may decide to engage in IS networking for a range of different reasons, and these reasons may be conflicting.

This common and reciprocal understanding enables the development of a vision for the network, defining what the network should achieve, on the short and long term. A report by the Swedish Business Development Agency (Berggren and Brulin, 2002) on clusters underlines that thinking in terms of clusters forces actors to think long term in order to make the systems work and showing the necessity of investment even in weaker periods.

Thus, agreeing on a long-term vision for an IS network, may guide the actors of the network on the short-term, making them aware of the necessity and benefits of individual steps. Developing a vision for an IS network is also important in the sense that it ensures that no intermediary step, which may appear beneficial when considered individually, blocks further evolution towards the final objectives of the network. This is notably important in terms of environmental improvements, as seen in section 2.1.1 above.

While most existing IS projects simply try to outline potential synergies between companies and their local community, a number of projects have defined a set of principles, codes,

covenants and restrictions, as in the case of the Cape Charles Sustainable Technologies Industrial Park, Virginia (Schlarb, 2002). So far this has however more often been the case for Eco-Industrial Parks (EIP) designed and developed "from scratch", either developing or attracting new businesses. It should however also be feasible and be beneficial for IS networks building on existing companies.

Regarding environmental objectives, in the initial phase of an IS network, initiators often face the dilemma of setting strict environmental targets, but thus risking low company participation, or not setting clear principles in an initial stage, and gradually increasing requirements on the members of the network once strong commitment and active participation of companies is ensured.

However, if IS networking is not to become an ordinary type of business network without tangible environmental improvements, the development of a vision including environmental objectives cannot be bypassed. This may imply setting at least the "seeds" of environmental improvement objectives already at an early stage, and confirms the benefit of recruiting environmentally aware and mature companies (see section 2.3.2 above).

Developing a vision for an IS network may however only be useful if it is developed by the actors of the network themselves. Furthermore, although developing a "vision" may be useful, it obviously needs to be followed by concrete action. It should also be flexible enough to allow adaptation to changing environmental conditions.

2.4 Conclusions

Based upon management and IR literature, it appears that the two main motivations for companies to engage in IS networking are institutional pressure and the search for competitive advantages. IS networking may provide companies with competitive advantage mainly by giving them access to critical resources, and by allowing for cost savings, and/or interorganisational learning.

It appears however that this potential of IS networking to provide companies with competitive advantages should not be exaggerated. The main driver for IS networking seems to be institutional pressure, mainly through environmental regulation. In this sense, IS networking can be seen as a sophisticated type of environmental management and as the continuation of internal environmental work.

IS networking may not be fully aligned with the business reality companies are confronted with. IS notably conflicts with the fact that decisions within companies are less and less taken at the local level. Because IS networking is not fully aligned with business reality, it needs to provide companies with clear benefits and safeguards.

It appears preferable for IS networks to recruit environmentally mature companies. This may help ensuring that IS networking complements rather than supplants internal environmental work of the involved actors. IS networks should also work on making other involved companies more environmentally aware.

The existing institutional platforms and linkages play an important role in IS networking, and should be fully taken advantage of, as they imply a high level of mental proximity, trust and social interaction between the members of a network. If these elements are not available,

they may be developed through the network, by the means of a coordination agent and of public/private partnerships.

It also appears to be important that the actors of an IS network reach a common understanding of what the network should achieve, both on the short and the long term.

Possibly most important is however to ensure strong commitment of the actors involved in the network. Indeed, while systems make IS networking possible, people make it happen (Cohen-Rosenthal, 2002).

3. Industrial symbiosis in Landskrona

This section introduces the Industrial Symbiosis (IS) project in Landskrona (Sweden). Section 3.1 presents the general background and objectives of the project. Section 3.2 describes the methodology used by the project team for the different phases of the project. In section 3.3, the Municipality of Landskrona is described, with an emphasis on its industry and its environmental history. Section 3.4 presents and analyses the specific characteristics of the project in Landskrona. Finally, section 3.5 outlines the main potential areas of collaboration that had been identified by the project team in conjunction with the companies involved in the project, as of September 2003.

3.1 Background and objectives of the project

The industrial symbiosis project in Landskrona was initiated by the IIIEE in 2002. The Institute has a long history of working together with companies located in Landskrona on environmental projects. Thus, already in the 1980s (between 1987 and 1989), a group of researchers from the IIIEE[10] worked on a cleaner production project in which some of the companies participating in the current project were involved.

After an initial assessment of the interest of companies located in Landskrona in participating in an IS network, the IIIEE tried various channels to secure funding for the project. Subsequently, after about one year's work funding[11] was granted by NUTEK, the Swedish Business Development Association in April 2003 for an initial 16 months. By July 2003, 19 companies (see Appendix 4 for a list of the companies involved in the project), and the Technical Department of the Municipality of Landskrona, registered their commitment to the project.

To ensure their active participation in the project, the involved actors were required to contribute financially to the project. This contribution was however kept at a rather low level in order to attract a sufficient number of companies[12]. More importantly, participating companies had to commit to allocating a minimum amount of time and dedicated personnel for working with the project[13]. The initial timeframe for the project is 16 months, thus going from May 2003 to August 2004.

The fundamental objective of the project is to implement the concept of IS in a Swedish context and to adapt it to this context. Within the project, the main objective is to identify possibilities for collaboration that provide environmental benefits. The project also aims at assessing the advantages and feasibility of these possibilities, and identifying barriers to their development. The provision of assistance to overcome these barriers notably by establishing an institutional framework is also among the project's objectives. Regarding the possible synergies, economic benefits are also given priority along with environmental ones.

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[10] Within the TEM Foundation at Lund's University (Stiftelsen TEM, 2003).

[11] 800 000 SEK, or approximately 85,000 € (2003, July 22).

[12] Companies had to contribute with 5000 SEK, or approximately 545 € (2003, July 22) to the project.

[13] Although this was not a formal commitment, companies agreed to spend a minimum of 2 hours weekly for working with the project, or a total of approximately 100 hours throughout the project.

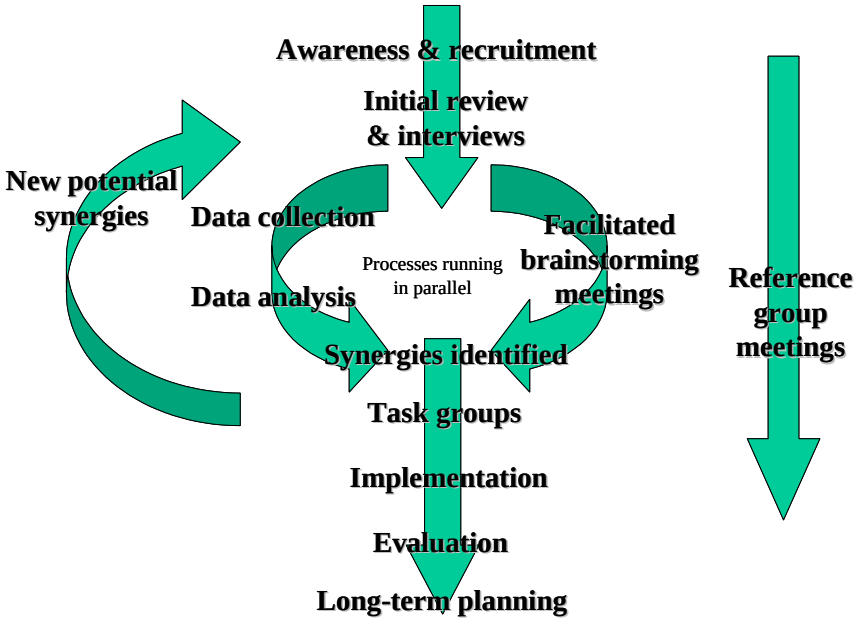
From a regional perspective, the objective is to strengthen the sustainability profile and competitiveness of the region. The final ambition with the project is to spread the concept of IS to other Swedish regions by engaging relevant parties, disseminating relevant findings, and proposing a model and a refined methodology for developing such networks. Besides these local and national objectives, through this project, the IIIEE aims also at assisting the build-up of an international network on IS.

Regarding specific targets for the project, the main ones are to identify a minimum of four feasible synergies and to have at least two synergistic collaborations functional on completion of the project (Mirata, 2003a).

3.2 Methodology of the project

Figure 3-1describes the methodology used in the project in Landskrona.

Figure 3-1: Methodology of the Landskrona IS project



The project started by contacting companies, presenting them the project and raising their awareness on the potential benefits to be gained through IS networking. A total of 19 companies were initially approached. For 8 of these, an initial review was performed by students of the IIIEE's Master Programme as a part of their education. The focus was on gaining a sound understanding of their activity and on starting to outline potentials for synergy.

The project team conducted interviews with the companies to gather qualitative data and identify potential synergies. To get more detailed quantitative data the companies were then given the task of filling data collection forms (see Appendix 5). These data collection forms contain data on their material, energy and water inputs, their main products, their by-products, their wastes, and their excess and needed capacities. These data collection forms were to set the basis for a data analysis aiming at discovering potential areas for symbiotic

collaboration between the companies. They were also to help identify improvement potentials within companies.

Internet-based questionnaires were to be used to obtain rapid information from the companies on specific issues, such as their possibilities and interest in collaborating on specific areas. To insure continuous interaction between the companies, so-called breakfast meetings were to be held every second month throughout the project[14]. These meetings were also meant to encourage common brainstorming of the actors involved in the project. These meetings were to be hosted by various companies, the hosting company notably organising a study visit of its facilities for the other companies, in order to increase the understanding of each other's production processes.

Once a series of potential synergies have been identified, companies were to be organised into smaller thematic groups on various areas, so-called task groups. These groups were to become the key to progress once the major synergies were identified, working on the actual implementation of the symbiotic linkages.

Reference groups were established at the national and international level (see Appendix 6). The national reference group is meant to help overcome potential barriers that can be encountered as part of the network's development. It is also intended to facilitate the spreading of the concept in Sweden by engaging relevant parties. The purpose of the international reference group, on the other hand, is to receive feedback on the project and benefit from the experiences from other projects. It should also provide a discussion forum, and raise the profile of the project internationally. Finally, a webpage was to be developed to present the project and for circulation of data and information between the involved actors.

To assess progress in the project, a set of indicators were to be developed, such as reductions in resource use, waste generation, and pollutant emissions. Furthermore, important actions to be taken were to be systematically discussed and agreed upon with the members of the project.

3.3 Landskrona

This section describes general features of the Municipality of Landskrona and presents its industrial background and its environmental history.

3.3.1 General presentation

The geographic scope of both the project and this research is the Municipality of Landskrona (*Landskrona Kommun*). There are approximately 300 municipalities (*kommun*) in Sweden with extensive administrative competences. The Municipality of Landskrona has a population of approximately 38,000 inhabitants. Landskrona is located between the larger cities of Malmö and Helsingborg, on the coast of the Öresund Straight. The town has a deep-sea harbour and has good road and rail connections.

Since the beginning of the twentieth century, Landskrona has been an industrial town. Until recently, the dominating industry was the production of fertilisers. The other main industrial

[14] The first breakfast meeting took place on the 20th August 2003.

activity until the beginning of the 1980s was the shipyard (*Öresundsvarvet*). The shipyard, which employed 3,500 of the 6,000 employees working in the manufacturing sector, closed down in 1982, resulting in massive unemployment. This led to the new-establishment of high environmental impact activities (*miljöfarlig verksamhet*), rather unusual at that time, but deemed necessary for the economic survival of the town. Today, the economy of the town is still dominated by the manufacturing industry.

3.3.2 Environmental history

Due to the industrial activities present in Landskrona, the town has a long environmental history. Major pollution problems arose in the 1960s and 1970s mainly because of the production of fertiliser and of sulphuric acid. This resulted in smog, acid rain and smell. Because the impacts on health and the environment were clearly visible, there was an increasing environmental debate and the Environmental Department of the Municipality grew in importance. As elsewhere in Sweden, the environmental debate was strongest in the 1980s. This coincided with a major environmental scandal in Landskrona. A recycling company, newly established in 1982 after the closure of the shipyard, was tried for discharging wastewater without appropriate treatment into the sea (Hansson, 2002). Actually, this company is one of the companies involved in the industrial symbiosis project. It has since then radically changed its approach to environmental issues, and is ISO 14001 certified since 1998.

This trial can be considered as marking a turning point in the environmental history of Landskrona. Under the pressure of the public opinion and the media, many companies started to work actively with environmental issues, several companies developing ISO 14001 certified Environmental Management Systems (EMS). The Environmental Department has also played an important role in this change[15]. Its influence has increased since the 1970s, to such extent that its head eventually got criticised for being too tough with industry and accused by some of scaring away companies from Landskrona[16]. Today, he is respected by company managers and seen as an influential character.

In connection with the Environmental Department of the Municipality, Landskrona has a history of environmental projects. As described in section 3.1 above, within a structure linking university and business (Stiftelsen TEM, 2003), a series of companies worked on cleaner production schemes. Furthermore, the Environmental Department of the Municipality has worked on two projects looking into optimisation of transportation activities (see section 3.5.3 below).

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[15] According to the Swedish Environmental Code (*Miljöbalken*), there are three main types of companies, A, B and C companies, and the Environmental Department of the Municipality is responsible for the supervision of B and C companies. A companies correspond to companies having an activity classified as having a high environmental impact (*miljöfarlig verksamhet*) and are supervised by the county administration (*länsstyrelsen*).

[16] At the end of the 1980s, the board of the Municipality of Landskrona actually wished to dismiss him, but the inhabitants of Landskrona marched in the streets of the town to demonstrate their support for his active environmental work (Svensson, 2000).

3.4 Specific characteristics of the project

This IS project has a series of rather specific and in some cases even unique characteristics. These should be kept in mind when drawing general conclusions or trying to replicate the project elsewhere.

As seen above, as of September 2003, a total of 20 industrial actors were involved in the IS project. This number may fluctuate somewhat during the project but has been deemed as a suitable size to ensure sufficient diversity and possibilities while ensuring that the network remains manageable. However, new companies showing a clear potential for symbiotic connections are still considered for acceptance into the project at a later stage[17]. It can be noted that many of the companies that joined the project are among the most pro-active companies in Landskrona, both environmentally and generally speaking (Hansson, 2003).

The companies involved in the project are located close to each other, but are split in three different industrial areas of the town. The biggest concentration is in the south of the town where 16 of the companies are located (including the Technical Department of the Municipality), while 3 are located together in the northern industrial area, and 1 is more isolated. However, no company is more distant than 4 kilometres from the other companies, most of them being located much closer to each other.

Public bodies involved in the project are the Environmental Department and the Office for Trade and Industry (*Utvecklingsstiftelsen*) of the Municipality of Landskrona.

3.4.1 A focus on manufacturing industry

The companies involved in the project are mainly from the manufacturing industry (see Appendix 4 for a list of the involved companies). First, this is due to the high concentration of manufacturing companies in Landskrona both in terms of the number of companies and of employees. Secondly, this type of industry is usually considered as being most adapted for symbiotic collaboration and the exchange of tangible resources. Hence, it has been the main focus of the project's recruitment process.

Although most companies are manufacturing companies, they are diverse in their activities (see Appendix 4). Four companies can be grouped in a category printing and packaging, five in a category recycling and waste management, two in a category agribusiness. Two companies are pure chemical industries. Two manufacture components for the automotive industry and one for rail-bound traffic. Finally there is one road transport company, an electroplating company, a company importing cement and the Technical Department (*Tekniska Verken*) of the Municipality of Landskrona, notably through its District Heating (DH) system and wastewater treatment plant.

3.4.2 From SMEs to international groups

Besides the diversity of the involved companies' activities, another feature is their varying size. Thus, the smallest company in terms of the number of employees – the company importing cement (see Appendix 4) which has no manufacturing activity of its own – has only 4 employees. The largest company, manufacturing brake components for heavy

[17] Thus, participating companies were encouraged to bring in new partners that presented a high synergy potential.

vehicles, employs 550 workers. Out of the 19 companies, 18 have fewer than 250 employees. A majority of the involved companies correspond thus to the European Union's (EU) definition of Small and Medium-sized Enterprises (SME)[18]. However, this definition does not reflect the fact that half of the companies involved in the project are subsidiaries of large international groups, nor the fact that although most of these companies formally are SMEs, many are rather big in a Swedish context.

3.4.3 Environmental awareness and ISO 14001 certification

A rather unique characteristic of the project in Landskrona is the fact that of the 20 involved companies, 11 are ISO 14001[19] certified, and among the companies that are not certified, some are in the process of developing a to be certified Environmental Management System (EMS), and most others have expressed their interest in ISO 14001 certification. This corresponds to a very specific situation compared with other countries. By the end of 2002, almost 2,400 Swedish companies were ISO 14001 certified, Sweden being in fourth position after Japan, the UK and Germany (Landskrona Kommun, Miljöförvaltningen, 2003).

Even for Sweden, Landskrona has a comparatively high proportion of certified companies. This specific feature should however not prevent the transferability of the Landskrona case. Even in countries with much lower numbers of certified companies, ISO 14001 certification is likely to increase. Indeed, in industries with international markets, ISO 14001 slowly becomes a standard requirement and eventually a necessity for companies to stay in the business (Sinding, 2002). This trend is likely to be further pushed by the globalisation of markets and economies.

As seen in section 2.3.2, the high number of ISO 14001 certified companies involved in the Landskrona IS network can be seen as an advantage of the project. This tends indeed to indicate a relatively high level of environmental awareness and maturity of the companies involved in the IS project. This appears to be also the case for most of the companies that are currently not ISO 14001 certified, which are mostly SMEs. Thus, several have in the past participated in cleaner production projects. It can also be noted that, although not all companies have a certified EMS, almost all of them have dedicated personnel working with environmental issues.

Furthermore, as discussed in section 3.5.4 below, a sub-project of the IS project in Landskrona, is so-called step-by-step group ISO 14001 certification. This sub-project would lead to an even higher proportion of ISO 14001 certified companies in the project.

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[18] According to the Commission Recommendation of 6 May 2003 concerning the definition of Small and Medium-sized enterprises (SMEs) Recommendation 2003/361/EC, replacing the one of 3 April 1996, Recommendation 96/280/EC, SMEs are enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million. Within the SME category, a small enterprise is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million. Within the SME category, a microenterprise is defined as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.

[19] ISO 14001 is the international standard for Environmental Management Systems (EMS) developed by the International Standardisation Organisation (ISO). By ISO 14001 certification is meant that a company's EMS has been certified by an accredited certification body as fulfilling the requirements set by the ISO 14001 standard.

It should also be noted that a 14 of the 19 involved companies are ISO 9000[20] certified.

3.4.4 Interaction and collaboration between the companies before the project

As seen in section 2.3.3 above, existing linkages between the companies involved in an IS network play an important role. Indeed, a high degree of social interactions and a strong sense of community allow for a high degree of trust and mental proximity. As seen in section 2.3.4 above, these two factors provide favourable conditions for IS networking.

In Landskrona there appears to be a rather strong local identity and sense of community. The town is rather small, and factors such as the local football team, which plays in the Swedish premier league, tend to bond the community. Furthermore, the economic hardships of the 1980s are regarded by some as having led to a certain degree of solidarity between the companies and the community in Landskrona (Aronsohn, 2003).

All companies involved in the project do however not share this view. While some do consider that there is a strong sense of community between the companies in Landskrona, others say that they miss such a feeling. Most companies however agree on the fact that there is not enough contact and collaboration between the companies in Landskrona.

The managers of the companies involved in the project did not have a formal structure to meet regularly before the start of the IS project. However, it appears that several of the company managers do have regular informal social interaction with each other. Indeed, several of them appear to be members in the same clubs and thus meet outside of their work.

Regarding actual collaboration, most companies had some collaboration with other local companies, not necessarily with the companies involved in the IS project. In most cases this collaboration was however rather limited. The chemical companies involved in the project have already been collaborating with each other to organise once every third year, within the Responsible Care[21] programme of the chemical industry, an open day at their facilities.

Some of the companies, such as the electroplating company (see Appendix 4) are part of a collaboration network that is managed by a local consultant. It meets to discuss mainly issues relating to training, marketing and compliance with regulation. The network also runs small projects, shares machinery and pools to purchase new equipment. This network consists of 8-10 companies, mostly in the mechanical industry, and is not limited to Landskrona.

Regarding linkages similar to those that the IS project aims to develop, there have been some cases, but these are very limited and correspond to minor exchanges[22]. The two chemical

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[20] ISO 9000 is the family of international standards for Quality Management Systems (QMS) developed by the International Standardisation Organisation (ISO). By ISO 9000 certification is meant that a company's QMS has been certified by an accredited certification body as fulfilling the requirements set by one of the ISO 9000 standards. The most common standards are ISO 9002:1994 and ISO 9001:2000.

[21] Responsible Care is a voluntary programme of the chemical industry meant to help it to raise its standards and win greater trust from the public. It focuses on continual improvement in all aspects of health, safety and environmental performance and on open communication about its activities and achievements (CEFIC, 2003).

[22] Disregarding the heat exchange between two companies and the DH system of the Municipality, described in section 3.5.1.

companies involved in the project (see Appendix 4) do thus occasionally have common purchasing and help out each other if one of them needs a basic component the other company has.

Some companies also occasionally share personnel, when one company needs to increase its production volume, while another company has a reduced activity. This was especially the case between the company manufacturing brake components for trucks and the one producing components for rail vehicles (see Appendix 4), as they used to be located within the same facility.

3.5 Potential collaboration areas and synergies

Although the data collection was not fully completed (as of September 2003), a number of areas for collaboration have already been identified. These potential synergies build upon the exchange of both tangible and intangible resources. Although the economic feasibility of these potential synergies has not been assessed in detail, several of them appear to be clearly feasible from a technical point of view.

3.5.1 Heat

The exchange of energy in the form of heat appears to be one of the most obvious and both technically and economically feasible options. Waste or excess heat exchange occurs in many other existing IS networks, either through direct exchange between industries, or by delivering heat to the local District Heating (DH) system[23]. In Landskrona, the situation is favourable to heat exchange, as the Municipality has a DH system[24]. It can be noted that this type of symbiotic exchange appears to be promising in Sweden in general, as, like Landskrona, many other Swedish municipalities have a DH system.

Several companies involved in the project produce waste or excess heat. Two of the companies, one recycling filter dust for steel works and the other one recycling lead and tin from car batteries (see Appendix 4), have smelters. They produce a constant flow of excess heat that they cannot eliminate or use internally. These companies already supply heat to the municipal DH system, but could supply even more.

Besides these two companies, another company, producing chemicals, could also supply heat to the DH system. This company uses a boiler (burning natural gas) to produce steam for its internal use. This boiler runs at 50% of its capacity, and the company has an interest in running it at full capacity. However, this boiler is 30 years old, and instead of supplying the DH system with surplus heat, the company could replace this boiler with a smaller one.

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[23] A good example of heat exchange involving a municipal District Heating (DH) system is the case of the city of Jyväskylä in Finland (Korhonen, et al., 1999).

[24] It should be noted that future trends regarding DH in Sweden are currently unclear (Johansson, 2003). Indeed, a committee has recently assessed the Swedish energy taxation system, which is considered not to fully respect EU regulation and principles on state aid (SNED, 2003). The final proposals of this committee may have an impact on the future attractiveness of DH, but are still under discussion.

Two other companies[25] produce waste heat in the form of hot air that they cannot eliminate or use internally. It is not clear whether they could also supply the DH system, but they may potentially supply this surplus heat to neighbouring private companies.

The possibilities for direct heat exchange between companies appear however more limited. Indeed, this requires that there are companies that need large amounts of heat. Furthermore, these companies need to be located close to the companies producing the waste heat. So far, one identified possible output for waste heat in private companies involved in the project is in greenhouses used by two of the companies[26] involved in the project. One of these companies is however located 4 kilometres away from the companies having excess heat. Two other possibilities have been identified between neighbouring companies. In one case, that might however imply that a company that so far has not joined the IS project does so.

The DH system is managed by the Technical Department of the Municipality, which is also involved in the IS project. In 2002 the DH system delivered 264 GWh of energy, requiring an energy input of about 298 GWh into the system to compensate for losses during combustion and distribution. The two companies who already delivered heat to the system delivered together 68 GWh (Larsson, 2003). Of the remaining 230 Gwh, 110 GWh were met by burning wood-pellets and waste derived fuel[27]. The remaining 120 GWh were produced through a mixture of natural gas and light oil.

The municipal DH system could use more heat delivered by private companies. However, according to the companies already delivering heat to the DH system, the Technical Department of the Municipality has shown little interest in such an increase of their deliveries.

Furthermore, the Municipality of Landskrona has decided to build a Combined Heat and Power (CHP) waste incinerator. This incinerator will deliver 95 GWh of heat to the DH system, replacing the oil and gas share. The objective is to combine the production of heat and electricity with the handling of unsorted household waste. From an environmental point of view, taking advantage from the existing waste heat seems to be preferable. Indeed, an incineration plant, even with Best Available Technology (BAT), would increase the total amount of air emissions.

It can be argued that the incineration of waste provides negative signals in terms of waste reduction, re-use and recycling. These are higher up in the waste hierarchy that serves as a basis for European Union (EU) waste legislation[28]. They are also, according to IE principles, superior to incineration from both an economic and an environmental perspective (Connelly & Koshland, 2001).

The Technical Department however claims that there is currently no viable alternative to incinerating burnable household waste. Furthermore, the Department plans to sign a contract with another already existing large incineration plant, to exchange mixed household

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[25] One of these companies is the one producing lights for cars and the other one is the one producing plastic packaging (see Appendix 4).

[26] These companies are the two companies producing seeds (see Appendix 4).

[27] This waste derived fuel consists of mostly plastic based pellets produced by the waste management company involved in the project (see Appendix 4).

[28] EU Waste Directive 75/442/EEC.

waste against cleaner fuels such as wood pellets. However, even this does not appear as optimal from an environmental point of view, as it implies increased transportation.

According to the director of the Technical Department (Johansson, 2003), despite the construction of this incinerator, the Technical Department is and will remain interested in receiving more heat from private companies. Indeed, in the environmental report of the DH facility of the Technical Department (Landskrona Kommun, Tekniska Verken, 2002), it is indicated that local resources such as biogas and excess or waste heat should be fully taken advantage of. Furthermore, although the DH system covers most parts of the town, it may be expanded to cover also industrial areas and more remote residential areas.

Despite the decision by the Municipality of Landskrona to build an incinerator, the exchange of waste heat appears thus to be a promising area of the IS project. From an organisational point of view, an interesting issue is the pricing of the waste heat delivered by private companies into the DH system. According to the Technical Department, currently, the price the department pays companies supplying heat is above market price and thus very favourable to these companies.

It is unclear why this is the case. The companies delivering the excess heat may have higher running costs than conventional heat suppliers. Even if that is the case, why does the Technical Department buy this heat? It seems to some extent be connected to the actual decision to develop a DH system in Landskrona. This decision was a political decision, and due to the will of the Municipality to link the local companies to the Municipality in a tangible way. This decision was taken in the beginning of the 1980s and coincides with the period of economic hardship Landskrona was going through at that time (see section 3.3.1 above). This was meant to help ensuring that companies delivering heat to the DH system stay in Landskrona.

Currently, there is no compensation mechanism if the companies do not deliver the heat they are supposed to deliver. As seen above, the companies already supplying the DH system claimed that the Technical Department showed little interest in receiving their heat. The Technical Department on the other hand, indicated that it is very interested in receiving this heat, but that several times, the companies failed to deliver the volumes agreed upon in the contract. Besides assessing the economic feasibility of heat exchanges, such practical issues will thus need to be further explored.

3.5.2 Alternative fuels, chemicals and water

A number of companies have waste flows that cannot be used directly or recycled. An example is a printing company that produces an unavoidable waste stream of wet-strength paper from slitting operations that cannot be recycled. Currently this paper is being landfilled by the waste management company, which is also involved in the IS project. Rather than being landfilled, this waste could serve as a fuel emitting only CO_2 during combustion.

This fuel could either be used on its own or mixed with another fuel, and be used either by another company. However, given the small volumes involved, other companies may not be interested in this fuel. If no private company is interested, it could be used by the new plant the Municipality has decided to build (see section 3.5.1).

Another waste that could be used as a fuel is agricultural dust produced by two of the involved companies[29]. This would however require processing the dust that currently has to be landfilled into pellets in order to eliminate the risk of explosion during combustion. This could be achieved by using another waste, an organic emulsion, from a chemical company involved in the project that could be used to bind the dust into pellets. Finally, one company currently incinerates organic solvents without energy recovery, and this waste could thus also serve as a fuel.

Another potential area for collaboration is the exchange of chemical substances, such as sulphuric acid, which is a by-product one of the company recycling car batteries (see Appendix 4). Currently, this company neutralises this sulphuric acid with caustic. This sulphuric acid could be recovered and used notably by the electroplating company (see Appendix 4). This would however require the acid to be purified. The sulphuric acid could also be used by one of the chemical companies (see Appendix 4) that uses sulphuric acid to neutralise caustic. This does not require purification. On the other hand, the chemical company could provide its caustic to the car battery recycling company. By mutual exchange, these companies could reduce the need for new sulphuric acid and new caustic.

Neutralizing the two substances with each other would be an improvement compared with using new resources. However, from an IE perspective, this is not an optimal outcome. Considering the work that has been put into purifying these substances, it would be preferable to use them as such in a process. As seen above, this however implies a higher degree of purity and concentration of the substances, which would require re-processing.

The emulsion waste that could be used to process agricultural dust into a usable fuel could also be used by the waste management company in its landfill. The same counts also for solvents, which, rather than being burnt, might possibly be recovered and reused. There may be possibilities of recycling and reusing the waste inks of the printing companies (see Appendix 4). There are many other substances for which an output could be found. A crucial issue is however also finding matches in terms of quantities.

Besides energy and chemical substances, another potential area for synergies is water. This is an area where two companies[30] involved in the project have already before the start of the IS project started to discuss the possibility of transferring the large amounts of water that one company uses but that remains clean enough to be used in another process by its neighbour.

There may be similar possibilities for other companies located closely to each other. Companies could also use treated wastewater in secondary processes such as cleaning, or as cooling water. As for heat exchange, exchanges may thus also involve the wastewater treatment plant of the Municipality, which is managed by the Technical Department of the Municipality of Landskrona.

3.5.3 Logistics and common purchasing

Another potential area of collaboration is transportation and logistics. In this case the synergy does not arise from a symbiotic exchange of tangible resources but from the

[29] These companies are the two companies producing seeds (see Appendix 4).

[30] The company that could provide water to its neighbour is the company producing lights for cars, and its neighbour that could make use of this water is one the company producing printed and unprinted plastic laminate for food packaging.

possibility of optimising transportation by coordinating it as much as possible between the companies. This would allow reducing the total transportation requirements and thus also the burden of transportation on the environment. One aspect is to coordinate road transportation to optimise the loading of trucks to and from Landskrona. Two issues may however make this difficult to achieve: the companies involved in the project have diverse and irregular transportation routes, and they work with different transport companies.

It appears that to coordinate their transportation activities, the companies may need to go more through the same transport companies. This has led to the invitation of a local road transport company into the project in July 2003 (see Appendix 4). This company is already used by several of the companies for some of their transports, however in most cases only for express deliveries, which represents only a very small share of their total transportation volumes.

This transport company is an independent company that used to be part of one of the very large transporters. Thus it cannot provide the same low prices as the large transport companies. It focuses instead on providing high quality services, notably through their proximity with customers and their intermediate storage facilities. This company is ISO 14001 certified. Although it is not the only certified transporter on the Swedish market, ISO 14001 certification is still a rather uncommon feature in the road transport branch.

A motivation for the other involved companies to increasingly go through this company could be related the continuous improvement of their environmental work. Indeed, as part of the continuous improvement of their environmental performance, an increasing number of companies try to have more and more ISO 14001 certified suppliers and service providers. Furthermore, this company is currently developing an innovative "No Paper Delivery" system. This system allows considerably reducing paper work through a computerised system, leading to a reduced use of paper and to reduced transportation requirements. Furthermore, this system allows for an improved overview of the transported goods.

Most involved companies may however judge the additional cost of changing to this local transport company as being too important. Furthermore, they may be bound by contracts with their current transporter, which means that they could not switch right away to this local transporter. Then, their current transport companies may have to be more directly involved in the project.

Most companies assume that these transport companies have already optimised their transports to the extent possible, but it is unclear whether that is really the case. A first step would thus be to make an assessment of the degree of coordination by mapping all transports from the involved companies. One difficulty for coordinating transportation is the very different nature of the goods to be transported, as they may not always be compatible.

It can be noted that the Technical Department of the Municipality is responsible for the maintenance of the roads within the Municipality. The department has thus an interest in reducing the volume of heavy road transport, because of the costs induced by the wear and tear to the roads of the Municipality.

The second aspect of reducing the environmental burden of transportation is the possibility of shifting transports from road to rail. Several involved companies have direct access to rail on their property and some already use rail for a significant share of their transport volumes.

Especially the southern industrial area, where most involved companies are located, is well covered by the rail network.

As seen in section 3.3.2 above, attempts have been made earlier by the Environmental Department of the Municipality of Landskrona to shift transport from road to rail, first in the 1980s and again in 1997. The latest project had been, according to most actors involved, very promising but eventually failed, apparently mostly because of a lack of will on behalf of the freight section of the Swedish national rail company.

Re-launching such a project within the IS project would be ambitious, given notably the likely suspicion of actors involved in the latest rail transport project. However, it would allow for significant improvements of the environmental performance of the involved companies. The synergy-effect would lie in the sharing of costs for the development of the required infrastructure. As in the previous project of 1997, the transport company involved in the IS project (see Appendix 4), which has already significant storage activities for its customers, could serve as a logistics platform and the link between road and rail.

The Technical Department of the Municipality is also in charge of the maintenance of the rail tracks within the Municipality that connect industries to the main rail network. There is a consensus within the Municipality to preserve and maintain these tracks, as they are considered as important for the local economy. The Technical Department appears thus to also have an interest in the local rail network being used more by companies.

Another potential area for collaboration that is connected to transportation is common purchasing. This area appears to be more realistic on the short term than the shift from road to rail. Furthermore, it seems to be of direct interest for the companies involved in the project. Several companies have indeed themselves mentioned this as an area they wished to explore.

The idea is that common purchasing would allow obtaining lower prices on the purchased goods, and would reduce the total transportation requirements. Some limited common purchasing already occurs for example between the two chemical companies (see Appendix 4) involved in the project. This common purchasing could for example take place for basic products that most companies use, such as paper, screws, etc.

Some companies also mentioned the possibility of pooling to obtain better prices for energy and for fuels, such as natural gas. This might allow some of the companies to switch over to fuels that may be cleaner than the fuels they currently use.

3.5.4 EMS group step-by-step certification

As seen in section 3.4.3, one area of collaboration, which is actually a sub-project of the IS project, is step-by-step group ISO 14001 certification. This sub-project may appear distant from the actual concept of IS. However, it does relate to it in the sense that it takes advantage of the synergy provided by group certification. Indeed, group certification allows

for lower certification costs for the involved companies compared with individual certification[31].

The step-by-step dimension allows companies to gain recognition for their on-going work before the final certification of their EMS. This is of particular interest for SMEs as a major barrier to certification for them is often precisely the delay between the start of the process and its final recognition. This sub-project of the IS project serves itself as a Swedish pilot project for step-by-step certification of EMS, the concept being also under discussion at the EU level. The Swedish Business Development Agency has therefore allocated an additional specific grant for this project.

From the companies involved in the IS project, six have expressed their interest in this sub-project. Other companies that did not join the IS project, particularly SMEs, are likely to also be interested. Therefore, the IIIEE project team has decided, together with the Office for Trade and Industry of the Municipality of Landskrona, to start this sub-project as a separate project also open to other companies located in Landskrona.

3.5.5 Other potential areas

A series of other more diverse potential areas are also under discussion. One area is the sharing of storage facilities, as some companies have excess capacity, while other companies occasionally need to rent additional storage space.

One potential area is very specific to one of the involved companies, which is a major lighting company, producing lights and providing consultant services on optimal lighting. The company could advise the other companies on the lighting of their facilities to make it more optimal and thus help reducing their electricity consumption. The feasibility of this collaboration will of course depend on the interest of the other involved companies. One involved company has already made an assessment of the lighting in its facilities, but considered its optimisation as being too expensive, the payback time being too long.

Regarding knowledge and skills sharing, one of the involved chemical companies has a long experience of effectively communicating with its stakeholders and the local community through a so-called "community council" (*Samhällsrådet*). Possibly this company could share its experience with the other companies involved in the project. However, as discussed in section 4.3.1, such collaborations have to also clearly benefit the company providing such a service, otherwise it will not spend valuable time and resources on just helping the other companies.

Another minor area is the recycling of scrap metal. One of the companies involved in the project is a rather small local scrap metal recycling company (see Appendix 4). It collects already the metal of most companies involved in the project. However, two of the larger involved companies go through a much larger scrap metal recycling company, which has operations all over Sweden. If these two companies switched to the local company for the collection of their scrap metal, this would result in reduced transportation requirements. Indeed, the larger scrap metal recycler is not located in Landskrona.

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[31] A similar initiative exists in a proposed Eco-Industrial Park in Plattsburgh, New York. Indeed, a key element in the design of this park was to certify the whole park according to the ISO 14001 standard and then assist individual companies in their compliance (Cohen-Rosenthal, 2000).

Another related issue is the fact that small quantities of scrap metal are also collected by the municipal waste management company. The collected scrap metal is currently first transported to the facility of the waste management company, and is then sent further to the local scrap metal recycling company. This scrap metal could be directly transported to the scrap metal recycling company, thus also reducing overall transportation requirements. It should however be noted that there are currently technical and practical reasons for the waste management company to do so, as it needs to monitor the exact quantities and the quality of the different collected metals it is selling to the scrap metal recycling company.

Furthermore, there are areas where a solution has not yet been found but where symbiotic exchanges seem feasible. Thus, one of the involved companies manufactures lights (windows) for the automotive industry (see Appendix 4). This company produces large amounts of currently unavoidable tainted toughened glass waste. The company is thus looking for a possible output for this glass that is currently landfilled. It seems that this glass could possibly be ground and used as an input to produce concrete. The cement importing company that is involved in the project (see Appendix 4) indicated the possibility to help broker a partnership for this company by creating contacts in the cement industry in order to find a company that would be interested by this glass.

The cement importing company produces some cement waste, resulting from the storage of the cement. This waste is currently used by a company in Gothenburg. It could possibly be used locally, notably by the local waste management company on its landfill site instead. This would thus imply reduced transportation requirements.

A possible symbiotic exchange still has to be explored around the sludge resulting from the municipal wastewater treatment plant's operations. However, currently, biogas is produced from this sludge, and most of this sludge is used for agricultural purposes, being of sufficient quality. Thus, its disposal or use does not appear as being problematic, and alternative uses would have to be clearly superior to the current ones.

Finally, collaboration could possibly also take place in areas such as sharing of equipment, machinery, human resources, training, joint utilisation of existing or projected facilities and even on management and Research and Development (R&D). Some of these collaborations, although on a rather small scale, do already take place, such as the occasional exchange of labour force between companies with similar activities.

3.6 Conclusions

The technical and economic feasibility of the symbiotic linkages outlined in the sections above still have to be explored. However, it clearly appears that there is a significant number of potential synergies in the IS project in Landskrona. Furthermore, Landskrona has a series of specific features that appear to be favourable to IS networking. Thus, the companies involved in the project, and local companies in general, notably as a result of the environmental history of the town, have a rather high degree of environmental awareness and maturity. There appears also to be a rather strong local identity and sense of community.

4. Analysis and interpretation

This section analyses various influences of organisational factors in the Industrial Symbiosis (IS) project in Landskrona. The factors outlined by the literature review in section 2 are studied in the context of observations made in Landskrona. The main objective of this study is to test the relevance of these factors and an assessment of their influence on a real example. This section also aims to outline other factors that either have not been outlined by literature or that appear to be specific to Landskrona and that possibly also apply to Sweden in general.

4.1 Motivations for engaging in Industrial Symbiosis networking

This section analyses the motivations of the companies involved in the Landskrona project for joining the IS network. Section 4.1.1 describes and analyses the main motivations of the companies involved in the project for engaging in IS networking. Sections 4.1.2 and 4.1.3 analyse the role that the factors outlined in 2.2 above, based on a review of IE, management and organisational literature, may have played in the case of Landskrona.

4.1.1 Main motivations of the companies in Landskrona

A major motivation for the involved companies' decision to join the IS project appears to be the issue of networking and increasing their contact with other local companies. Some companies already have a rather comprehensive network of contacts with other local companies. However, several companies see this as one of their weaknesses and consider that the lack of contacts between companies is a problem in Landskrona. Some have argued that this is a general problem in Sweden, compared to other countries where companies have much more formal and informal contacts with each other (Helgeson, 2003).

Fundamentally, a majority of companies involved in the project appear to perceive a need for networking and increased contacts with other companies in Landskrona. This feature may be very favourable to the development of the IS network, as it may indicate that the companies will be committed and participate actively in networking activities. As seen in section 2.3.5 above, commitment of the participants is an important factor in IS networks.

There is also a general interest in the concept of IS that is new to most companies involved in the project. They seem to see a certain potential for future developments in it, many considering it as a natural evolution of industry. As also discussed in section 4.3.1 below, some of the companies, such as the scrap metal recycling company and the waste management company (see Appendix 4), actually explicitly consider IS as an extension of their current activity.

As seen in section 3.4 above, most of the companies involved in the project are companies that are known in Landskrona as the ones that usually get involved in that kind of projects. Several companies claim that they always try to be on the forefront in terms of developing innovative solutions and concepts and do not want to miss out on an opportunity. This appears to be notably the case in the environmental field, and is thus also a clear indicator of their environmental maturity.

The general perception of the IS project by the involved companies varies. Several companies explicitly consider the IS project as an environmental project. Some of them have also consciously and actively integrated it as a part of their internal environmental work. On the other hand, one company clearly indicates that it does not perceive the project as an environmental project. This is notably due to the fact that this company believes that it already has significantly optimised its activities. It thus views the possibility that significant new potentials for improvements will be discovered through the project as very unlikely. However, for most companies involved, the decision to join appears to be a combination of environmental and economic considerations[32]. This coincides well with the definition of IS given in section 2.1.2 above.

Some companies appear to have joined the project because they could see direct business opportunities in it. One company sees the project as an opportunity to be seen by the other companies involved in the project, and hopes to gain new customers through the project.

Some companies have joined the project because they had potential collaboration areas in mind or were hoping to solve a specific problem. Thus, the main motivation to join for the company doing flexible printing of packaging materials (see Appendix 4) was the will to find an output for its paper waste (see 3.5.2 above).

However, for most companies, it appears that the main motivation for joining is not the hope or expectation of solving a specific and clearly identified problem through the project. They clearly hope and expect it to provide them with benefits. However, it appears unclear to many of them what exact form these benefits may take and how important they may be.

An interesting question is why these companies have not decided to develop a similar initiative before. As seen in section 3.4.4 above, some of the companies already have IS-type collaborations, but these were rather limited. Most companies have expressed the need for an external body to push for such an initiative. Furthermore, they themselves were not willing to spend the resources required to coordinate a network[33]. The project proposal by the IIIEE was attractive as it provided an external coordination body and funding. As discussed in section 4.3.5 below, it also appears that the IIIEE was perceived as a credible research institute with a high level of expertise in IS.

Furthermore, many companies indicated that the timing was favourable, the project coming at a good point in terms of their activities and their environmental work. It can be noted that a number of approached companies turned down the invitation to join the project because they could not spend the required time and resources to work with the project at that time. This is thus mainly a timing issue, and it may indicate that the interest of companies in joining such a project can be much bigger than what is reflected by the number of positive responses.

4.1.2 Institutional pressure and legitimacy

Besides the specific motivations stated by the companies, institutional pressures clearly appear to have played a role in Landskrona. First, as seen in section 2.2.1 above, IS networks

[32] These economic considerations are detailed in section 4.1.3.

[33] This confirms what has been discussed in section 2.3.6.1.

may be more likely to form for purposes of enhancing legitimacy in a context of explicit institutional and public criticism. In the Landskrona case, this has certainly been a motivation for companies to start more comprehensive environmental work since the 1980s (see section 3.3.2). This pressure is less explicit today, but it appears to have motivated at least indirectly some companies' decision to join the IS network.

Fundamentally, regulation and policy also played an obvious and important role in Landskrona. Regulation clearly conditions all choices of the companies involved in the project. This is especially the case, as, in Landskrona, as seen in section 3.3.2 above, the Environmental Department appears particularly active in its supervision work.

Furthermore, several of the companies involved in the project in Landskrona do only exist directly or indirectly because of environmental regulation taken at various levels. This is notably the case for the company recycling filter dust from steel works (see Appendix 4). The company recycling car batteries (see Appendix 4) only exists because of regulation on Extended Producer Responsibility (EPR). The same is clearly also true for the waste management company (see Appendix 4).

Besides regulation, institutional pressure appears to also materialise through policy. Thus, regarding the exchange of waste heat with the DH system, the driver is the Technical Department's policy urging it to take advantage of local resources such as waste heat. Fundamentally it can be noted that if many Swedish municipalities have comprehensive DH systems, this is notably due to the fact that this form of heating has been encouraged by national policy and energy taxation.

Regarding the legitimacy argument described in section 2.2.1 above, it appears that it has also played an important role for some companies. For example, for one of the chemical companies (see Appendix 4), participating in the project regarded to contribute to maintaining the company's "license to operate". This company is a subsidiary of an international group, which has a "sustainable entrepreneurship" programme. This programme encourages units of the group to collaborate with other actors and participate in various forums. The company's decision to join the project is thus partly also a result of this "sustainable entrepreneurship" programme. Other companies, although it is not part of an explicit policy, have also expressed a general sense of responsibility in contributing to the well being of the local community.

As seen in section 2.2.1 above, according to the concept of mimetic isomorphism (Sinding, 2002), in order to comply with prevailing norms, companies may engage in IS networking because neighbouring companies have done so. Although it is unclear to what extent, this does seem to have been the case for some companies in Landskrona. Thus, it appears that the company manufacturing brake components for trucks (see Appendix 4), being the largest company in Landskrona, has often been perceived by smaller local companies as a model to follow. As seen in section 4.1.1, some companies joined because they did not want to be left out and miss a potentially big opportunity.

Mimetic isomorphism however clearly does not appear to be a sufficient motivation for companies to join IS networks. A risk with companies joining IS projects because of mimetic isomorphism is that the project may fail to deliver value to such companies. If that happens, these companies are likely to drop off, and may actually burden IS projects, that may as a consequence also fail delivering value to the other companies.

Thus, IS networks may benefit from analysing the real motivations of companies for joining the network. The project coordinators may also try already in an early stage to make sure that there are indications of potential synergies for the companies they recruit.

4.1.3 Competitive advantages, increased efficiency, saved costs and interorganisational learning

In the Landskrona project, companies have not explicitly mentioned the possibility of gaining competitive advantages through IS networking. However, a majority of the companies involved in the Landskrona project clearly stated that they hope to eventually gain financially from the project. On the other hand, as seen in section 4.1.1, most companies do not have clearly identified expectations regarding benefits they may obtain through the project.

Regarding the issue of accessing critical resources, discussed in section 2.2.2 above, it is unclear how critical the resources, around which the companies in Landskrona may collaborate, are for these companies. This is notably due to the fact that the data collection process was not fully completed as of September 2003. Thus, the exact share of the costs associated with wastes and by-products within overall company costs is not known.

However, it appears that for some of the companies, these resources may be considered as critical resources. Obvious examples are the waste management company and the scrap metal recycling company (see Appendix 4). The resources they are likely to exchange with other companies are indeed at the core of their business. Another resource that may possibly be considered as critical is heat. This is the case of the Technical Department, for which delivering heat to the DH system is a central activity.

Heat can on the other hand, as seen in section 2.2.2 above, also be seen as critical for the companies supplying their excess heat to the Technical Department. The filter dust recycling and the car battery recycling companies (see Appendix 4) have indeed energy-intensive activities and inevitably produce large quantities of heat as a by-product. Finding a commercially valuable output channel for this excess heat is thus a critical issue for them.

Furthermore, for some companies the by-products that are considered for utilisation by others currently constitute substantial costs. This is notably the case of the chemical company having an organic emulsion as a by-product (see section 3.5.2 above). It currently costs the company a substantial amount of money to dispose of that by-product.

Despite the fact that for some companies the resources on which the IS project focuses can be seen as critical, observations in Landskrona may lead to a radically different finding. In fact it appears that some companies may have agreed to join the project precisely because it does not address too critical resources. Indeed, as seen in section 2.3.1.2 above, these companies may be reluctant to collaborate on truly critical resources, because of the risk of proprietary information disclosure. This appears notably to be the case for the company manufacturing brake components for trucks (see Appendix 4) regarding lubricants.

This may imply that via IS networking, companies may initiate collaborations with each other that would not have occurred if core resources were on the agenda. As interactions start to evolve, they may then find other grounds for collaboration.

A search for increased efficiency has certainly been a consideration for the companies involved in the Landskrona project. However, again, the companies do not appear to have

clear expectations regarding such increased efficiency. As seen in section 2.2.3 above, IS networking may possibly also attract companies because of the economies of scale it may induce. In the case of Landskrona, economies of scale do appear to be a relevant factor. Thus several companies have at a very early stage identified common purchasing as an attractive potential area of collaboration (see section 3.5.3).

None of the companies in Landskrona have explicitly mentioned the possibility of reducing their transaction costs as a motivation for engaging in IS networking. However, all insisted on the fact that they had long-term and close relationships with their customers and suppliers. This tends to indicate that the possibility of reducing transaction costs in this way within an IS network corresponds to something the companies already try to achieve in their current way of making business.

Furthermore, it clearly appears that, as the possibilities for collaboration become more clearly identified, there will be areas where collaboration with local actors will provide the companies involved in the project with closer business interactions. This may also reduce certain transaction costs, such as those associated with waste handling.

Interorganisational learning (see 2.2.4 above) is clearly also an important factor in Landskrona. Companies involved in the project do hope to learn from other companies participating in the project, and that together they may possibly find innovative solutions to their problems. The company recycling filter dust (see Appendix 4) has thus expressed interest in benefiting from the experience of one of the chemical companies (see Appendix 4) in communicating with the local community (see section 3.5.5 above).

Furthermore, after only two formal meetings of all the companies, evidences of knowledge sharing between the companies has already been observed. So far, it has been taking place in the form of learning about new potential business partners rather than direct transfer of know-how.

4.2 Risks and barriers

As seen in section 2.3.1.2 above, a series of actual or perceived risks may deter companies from engaging in IS networking. This section presents both risks and barriers that are perceived by the companies in Landskrona and potential risks and barriers that have been observed, although they are not explicitly expressed by the companies.

4.2.1 Perceived risks and barriers

The companies involved in the Landskrona project appear to perceive little or no risks connected with IS networking. This low risk perception may however be due to the fact that the concept of IS networking is new to the companies, and they have no real experience of its practical implications. Furthermore, so far, they do not have a clear view of what kind of partnerships they may engage in.

As seen in section 2.3.1.2 above, IS networking may induce monopoly-type phenomena, if for example one company becomes the exclusive provider of a service or product within a network. In the case of Landskrona, this has been expressed as a matter of concern by some companies. Examples of companies for which this might be the case are the waste management company, the transport company, or the scrap metal dealer (see Appendix 4).

These companies may hope to become the exclusive service providers of the companies engaged in the network.

However, these companies do not appear to be in a position of abusing of a monopoly-type exclusive partnership agreement on the other companies. Indeed, the other companies can always switch to external suppliers or service providers. This possibility allows maintaining sufficient pressure on these companies and thus ensuring adequate service and prices. This however means that such flexibility needs to be in place, and that contracts within IS networks should be neither too binding nor too long-term. Not having long-term contracts may pose problems in certain cases where companies need to have long term guarantees to take the risk of making large investments.

Another risk perceived by some of the actors is, as discussed in section 2.3.4 above, too significant cultural differences between private companies and public bodies. Some private companies have expressed the concern that if public bodies are involved in the coordination of the network, procedures within the network may become too bureaucratic and complex. As seen in section 4.3.4.1 below, private companies are also concerned with the fact that the Environmental Department may not be sufficiently aware of the constraints of the private companies. Thus, some are afraid that it may pressure them to implement synergies that they do not consider as being economically viable.

On the other hand, the Technical Department has already been confronted with the problem that private companies consider that it has not as strict constraints as they do. They tend to consider that the Technical Department does not have to meet the same requirements in terms of profitability of its investments. They may thus expect it to participate to a greater extent in common investments than it itself wishes to. It is true that regarding payback times for investments, these can in general be much longer for public bodies such as the Technical Department than for private companies. Furthermore, because it is public, the Technical Department may and should also consider more general interests than what private companies may do. However, a balance has to be found, and neither side should take advantage of this difference in nature between the public and the private actors of the network.

4.2.2 Globalisation: a potential barrier to industrial symbiosis

A potential barrier to IS networking, as discussed in section 2.3.1.1 above, is the general globalisation trend of markets and company structures. An increasing number of companies are subsidiaries of international groups.

The Landskrona project is a clear illustration of the fact that globalisation may constitute a barrier to IS networking. As seen in section 3.4.2 above, half of the companies involved in the project are subsidiaries of international groups. It appears that this may limit the extent to which these companies can collaborate with other companies at the local level.

First, the fact of being subsidiaries of international groups implies that these companies have reduced autonomy in their decision-making. This did in most cases not influence their decisions to take part in the project. However it may become influential for investments that can be required in the future as investments above a certain level have to be approved at group level.

Furthermore, in several cases, the company's group has set restrictive standards and requirements. Especially in the chemical industry, groups set standards both for products and for processes. The objective is that a product be the same regardless of the unit where it has been produced. This may make it impossible for a company to change an input into its process by using another local company's by-product or waste.

In some cases this standardisation can be positive, as group safety and environmental policies force all subsidiary companies to respect common standards. This is however not so relevant in a Swedish context, as Swedish standards are often higher than the international standards groups set for their activities all over the world.

It appears that group policies may also be a barrier to IS networking. Some companies' groups have restrictive secrecy policy that forbids collaboration with competitors and information disclosure. This may make collaboration impossible, even when there is no real threat of disclosing sensitive information at the local level.

Another barrier due to the concentration of companies into large international groups was observed in the Landskrona project. It is the fact that groups increasingly sign regional, e.g. European-wide contracts with suppliers. This strongly reduces the possibilities for common purchasing between different companies at the local level (see section 3.5.3). Thus, economies of scale are still or possibly actually increasingly a barrier to local decentralised solutions.

However, in some cases, the fact for companies of belonging to an international group can be a driver for joining IS projects, as it has been the case for one of the companies involved (see section 4.1.2 above). Thus, globalisation is not necessarily only a barrier to IS networking.

In general, it can be noted that, although the companies involved in the project acknowledge these potential barriers, they seem to consider that these can be overcome.

In some cases, companies have informed their group about their involvement in the project and the group is very supportive of this involvement. However, in most cases the project is considered as a small local project and the group has often not been informed. It appears to be important that once more tangible progress has been made in the project, companies inform their groups of their work in this field. Indeed, this may notably contribute to ensuring that the companies' groups do not make decisions that compromise these efforts at the local level.

4.2.3 Other potential barriers and risks

Although most companies say that they do not perceive major risks connected with IS networking, it appears that in practice, there clearly are things that they are reluctant to do.

Thus, the companies in Landskrona appear rather reluctant to the idea of changing from a current service provider to one of the companies involved in the project. This is due to the fact that this implies developing a new relationship from scratch and replacing a well-functioning relationship for one with a, although more local, less known or even completely unknown company. Most companies claim that if the price for the provided service is the same, they will take the step of choosing the local supplier or service provider.

It is however unclear to what extent this will really be the case. Indeed, a specific case where companies could change to a local service provider is, as seen in section 3.5.5 above, for the collection of scrap metal. When asked why this had not already been done, the concerned companies provided various reasons for not doing it, although they had agreed on the theoretical possibility of implementing such a change.

This does anyhow indicate that more local solutions should not be more expensive than the existing linkages. They may possibly even have to be cheaper or provide better service for the same price for companies to opt for them.

Similarly, most companies say that the issue of information sharing should not be a barrier to IS networking, as the information required for IS networking is not confidential. However, most of them appear reluctant to the idea of disclosing the data collection forms (see Appendix 5) to all other companies. The reasons for this reluctance are unclear. One possible explanation is that this information, although not confidential, could be useful for competitors, and thus companies are not willing to make it freely available. On the other hand, this reluctance may simply be a remnant of the traditional reluctance by companies to share information.

As seen in section 2.3.6.1 above, this barrier can however be overcome through the means of the coordination agent of the network. Indeed, companies appear to agree more easily to share information with this agent, which then can help identifying potential collaboration areas. Sharing the data collection form with the other members of the network could however be useful to discover potential synergies that the coordination agent has missed. Companies are more likely to discover a possible use of another company's by-product, given their much better knowledge of their own processes. The visits of each other's facilities that was actually suggested by the companies themselves, may help in this respect.

Most companies involved in the Landskrona project are rather keen to develop new products, or outputs which have higher added value, as a result of IS collaboration. However, most of them appear, at least on the short term, to exclude the eventuality of changing their main products as a result of IS collaboration. This may represent an important barrier in the sense that a by-product or a waste of another company will seldom be identical to a virgin raw material. Thus, the use of a by-product or a waste as an input almost inevitably implies somewhat changing the characteristics of a product.

Besides being a potential barrier to IS networking, this could also be seen as a missed opportunity. Indeed, the use of wastes or by-products might favour product differentiation, which is traditionally seen as a source of competitive advantage (Porter, 1985). However, it is unclear whether product differentiations resulting from IS networking could be strong enough to provide companies a competitive advantage, or whether any differentiation can be gained to start with. If not, this would tend to indicate that it is difficult to reflect the connections IS networking provides to the market, this thus being a weakness of IS networking.

A potential problem that has been observed in Landskrona is the fact that some company managers say they need to have a clearly identified problem to start collaborating with other companies. For some of the companies there is not this concrete driver of solving a specific problem. This makes that these companies have no clear incentive to collaborate. This may lead to a catch 22 situation. Thus, some companies say that they will open themselves up and

collaborate accordingly to the possibilities they see. However, these possibilities may only be uncovered if the companies do collaborate and are willing to share information.

As discussed in section 2.2.5 above, there may be power struggles within IS networks which may lead to opportunistic behaviour that may eventually compromise collaboration. There appears to be a certain risk of power imbalance among the companies involved in the project in Landskrona because, as seen in section 3.4.2 above, the project consists of companies of very different sizes.

Besides imbalances due to the varying size of the different actors, power struggles may also occur because companies are competing for the same resources. Thus, although the companies in Landskrona do not perceive each other as competitors, companies may for example compete around the exchange of heat. Thus, if the Technical Department does not need all the heat the companies involved in the project are willing to provide, these companies may compete with each other to obtain the best contract with the Technical Department.

Rather than being a problem, this may actually be positive in the sense that the price of the heat may thus be closer to the market price. Thus, this may indicate that such elements of competition and power struggle may to some extent be healthy for IS networks.

There may also be problems due to a lack of reciprocity between the actors in the network. As seen in section 2.3.1.3 above, both parties involved in a collaboration must clearly benefit from the collaboration. In Landskrona, it is not sure that all parties are systematically interested to collaborate on certain issues.

Finally, some actors do not appear to be sufficiently motivated and committed to the project. This is further discussed in section 4.3.2 below.

4.3 Organisational factors influencing the outcome of networking

This section analyses the main organisational factors that may influence the outcome of the IS project in Landskrona. The purpose is to test the relevance of the factors outlined by the literature. Besides demonstrating the relevance of most of these factors, and the way they exert their influence, the analysis of the Landskrona project indicates some specific factors that have been observed in Landskrona. Some of these factors may apply to IS networking in general while other appear to be dominantly specific to Landskrona and a Swedish context.

4.3.1 Alignment of Industrial Symbiosis networking with business realities

It clearly appears that the companies involved in the project in Landskrona have joined the project because they could see potential business opportunities in it. This to some extent indicates that they fundamentally consider IS networking as sufficiently aligned with their business realities.

Because the project is still at a very early stage, it is difficult to draw conclusions on how compatible IS networking actually is with the constraints of the companies in Landskrona. Incompatibilities between potential collaborations and the business constraints of the

companies may only clearly appear, once the companies have started concrete discussions on how to proceed. However, already at this stage it is possible to outline some elements.

The companies say that they are open to most things, and that there is no real limit to how far companies are willing to go in terms of collaboration, as long as it makes business sense. However, as soon as practical collaboration possibilities that seem rather easy to implement were mentioned, the companies seemed to consider these collaborations not feasible. For example, as seen in section 4.2.3 above, companies seem to be reluctant to the idea of changing to a local supplier or service provider when they have developed a good relationship with their current supplier.

If companies are in effect reluctant to implement these minor measures, it becomes a valid concern whether or not they will be willing to engage into more complex collaborations requiring notably more substantial investments. Indeed, as discussed in section 2.3.1.1 above, one aspect that makes IS networking not aligned with business realities can be investments. The payback time for these investments is often longer than what is standard for private companies. This is clearly the case in Landskrona. Although it is difficult to speak in general terms, most companies, notably because of pressures from their group, require short payback times, often one to two years.

It should be noted, however, that most of the companies distinguish between different types of investments, with different payback time requirements. These different types of investments can be summarised as pure capital investments, investments related to compliance with regulation, health and safety or the environment, and strategic investments. For pure capital investments, the payback time has to be very short. For the two other types of investments, longer payback times can be considered. However, although some of the investments within IS networking could be categorised as environmental investments, it appears that most of the time, these investments would be considered as capital investments.

Another central issue is contracting, which is, as seen in section 2.3.1.4 above, an important safeguard for the partners of symbiotic exchanges. As seen in section 3.5.1 above, contracting has already shown to be problematic in Landskrona. Thus, in the existing heat exchange with the Technical Department, there is no compensation mechanism built in the contract. Such a compensation mechanism appears necessary, as the companies supplying heat to the DH system have in the past failed to deliver the quantities agreed upon in the contract.

In a transactional relationship between two private companies, such a failure to deliver would most probably not be tolerated and exchange partners would protect themselves against such risk. By not properly compensating the Technical Department, the private companies appear to be taking advantage of the fact that the Technical Department, in their eyes, does not have to meet as stringent economic requirements as private companies have to.

If the private companies' failure to deliver is really due to technical problems beyond their control, this could also be a problem for future heat exchange. It is indeed questionable whether they can deliver much more heat to the DH system, if they already face problems with the current delivery volumes. Thus, properly designed contracts clearly appear to be an important requirement for certain types of exchanges.

Pricing is also an issue that has to be handled. The companies involved in the project in Landskrona do not appear to be willing to pay a price premium for collaboration within the

network. Most of them will only change from their current supplier or service provider to a company in the network if the price for a provided service is the same. This is a major limitation, as many local small companies cannot compete on price with their much larger competitors and focus on service quality.

Pricing appears to also already be a problematic issue in existing exchanges in Landskrona. As seen in section 3.5.1 above, according to the Technical Department, currently, the price the Department pays to companies supplying it with heat is above market price. This may to some extent be motivated by higher running costs. However, artificially high prices may not be viable on the long-term. As seen in section 2.3.1.3 above, symbiotic exchanges have to be truly beneficial for both parts.

Thus, the Technical Department has to clearly benefit from the exchange. As seen in section 3.5.1 above, the Municipality of Landskrona has decided to build a waste incinerator. With this new plant, the Technical Department may not be as dependent on other sources of heat. If the excess heat delivered by the private companies is not attractive enough, it is not sure that the Technical Department will continue buying it, despite its policy to take fully advantage of local resources and the political decision originally motivating the development of the DH system (see section 3.5.1 above).

Furthermore, this artificially high price could be seen as a subsidy. As discussed in section 2.3.6.2 above, public financial support may sometimes be required to support the initial phase of an IS network. However, this financial support should not lead to the development of non-viable linkages.

Thus, prices within IS networks should aim at either being below, or at least reflecting market prices. Indeed, even if exchanges imply significant environmental improvements, they are less likely to be sustained if these environmental improvements are perceived as too expensive and are not coupled with economic benefits.

In cases that involve public bodies, such as the heat exchange in Landskrona, it can be argued that giving priority to general interest considerations is one of the roles of public bodies. Thus it can be argued that they should subsidise initiatives whose environmental benefits are not matched with their economic ones. However, there are clearly limits to how much even public bodies can do this, as they also have financial constraints.

Besides pricing, another cost-related issue, as discussed in section 2.2.3 above, is transaction costs. IS networking may both imply increased transaction costs and to some extent contribute to reducing the transaction costs of companies. As discussed in section 2.2.3 above, one way it may reduce transaction costs is through sourcing locally instead of from distant suppliers. Observations in Landskrona however indicate that this may actually increase transaction costs for companies. Indeed, the subsidiaries of international groups have regional group agreements with suppliers, which allow for low transaction costs. Changing to small local suppliers may actually increase these costs.

Regarding the relationship between companies collaborating within the network, most companies in Landskrona seem to consider that it would not radically differ from a more traditional supplier-customer relationship. Increased dependency on the network is not seen as a problem, as most companies already try to develop long-term relationships with their suppliers and customers. However, again, it is difficult to draw conclusions on this issue

from what is expressed by companies at such an early stage, as they have not experienced actual collaboration through the IS network.

As seen in section 2.3.1.2 above, another aspect through which IS networking is not fully aligned with business constraints is the fact that it requires significant information sharing. Companies are therefore likely to be reluctant to collaborate with companies they see as direct competitors within an IS network. In the case of Landskrona, it clearly appears that several companies would have more hesitated to join the project if some of their direct competitors had been involved in the project. Thus, although it is possible to identify collaboration areas among competing firms that can only be realised by collaboration and that can benefit them both equally, IS projects may try to avoid recruiting direct competitors.

On the other hand, an element of competition within IS networks might to some extent be beneficial, as it might prevent problems such as too high prices and opportunistic behaviour. Internal competition is a key feature of Porter's (1998) cluster theory. This poses, similarly to developing environmental target for an IS network (see section 2.3.7 above), a dilemma between recruiting enough companies, and recruiting the right mix of companies.

Finally, the relatively low fee companies had to pay in order to participate in the IS project (see section 3.1 above) probably played an important role in attracting companies into the project. Thus, although, as discussed in section 2.3.5.1 above, a participation fee may help ensuring a high level of commitment of the companies, in the case of Landskrona, a higher fee would probably have deterred several companies.

4.3.2 Commitment and active collaboration

As covered in sections 2.3.4 and 2.3.5 above, important factors for the outcome of IS networking are the level of commitment and of communication between the members of a network. So far, the project in Landskrona has provided a mixed picture. However, again, it is difficult to draw far reaching conclusions on these factors in Landskrona, as the project is still in its early stages (as of September 2003, there have been only two formal meetings gathering all actors of the network).

At the first meeting, attendance was rather low, only about half of the companies being present. This was however due to an unlucky event. Many participants did not manage to attend the meeting, because of a car accident that blocked them on the motorway between Landskrona and Lund, where the first meeting was hosted by the IIIEE. Furthermore, some of the participants could not attend because of unforeseen events in their companies. A practical indication of this is that already with 20 companies involved, it is very difficult to have meetings with all actors present simultaneously.

It is difficult to judge the degree of commitment and active collaboration on such basis. However, during the meeting, the degree of both formal and informal communication was very low, even during the dinner consecutive to the meeting. Most companies considered this as being normal for the first meeting, and possibly typical for a Swedish context. This may indicate that IS projects in a Swedish context may require more time for participants to communicate openly with each other than it might be the case in other countries. However, again, it is very difficult to draw such conclusion based on one isolated case.

This first meeting is however not very representative, and during the second meeting[34], attendance was higher, and there was already much more interaction between the companies. This may to some extent be due to the fact that the companies involved in the project had already a better knowledge of the concept of IS. They also had a clearer picture of potential collaboration areas and partners, as a result of the interviews conducted by the project team. This confirms the fact that it is much easier for companies to collaborate with each other, once they have identified specific potential areas. Furthermore, it indicates that interactions intensify, simply, as time goes by.

Besides these general meetings, it seems that, at least before the second general meeting, most companies had not started to discuss on a bilateral basis. The only case that has been observed is that of the two companies, which had started discussing the possibility of exchanging water already before the start of the project (see section 3.5.2 above). In the second general meeting, the companies were encouraged by the project coordinators to form thematic groups according to the main synergies that had been outlined so far. The companies were encouraged to continue discussions within these groups between general meetings. It is so far unclear whether they have started to do so.

The first two general meetings were hosted by the IIIEE and the Office for Trade and Industry of the Municipality of Landskrona. The next meetings are to be hosted by some of the larger companies involved in the project. These companies are to organise, in connection with these meetings, study visits of their facilities for the other companies. This may help companies to identify new potential synergies, as they get to see each other's actual processes. It would be desirable that even the smaller companies that do not host general meetings organise such study visits.

It is difficult to comment on the general degree of commitment of the involved companies to the project. From the meetings and interviews, most company managers appear committed. As discussed in section 4.3.3 below, there is no company that stands out as having a much higher degree of commitment than the other companies and thus being able to claim the title of project champion. However, there are clearly some companies that are more active than others.

As seen in section 4.3.3 below, the project in Landskrona has neither an explicit anchor tenant. One actor, the waste management company (see Appendix 4), has expressed great ambitions within the project. However, so far, it has actually not participated very actively in the project, notably not attending general meetings.

While most companies however have so far participated sufficiently in the project, one actor that has not participated enough is the Technical Department of the Municipality of Landskrona. Here, it even was very difficult for the project team to finally have a meeting with the head of the Department to conduct an interview. This lack of active participation is of concern, as the Technical Department is a central actor in terms of potential synergies. It is further discussed in section 4.3.4.3 below.

In general, however, it appears that the companies involved in the project do not work more with the project than directly requested by the coordinators of the project. Most companies were rather late in filling in the data collection form, which is a basic requirement for the

[34] This was the first so-called breakfast meeting (see section 3.2) of the project.

project coordinators to explore potential synergies. Furthermore, none of the companies replied to an internet-based questionnaire that was sent to them to receive feedback on the second general meeting. This was the case, although the companies had said that they were willing to use such web-based tools, provided their use was not too time consuming.

Although there was a requirement for companies to spend a minimum amount of time and resources on working with the project, most companies do not appear to have spent this time and these resources. However, again, it is difficult to draw definite conclusions on their commitment based on these observations, as this may be due to specific circumstances, such as the fact that the project started just before the summer, when activity in most companies runs low. Furthermore, the author did not trace what has been happening after the second general meeting.

It clearly appears that the project coordinator constantly has to push the companies through regular follow up and contact. This underlines the importance, as discussed in section 2.3.6.1 above, of the coordination agent. This agent should be highly committed himself, and also have sufficient resources to be able to fulfil his work.

However, the observations above indicate that many of the actors involved in the project rely too much on the work of the coordination agent. It is clear that this coordination agent cannot develop a viable IS network alone. Thus, although this seems very obvious, companies have to participate and collaborate actively. It is important that the coordination agent succeeds in convincing the members of the network to willingly and spontaneously maintain high levels of interaction with other project participants as quickly as possible. This is however clearly a very difficult task, and it is unclear how this could be achieved.

IS networks probably require coordination agents even once they are up and running to remain adaptive. However, if companies do not manage to do their share of the work to coordinate the network, they will need to finance more substantially the work of the coordination agent.

4.3.3 Relevance of champions and anchor tenants

Section 2.3.5.2 above discussed the importance for an IS network of having a champion and/or an anchor tenant. As seen in the section above, in Landskrona, there does not appear to be a clear champion, nor anchor tenant. This poses the question of how relevant the issue of having a champion or an anchor tenant is.

In the Landskrona project, the Technical Department could, to some extent, be seen as an anchor tenant, in the sense that it demands high quantities of heat, which can be sourced from companies participating in the network. However, as seen in section 4.3.2 above, the Technical Department has so far not participated actively enough in the project. Thus, it does not provide the network with the advantages an anchor tenant is supposed to provide in terms of helping to ensure the commitment of the other actors to the network.

One actor, the waste management company (see Appendix 4), has indicated that it could envision its role as the coordinator of the network (Hafström, 2003). It perceives such a coordination role as a natural extension of its current activities. With such an ambition, the company could be expected to act as a champion of the network. However, similarly to the Technical Department, so far, this company has not participated actively enough in the network to claim the title of champion of the network.

Besides, it can be noted that it may not be desirable to have the waste management company as the coordinator of the network. The company may want to establish and be an intermediary for all the linkages, thereby blocking the development of one to one interactions.

This poses the question of whether it is always necessary to have an anchor tenant or a champion. If arguments about the necessity of an anchor tenant are correct, the absence of such anchor tenants or champions in Landskrona may appear as a weakness of the project. On the other hand, the situation in Landskrona may indicate that is not absolutely necessary for IS networks to have an anchor tenant or a champion.

Such actors certainly may contribute to the successful development of a network by helping to ensuring a high level of commitment of the other actors. However, if the project coordinator manages to secure such commitment through other means, anchor tenants and champions do not appear as necessarily required to develop an IS network. This may actually even be a better way of development, as it allows avoiding the risk for opportunistic behaviour discussed in 2.3.5.2 above.

4.3.4 The ambiguity of the role of the public bodies involved

Section 2.3.6.2 above outlined the role that public bodies may play in the development of IS networking. As seen in section 3.4.1, the Municipality of Landskrona is involved in the project through its Technical Department, and to some extent by the involved waste management company (see Appendix 4), which is owned by the Municipality. From an institutional perspective, the Municipality is involved in the project through its Environmental Department and its Office for Trade and Industry.

It appears, however, that the role that these institutions should play in the network is currently still rather unclear. Furthermore, it appears that the Municipality may need to be more actively involved in the project.

4.3.4.1 The Environmental Department of the Landskrona Municipality

As seen in section 3.3.2, an interesting feature of the project is the strength of the Environmental Department of the Municipality, as this may represent a significant leverage point to implement symbiotic collaborations. Companies were asked to describe what according to them should be the role of the Environmental Department in the project. All companies considered it important that the Environmental Department was involved in the project.

Some companies had no vision of what this role should be. A significant number of them actually envisioned an active role for the Department, arguing that, as a supervision authority, the department ought to have a good knowledge of the involved companies' activities and of their environmental aspects. They argued that the Department could contribute to finding new potential areas for collaboration between the companies.

Another mentioned potential role was to advise the network on environmental regulation and its likely evolution. The Environmental Department might possibly even be able to contribute to eliminating regulatory barriers to symbiotic linkages by lobbying national authorities, notably through the National Reference Group (NRG) (see section 3.2 above and Appendix 6).

Not so surprisingly several companies wish that the Environmental Department became a bit more flexible, and more aware of their constraints, and hope that the IS project will contribute to such an evolution.

Although most companies see the Environmental Department as playing an active role in the project, the Department itself appears not to be sure whether it is willing to play such a role, as it might compromise its objectivity as a supervision authority. Furthermore, the Department considers that it has not the resources to play an active role. It seems to have itself a rather unclear picture of what its actual role should be in the network.

The fact that the Environmental Department is the environmental supervision authority for many of the companies[35] may imply that there is a conflict of interest between this supervision role and an active role in the project. This is not only a concern for the Environmental Department itself. Although most companies state that the Environmental Department should play an active role, some are concerned that this may actually hinder the progress of the project. Indeed, discussions on potential collaboration areas may provide the Environmental Department with knowledge it may use against the companies. It could for example force them to implement measures that they deem as not sufficiently economically viable. This risk might inhibit some companies from collaborating openly in the network.

Thus it appears that although there is a consensus among the companies on the importance of the Environmental Department being involved in the project, the nature of its role is unclear. It may be limited to being informed at an early stage about planned collaborations, so that it can intervene in the design stage of the process and insure compliance of the collaboration with regulation.

The difficulty of defining the role of the Environmental Department in the project in Landskrona indicates that IS networking requires the role of the various actors of a network to be properly defined. Otherwise, there is a risk that they just attend meetings, and do not contribute to the development of IS networks in an effective and efficient way.

4.3.4.2 The Office for Trade and Industry

Also regarding the Office for Trade and Industry (*Utvecklingsstiftelsen*) the picture regarding its role in the network is somewhat unclear. Many IS networks documented by literature were initiated and/or managed by regional trade associations or business councils.

As discussed in section 2.3.3 above, these structures often are an already existing link between the companies involved in a network and already provide a frame in which these companies meet regularly. This was notably the case of the Tampico By-Product Synergy project initiated by the Business Council for Sustainable Development – Gulf of Mexico (BCSD-GM). A key player in ensuring the success of this network was the pre-existing local industrial association, which was seen by the involved companies as a valid partner (Duret, 2003).

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[35] According to the Swedish Environmental Code (*Miljöbalken*), there are three main types of companies, A, B and C companies, and the Environmental Department of the Municipality is responsible for the supervision of B and C companies. A companies correspond to companies having an activity classified as having a high environmental impact (*miljöfarlig verksamhet*) and are supervised by the county administration (*länsstyrelsen*).

In Landskrona, it seemed natural to involve the Municipality's Office for Trade and Industry into the project. However, although the Office claimed that it has frequent contacts with most companies involved in the project, many of the companies said they had little contact with the Office. Many of them did not consider the Office as the natural platform for interaction between companies described above.

Some of the companies did not even know exactly what the Office for Trade and Industry was doing. This may to some extent be due to the fact the interviewees within the companies were not always the Managing Directors (MD) of the companies. The environmental or production manager was not necessarily aware of contacts between the company's MD and the Office. Another explanation is the fact that the Office primarily focuses on attracting new businesses to Landskrona. The Office for Trade and Industry was created in 1982, when the shipyard closed down, with the explicit task of attracting new industry to provide new employments in Landskrona.

Besides publishing brochures and a catalogue of the companies established in Landskrona, the Office for Trade and Industry organises focus meetings with presentations on specific topics, such as e-business, for example. Invitations are sent to all companies in Landskrona, but most companies only attend when they have a direct use for the meetings' topic. As most interviewees claimed their company had little contacts with the Office, they did not have a clear picture of the role that the Office should play in the network.

The Office for Trade and Industry sees its role within the IS project primarily as one of legitimising the project through institutional backing. As its main focus is on new establishments, the Office has little resources for working with already established companies.

One company argued that this focus on attracting new companies has limitations, as the business climate, which is central in attracting new businesses, is to great extent determined by a healthy development of the existing companies. The Office does actually also provide direct help to established companies, but this part of its activity appears to be little known by the companies involved in the IS project. This may be due to the fact that the Office has a secrecy policy, which implies that it cannot make publicity of the help it has provided to a company.

The second general meeting (see section 4.3.2 above) was hosted by the Office, and this may have contributed to improving the contact between the companies involved in the project and the Office. It is unclear to what extent the Office will be able to play an active role in the future development of the network. However, it is already playing an active role in the step-by-step group EMS certification sub-project (see section 3.5.4 above), and may notably play a useful role in attracting new companies into the network.

The project team discussed the possibility for the Office of basing its recruitment of new companies on IE principles. The Office does not currently do this as such. However, in planning the development of a new industrial area of Landskrona (*Kronan*), objectives have been set to attract only clean and light manufacturing industries to this new area. The Environmental Department had previously rejected the establishment of a high environmental impact industry in the area. However, as Landskrona already faces strong competition from neighbouring locations considered more attractive by companies (two larger port cities, Malmö and Helsingborg, and a major university town, Lund, in close

proximity), there is limited incentive to set too high requirements on companies willing to establish in Landskrona.

Similarly to the Environmental Department, the role of the Office for Trade and Industry has so far not been clearly defined. This will have to be done as quickly as possible, so that it can effectively support the development of the IS network in Landskrona. It will not be able to play the role of a natural pre-existing institutional platform for the network. However, after the second general meeting of the project, it has proved its determination to play a more active role in the network. It has also decided to plan a study visit with the companies involved in the project to the IS network in Kalundborg.

It appears that, similarly to the companies involved in the project, the interest and commitment of the Office for Trade and Industry has grown since the start of the project. This seems to be due to the fact that the Office has gradually gained a better understanding of the opportunities IS networking may represent in terms of economic development. This, together with the increased importance of the role of the Office, confirms the importance for IS networks to involve such actors.

4.3.4.3 Lack of involvement of the Municipality

Although the Municipality of Landskrona is involved in the IS project through different branches of its activities, it appears that it may have to be even more involved and committed to the project.

First of all, as seen in section 4.3.2 above, the Technical Department of the Municipality, although it is a key actor of the IS project in terms of potential synergies, has so far not been sufficiently committed to the project. The director of the Technical Department has indicated that the Department has joined the project, because it was not an option for it not to join it (Johansson, 2003). It just could not, not be involved in such a project involving major companies in Landskrona and other departments of the Municipality. This was thus also an institutional issue.

Although this may be a valid argument, it cannot replace the will to actively participate in the project. So far, the Technical Department was notably not able to participate more actively, because the director of the Department was himself the contact person working with the project. The Technical Department, as the private actors, to work properly with the project, will thus need to allocate dedicated resources and personnel for working with the project.

Besides a more active participation of the Technical Department of the Municipality, another issue is the involvement of the Board of the Municipality. So far, the Board of the Municipality, i.e. its political leadership, has not been informed about the project, and is thus not involved at all. The director of the Technical Department considers that the Board of the Municipality should not be involved in the project, at least not in its initial phase. He argued that involving it would imply a risk of slowing down the whole process and making it unnecessarily bureaucratic (Johansson, 2003).

However, it seems that the Board of the Municipality should at least be informed about the main developments of the project. If it is not, it may take decisions that act against the development of the IS network. Although it does not directly compromise the IS project, an example of a decision that may interfere with developments in the project is the decision that was made by the Board of building a waste incinerator. This decision was taken without any

knowledge of the projected increase of excess heat delivery to the DH system by private companies.

Thus, the Board of the Municipality should be informed about the IS project, the potential areas for collaboration and their connected benefits. This would reduce the risk of compromising the project through other decisions it may take, and would possibly also allow to ensure consistency within the project. It would also be useful that the Board of the Municipality clearly defines its position on the IS project and on aspects of it that may have a political dimension.

There is a need to involve more the whole Municipality and not just individual departments. Increased coordination and integration between the activities and decision-making of the various departments may also be required. Otherwise, one department may block the initiatives taken by another department. It is interesting to note that institutional barriers in the Landskrona project appear to be stronger within public bodies than within private companies.

The need to involve the whole Municipality indicates that all actors that may have a stake or a significant influence on the outcome of an IS network should be involved to some extent in IS networks or at least be sufficiently informed and consulted on these projects. This should however not be done at a too early stage, when the potentials for collaboration have not been confirmed, as this would only make projects more difficult to manage.

4.3.5 The role of the coordination agent

Section 2.3.6.1 above has underlined the importance of the role of the coordination agent for the development of IS networks. This importance has been confirmed throughout this thesis and by the project in Landskrona.

As seen in section 3.4 above, the companies in Landskrona were more prone than average to take part in IS networking. Notably because of their high degree of environmental maturity, these companies are at a stage where it is rather easy to attract them into such initiatives. This, although a very good beginning, does not remove the pressure on the coordination agent of having to rather quickly deliver tangible results to these companies.

The companies clearly expect the coordination agent, the project team from the IIIEE, to play a central role in the IS project. Besides coordinating the network, the companies expect the project team to identify potential collaboration areas that the companies have not been able to uncover themselves. The companies involved in the project in Landskrona seem to perceive the IIIEE as a credible research institute with a high level of expertise in IS.

The first role of the coordination agent, before coordination and the identification of synergies, is to increase companies' knowledge and understanding of IS, especially of its practical constraints. The coordination body can notably do this by using external examples to help the companies understand the potentials and difficulties.

In the Landskrona project, the project team thus presented experiences from the Humberside IS Programme in the United Kingdom (UK) (see Appendix 3 for a brief description of the project). An expert was also invited to make a detailed and up-to-date presentation of the IS network in Kalundborg. The characteristics of the examples given

should be as close as possible to those of the project itself, so that the companies can really relate to these examples.

Besides increasing the understanding by the companies of IS networking, a more basic but very important task of the coordination agent is to increase the knowledge the companies have of each other's activities and processes. Indeed, a major bottleneck in IS networking is that even if companies know what by-products, needs and capacities they themselves have, they don't know where to find a complementary partner.

In the case of Landskrona, the project team notably dealt with this issue by asking the companies to organise study visits to each other's facilities. The first study visit was to take place in connection with the third general meeting. It is thus not yet possible to discuss how effective such study-visits are. However, the companies themselves indicated that this was the best way for them to get a more concrete picture of what the other companies were doing.

The coordination agent also plays an important role in singling out the type of communication taking place between some members of the network and publicising it to the others. This provides these other companies with good examples of how they could themselves proceed in other areas.

The coordination role implies a very regular follow-up of the meetings. The coordination agent has to ensure that all required information is spread to all the members of the network. The use of electronic tools such as e-mails and a webpage can be useful, but only if the members of the network make an active use of them. In Landskrona, communicating by e-mail functions rather well, but it does not replace face-to-face contact and phone communications. This implies that already with 20 companies, this coordination role is very demanding in terms of time and resources. However, it is absolutely vital to keep the companies actively working with the project.

The companies in Landskrona expect the coordination agent to identify potential synergies that they have not uncovered themselves. Although this expectation of the companies is rather typical it is a demanding one. The coordinator is expected to discover possibilities that the technicians who know perfectly the processes of their companies have not discovered. The coordination agent thus needs to possess comprehensive technical competences. In the case of Landskrona, although the team project possesses technical skills, its knowledge may not always be deep enough to solve the technical problems connected with potential synergies.

The coordination agent should identify in a rather basic way the potential areas missed by the companies. The companies should then look into the technical aspects of these potential synergies. However, when neither the coordination agent, nor the companies have the technical capacity to find innovative solutions, IS projects may gain from collaborating with universities.

In the case of Landskrona, a favourable factor is the fact that the IIIEE is itself a part of Lund University. It could thus easily use the competence of other departments within Lund University. Solving technical problems of the IS network could possibly even be integrated in the curriculum of students. This requires however reaching agreements in terms of the allocation of property rights over new technologies and innovations.

Although the coordination agent should not replace the companies in working on the technical implementation of synergies, the coordination body should also assist the functionalisation of synergies. Indeed, once the technical aspects are solved, the real difficulty is the actual implementation of the synergies, with issues such as contract design and pricing.

However, again, on issues such as pricing, the coordination agent should not interfere too much with the natural negotiation process between the companies, but mostly ensure that it does take place. Otherwise, there is a risk that synergies, although technically and economically feasible, remain good ideas that never get implemented.

The coordination agent can also help companies to reflect potential IS benefits to the market and raise their profile. The coordination agent can thus for example highlight the possibilities for product differentiation as a result of IS networking.

Another important role of the coordination agent is to ensure that the implementation of identified synergies does lead to an improvement and not a deterioration of the overall environmental performance of the IS network. It should also ensure that measures that on the short term lead to environmental improvements, do not compromise more substantial improvements on a longer term. In the case of Landskrona, the project team can be assisted in this role by the Environmental Department of the Municipality.

As seen in section 4.3.2 above, coordination activities require substantial resources in terms of time and personnel, as the actors of the network tend to rely very much on the work of the coordination agent. It is therefore important for the coordination agent to clearly define what it can do and what companies should not expect it to do, thus clearly indicating its strengths and limitations.

Although there are limitations to what the coordination body can do, it is absolutely crucial that the coordination body consists of very committed individuals. As seen in section 2.3.5.2 above, they need to be the first champions of IS projects.

Finally, although, as seen in section 4.3.2 above, the actors of an IS network should not rely too much on the network's coordination agent, such a coordination agent appears to be necessary even once an IS network is up and running. It helps the network remain adaptive to changes in its institutional, regulatory and business environment, and thus sustain itself over time.

4.4 Conclusions

Observations made in the IS project in Landskrona confirm the importance of the factors outlined in the literature review in section 2.

Regarding the motivations for engaging in IS networking, an aspect that appears more specific to Landskrona is a general will by the companies to increase their contacts with each other. This will, although clearly connected to the hope to benefit economically from increasing these contacts, does not correspond to a clearly identified objective. It is more an acknowledgement of the fact that in the past companies have not been sufficiently open to each other, and that they can benefit from having more contacts. This is a clear opportunity for the development of IS networking.

Regarding organisational factors influencing the development of IS networking, it appears that in a Swedish context, companies, although they have a generally more open attitude than companies in other countries, may need time to start speaking openly with each other. This cultural aspect should thus not be neglected, and a special emphasis may have to be put on the social interactions in the initial stage of IS projects.

A problem may be the fact that companies tend to rely too much on the work of the coordination agent. Although this coordination agent does play a central role, it is important for this agent to ensure that the companies do their share of the work.

5. Conclusions, implications and recommendations

The analysis of organisational factors influencing Industrial Symbiosis (IS) networking is complex. Indeed, the number of factors that may have such an influence seems to be limitless. The IS project in Landskrona appears to be in conformance with the influence of the main factors outlined by the review of Industrial Ecology (IE), management and organisational literature.

However, it should be reminded that there is no "one size fits all" in IS networking. In Landskrona, the main specific feature appears to be the general will by the companies to increase their contacts with other local companies. This is a very favourable context for the development of IS networking. Another characteristic of Landskrona is the fact that although there clearly are potentials for the exchange of tangible resources such as energy and by-products, an even bigger potential may lie in the exchange and sharing of more intangible resources.

Rather than a "traditional" IS network corresponding to the definition by Chertow (2000), it may possibly benefit from being a more flexible type of network, based on the sharing of information and knowledge.

5.1 Conclusions about the research questions

The two main research questions of this thesis were the following:

- ***What are the organisational factors that have major influence on the development and operation of Industrial Symbiosis networks?***
- ***How can the coordination bodies help provide the right set of organisational factors to facilitate networking?***

Answering the first research question required also analysing what major factors influence companies' decision to participate in IS networks. The main factors outlined are institutional pressure, access to critical resources, costs savings and efficiency and interorganisational learning. The three last ones correspond in some way or another to the objective of gaining competitive advantages through IS networking. On the other hand, institutional pressure appears to remain the factor having the strongest influence over this decision.

An important organisational factor influencing the development and operation of IS networking is the degree of alignment of IS networking with business reality. IS networking is not fully aligned with this reality. However, it is attractive for private businesses, provided it allows them to achieve rapid and clear benefits.

Another important factor is the degree of environmental awareness and maturity of the actors involved in an IS network. IS networks benefit from recruiting environmentally "mature" companies, as this ensures that IS networking does not replace but is the continuation of sound internal environmental work.

The existing institutional platforms and linkages are crucial and should be fully taken into consideration and taken advantage of. They allow for a high degree of mental proximity, trust and communication, which are other central features in IS networking.

Public/private partnerships are very important and appear to almost be a requirement for the development of IS networking. They may notably provide various sorts of resources to support the development and sustained operation of IS networks. This includes helping to develop a vision for the future development of networks, which is desirable in order to ensure that IS networking leads to tangible environmental improvements.

However, possibly the most central factor is the degree of commitment of the actors to an IS network, a high degree of commitment being the key to IS networking.

The coordination body plays a central role in ensuring that all these factors are in place. It plays an especially important role when favourable conditions such as pre-existing institutional platforms and linkages are not in place.

The coordination body fosters the development of trust and mental proximity between the actors by facilitating communication and face-to-face contacts between these actors. A way of doing this is notably by organising study visits for the companies involved in a project of each other's facilities. The coordination body can also single out the type of communication taking place between some members of the network and publicise it to the others.

The coordination body also helps reducing transaction costs within IS networks by centralising information and helping the actors identify potential synergies. Although the companies should work on the technical aspects of the implementation of these synergies, the coordination body should assist the functionalisation of these synergies. It can also help companies benefit fully from these synergies, by reflecting them as competitive advantages on the market.

The coordination body should however also ensure that the implementation of these synergies does lead to an improvement and not a deterioration of the overall environmental performance of the IS network.

There is a need for a coordination body to play all these roles, even once an IS network is up and running, notably in order to ensure that the network remains adaptive to changes in its environment. However, in order to play these roles, the coordination body needs to be fully committed and to have sufficient resources in terms of time and personnel.

5.2 Implications for practice and theory

First, an implication of this research for IE theory is that IE clearly benefits from integrating parts of other bodies of theory and literature. In the case of IS networking, management and organisational literature can further inform IS literature on the practical development of networks. However, findings from these bodies of literature should not be blindly and directly transferred to the field of IS but should be adapted to its specific characteristics.

There is a series of other implications that apply mostly for practice, but also to some extent for theory.

The fact that institutional pressure remains the central factor influencing companies' decision to engage in IS networking indicates that more efforts should be put in designing policy and regulation that encourage the development of IS networking. This is especially important from an environmental perspective. Indeed, without appropriate regulatory pressure,

companies may be interested by IS networking, but may "cherry-pick" its short-term economic benefits without actively working to improve their environmental performance.

Besides designing policy and regulation to encourage IS networking, at the same time, it is important to modify regulations that constitute an unnecessary barrier to IS networking, provided that this does not actually lead to deteriorations of the level of environmental protection.

Regarding the alignment of IS with business reality, IS related benefits are currently difficult to reflect onto the market. Finding ways to make these benefits more recognised on the market may be yet another task for the coordinators of IS networks.

A potential barrier to IS networking is the fact that an increasing number of companies are subsidiaries of international groups, and thus decisions are less and less taken at the local level. Local policies and regulation may thus play a particularly important role, as subsidiaries of international groups may more easily engage in IS networking if this move is dictated by the need to comply with local regulation.

The fact that IS networking requires a high degree of environmental awareness and maturity of the actors involved, may indicate that raising this environmental awareness and encouraging sound internal environmental work should in many instances still be the first priority.

Regarding the need for public/private partnerships, it appears important not only to increase the knowledge and awareness on IS networking of private companies, but also of public bodies. This is especially the case if these public bodies are to initiate and even coordinate IS networks.

Coordination agents are essential for the development of IS networks. This may indicate a need to educate and train these agents. This may notably be achieved through specific degrees in universities. Such degrees have actually already started to emerge. These degrees should not focus exclusively on engineering and technical skills, management and general coordination skills being at least as important.

Finally, regarding the direction of IS networks, coordination bodies should provide guidance on the development of the network so as to better align it with long term sustainability requirements.

5.3 Suggestions for further research

Two types of suggestions for further research can be made. This thesis may indicate further research that may useful in the specific case of Landskrona, and research that may be desirable for IE theory in general.

In the case of Landskrona, if possible, it would be interesting to analyse the reasons why approached companies refused to join the project. This would give useful indications on whether there was a lack of interest, or a lack of time and/or resources. It would also indicate whether these are intrinsic and structural factors, or whether they mostly depend on other factors such as the timing and set-up of IS projects.

Regarding the issue of how critical the resources that IS networking focuses upon are, it would be useful to analyse what share of the overall costs of the companies do their wastes and by-products represent. Furthermore, it would be interesting to analyse to what extent savings induced by IS networking may contribute to the overall financial results of companies.

Future research on the IS project in Landskrona could also study how transferable the case of Landskrona is to other regions of Sweden. It would notably be interesting to study whether the need to increase contacts with the local environment is also perceived elsewhere in Sweden.

For future research on IE in general, it would be desirable to further examine how valid factors taken from the fields of management and organisational theory are for IS networking. Indeed, a fundamental problem is the fact that management and network theory are aimed at the main products of companies. It is not clear to what extent they can be applied to networks focusing on wastes and by-products. This is especially the case for resource dependency theory. More empirical testing of these theories in an IS networking context is thus required.

Finally, there is a need to develop criteria and indicators against which the success or failure of IS initiatives can be judged.

5.4 Recommendations

A series of recommendations can be made for the future development of the IS project in Landskrona.

There is a need to properly define the roles the Environmental Department and the Office for Trade and Industry of the Municipality of Landskrona should play in the IS project. There is also a need for a more active involvement of the whole Municipality. The project coordinators should strive to make the Technical Department of the Municipality participate more actively in the project. Furthermore, the Board of the Municipality should at least be informed about the project and its developments.

Regarding the coordination and management of the project, it is important that the project team manages to make companies actually spend the time they have committed to allocate to the project working with it. A special emphasis should be put on making the companies become as quickly as possibly more autonomous in their work within the project.

Although the project is still in its initial phase, it is important to plan the future development of the network. One aspect to consider is the network's future financing. As Sterr (2000, p.292) has put it, "structures that promote sustainability have to be sustainable themselves, which includes that their financing has to be ensured". Thus, the project team should start finding future sources of financing for the network.

Besides the financing of the network, an important question to be addressed is who will coordinate the network in the future. Currently, the IS project is planned to run for a period of 16 months, a quarter of this period of time having already passed. The Office for Trade and Industry may be a suitable coordination agent, but this implies that it already now prepares actively to take over this role from the IIIEE. Who ever coordinates the network in the future will need to have sufficient resources to fulfil this demanding task.

Finally, if IS networking is not to merely become an ordinary type of business network without tangible environmental improvements, there will need to be a discussion on the development of a vision including environmental objectives for the network. This would allow setting the "seeds" for more decisive moves towards a sustainable industrial ecosystem.

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Abbreviations

EID	Eco-Industrial Development
EIN	Eco-Industrial Network
EIP	Eco-Industrial Park
EMS	Environmental Management System
DH	District Heating
IE	Industrial Ecology
IFC	Inter-Firm Collaboration
IR	Interorganisational Relationship (sometimes also referred to as IOR)
IS	Industrial Symbiosis
n.d.	no data
SME	Small and Medium-sized Enterprise

Appendix 1: List of interviewees

Organisation	Name	Date
AB Landskrona Galvanoverk	Johann Magnusson (Managing Director) Lennart Magnusson (Production Manager)	June 10, 2003
Auxilia	Benoît Duret (Project Manager)	
BAS Metal	Staffan Aronsohn (Managing Director) Ola Wilhelmson (n.d.)	June 16, 2003
Boliden Bergsöe AB	Nils-Eric Winquist (Environmental & Quality Manager)	July 3, 2003
DSM Resins Scandinavia AB	Alf Jönsson (Managing Director) Bertil Winér (Safety/Quality Assurance Manager)	
Embra AB	Lars Hansson (Technical Manager)	June 13, 2003
Flexmed AB	Tomas Ahlström (Managing Director) Cecilia Lundgren Jönsson (Sales Assistant)	June 11, 2003
Haldex Brake Products AB	Jonas Nilsson (Workshop Manager) Claes Hallberg (Environmenal Coordinator)	June 19, 2003
Landskrona Svalövs Renhållnings (LSR) AB	Mats Hafström (Development and marketing manager)	June 23, 2003
Environmental Department, Municipality of Landskrona (*Miljöförvaltningen*)	Högni Hansson (Director) Charlotta Barthelson (Environmental Inspector)	July 4, 2003
NB Olssons Transportservice AB	Jonas Olsson (n.d.)	July 10, 2003
Øresund Environment Acacemy	Noel Brings Jacobsen (Administrative Director)	August 28, 2003
Parajett AB	Anders Lundqvist (Managing Director) Roland Rundqvist (Environmental Coordinator)	July 1, 2003
Pilkington Automotive Sweden AB	Anderz Boij (Process Improver)	June 10, 2003
Rohm and Haas Nordiska AB	Erik Vestergård (Technical Manager)	July 1, 2003
SAB Wabco Nordic AB	Jörgen Andersson (Production Manager) Lars Jansson (n.d.)	June 17, 2003
Scandiflex AB	Ivan Nilsson (Managing Director)	July 7, 2003
ScanDust AB	Ulf Helgeson (Managing Director)	June 24, 2003
Svalöf Weibull AB	Bengt Johnson (Production Manager) Bengt-Åke Carlsson (Environmental/Quality Coordinator)	June 12, 2003
Syngenta Seeds AB	Bengt Bentzer (Managing Director) Lena Johannesson (Manager - Pre-commercial seeds department)	June 25, 2003
Thorn Lighting AB	Tomas Wilson (Production Manager)	June 17, 2003
Trioplast Landskrona AB	Leif Nilsson (Managing Director)	June 24,

		2003
Technical Department, Municipality of Landskrona (*Tekniska Verken*)	Jörgen Johansson (Director) Kåre Larsson (Director, District Heating and Water Distribution and Treatment Department)	August 18, 2003
Office for Trade and Industry, Municipality of Landskrona (*Utvecklingsstiftelsen*)	Claes Nilsson (Director)	July 7, 2003

Appendix 2: Interview questions

(Common) Questions for semi-structured interviews:
(Goal: to understand the motivations of the companies for joining the Industrial Symbiosis project and analyse how far the companies are willing to go in terms of collaboration)

1. Could you start by describing the activities of your company?
2. What level of autonomy does the company have in its decision-making?
3. Which are the factors that are critical for the business success of the company?
4. Why do you work with environmental issues?
5. What are your main environmental aspects?
6. What role does the environmental performance of the company play in relation to its overall financial results?
7. Why is the company located in Landskrona? What advantages/disadvantages are connected with Landskrona?
8. What has been the level of interaction/communication with other local/regional companies before the start of the project? Is there a sense of community between the companies involved in the project?
9. What kind of inter-organisational collaboration has been considered/carried out earlier?
10. Why has the company decided to join the Industrial Symbiosis project? Why now?
11. Have possibilities similar to those we are hoping to identify been considered before? If so, has any action been taken? Why, why not?
12. What are the main expectations of the company on the potential outcomes and benefits of the project? What is the importance of such benefits?
13. Which ones are the areas where the company sees potential for exchanges and networking?
14. Does the company already have specific partners in mind? If yes, who are they?
15. How far is the company ready to go in developing interorganisational relationships through the network, in terms of making capital investments, information sharing, skills sharing, financing of a common coordination body, etc.?
16. What kind of changes could the company foresee in its operations as a consequence of the project? Could collaboration result in a change in the company's processes or products?

17. Would the relationship with companies within the network differ from traditional customer-supplier relations? If yes, in what way?

18. What is the timeframe during which the company has planned to work on this project?

19. What are the managerial skills that act as critical resources for collaboration?

20. What are the company's expectations from the other actors of the network: from other companies, from the IIIEE, from the Environmental Department of the Municipality, from the Office for Trade and Industry?

21. What does the company think of the present format of the project? Is there something that should be done differently?

22. What is the current level of communication (since the project has started) with the other involved companies on respective needs and capacities and on possible partnerships?

23. Does the company perceive potential risks connected with Industrial Symbiosis networking?

24. Does the company perceive some of the other involved companies as direct or potential competitors? Could this restrict the range of possible partnerships?

Appendix 3: Description of mentioned Industrial Symbiosis networks and similar projects

Name and location	Description
Avedøre Project, Denmark	Pilot project under the Danish State Energy Agency running from 1998 to 2001, involving 30 industrial companies, in which a consultancy firm made an inventory of possible exchanges and developed proposals for projects (Anderberg et al., 2003).
By-Product Synergy, Tampico, Mexico	Project conducted from 1997 to 1999 and led by the Business Council for Sustainable Development – Gulf of Mexico (BCSD-GM). It gathered together 21 local industries (Chertow, 2000). The project proved rather successful, resulting in an active IS network (Duret, 2003).
Cape Charles Sustainable Technologies Industrial Park, Virginia, United States	This Eco-Industrial Park project provides infrastructure for industrial ecology linkages among companies, while improving the economic, natural, cultural, social and living environment of the site and the surrounding region. The park consists of a multi-tenant building designed with the flexibility to accommodate a range of light manufacturing firms. The park was developed based upon a set of principles and objectives to guide the sustainable redevelopment of the community and its stagnant economy (Schlarb, 2002).
Golden Horseshoe By-Product Synergy Project, Ontario, Canada	Eco-Industrial Network project running for a year from January 2001. This project was not very successful as it failed to attract a sufficient number of companies to participate fully in the project (Seth, 2002).
Humberside Industrial Symbiosis Programme, United Kingdom	Project initiated in 2000, coordinated by he Business Council for Sustainable Development – United Kingdom (BCSD-UK), with the objective of systematically catalysing the development of an IS network in the Humber region (Mirata, 2003b).
Industrial Symbiosis in Kalundborg, Denmark	The IS network in Kalundborg, which has more than 30 years of history, is often considered as the first IS network, and appears even today as the most successful and mature case of IS. It developed as a result of an evolutionary and mostly spontaneous process (Ehrenfeld & Gertler 1997).
Inter-Industrial Materials Flow Management Rhine-Neckar Experience (AGUM), Germany	Project run by the Institute for Eco-Industrial Analysis (IUWA) based in Heidelberg. The project started at the level of an industrial estate, the industrial estate of Heidelberg-Pfaffengrund, and developed into a regional network (Sterr, 2000).
Jyväskylä Region, Finland	Regional energy supply system that fits well with Industrial Ecology theory. Energy is supplied from co-production of heat and electricity and industrial wastes are used as fuels. Although this system can be viewed as a case of IS, it is not an active and conscious IS network as such (Korhonen, et al., 1999).
Londonderry Ecological Industrial Park, United States	The town of Londonderry assembled a 100-acre parcel close to an airport, specifically to create an Eco-Industrial Park. The project was turned over to a private developer who agreed to purchase the land and follow a set of performance requirements and environmental guidelines and practices. The park builds around a combined-cycle gas power plant (Chertow, 2000).
Rotterdam Harbour INES project, Netherlands	Industrial ecosystem project (INES) in the Rotterdam harbour area. The main industries involved are crude-oil refineries, petrochemical and chemical industries. The project was initiated by an industrial association (Baas, 1998).
Triangle J Council of Government Industrial Ecosystem Development Project, North Carolina, United States	This Eco-Industrial Network project had the following objectives: cut costs and reduce the use and disposal of natural resources by industries, and create more sustainable communities by identifying ways to turn wastes into useful products and reduce the generation of greenhouse gases in the air, pollution in the water, and waste in landfills. The project focused on three activities: Region-wide by-product exchange, partnerships between industries in existing industrial parks, and new infrastructure for planned industrial parks (Schlarb, 2002).
Plattsburgh Eco-Industrial Park, New York, United States	Proposed Eco-Industrial Park, in which a key element of the design was to certify the whole park according to the ISO 14001 standard and then assist individual companies in their compliance (Cohen-Rosenthal, 2000).

Appendix 4: List of involved companies

As of September 2003

Company Name	Sector and activity	Number of employees	Turnover (SEK)[36]
AB Landskrona Galvanoverk	Metal Electroplating: electroplating of metal objects with zinc and chromium using drum and conveyor lines.	8	6 MSEK
BASMetal AB	Metal Recycling: collection, sorting, and pre-processing of various sorts of metals for recycling	11	n.d.
Boliden Bergsöe AB	Metal smelting and recycling: recovery and recycling of lead and zinc from car batteries discarded in Nordic countries	130	265 MSEK (2002)
DSM Resins Scandinavia AB	Chemicals (binding materials): production of binders for paint manufacturing by emulsifying various monomers in water and solvent based solutions	54	139 MSEK
Embra AB	Cement Distribution: Intermediate storage and handling of cement in port terminals	4	100 MSEK (2001)
Flexmed AB	Flexible printing of packaging materials: Water-based printing, coating and slitting of a wide range of flexible peelable and non-peelable packaging materials	33	82 MSEK (2002)
Haldex Brake Products AB	Automotive components: Production of brake parts for heavy vehicles	550	730 MSEK
Landskrona Svalövs Renhållnings (LSR) AB	Waste Management: collection, transportation, sorting, treatment and off-site recycling of household waste and industrial waste; on-site production of plastic pellets for combustion; on-site production of woodchips for combustion; landfilling and biogas recovery of organic waste and household waste; composting of garden waste; handling of hazardous wastes	50	53 MSEK (2002)
NB Olsson Transport AB	Transportation and Logistics: Provision of transportation and logistics services within Sweden and Denmark	52	60 MSEK
Parajett AB	Printing: communication and printing solutions	220	215 MSEK (2002)
Pilkington Automotive Sweden AB	Glass products: production of toughened glass to be used as backlights, sidelights, and rooflights (windows) by various car manufacturers	109	200 MSEK
Rohm and Haas Nordiska AB	Speciality chemicals: production of water based suspensions by mixing acrylic based monomers with water and other chemicals and producing water borne polymer suspensions	90	461 MSEK (2001)

[36] 1 SEK = 0.11 € (2003, September 11).

SAB Wabco Nordic AB	Rail vehicle components: production of brake components for rail vehicles	130	3 BSEK (group)
Scandiflex AB	Packaging: production of printed and unprinted plastic laminate for food packaging	55	125 MSEK
ScanDust AB	Metal Recycling: recycling of filter dust from stainless steel industry	65	150 MSEK
Svalöf Weibull AB	Agricultural and horticultural seeds: breeding and production of various agricultural and horticultural seeds	60	1.1 BSEK (group)
Syngenta Seeds AB	Agricultural Seeds: breeding and production and packaging of sugar beet seeds	220	54 MSEK
Tekniska Verken, Landskrona Kommun (Municipality of Landskrona Technical Department)	Infrastructure and utilities: maintenance and operation of all infrastructure, including water and energy utilities, of the Municipality of Landskrona	82	300 MSEK
Thorn Lighting AB	Indoor and outdoor lighting equipment: production of components of indoor and outdoor lighting equipment	340	461 MSEK (2001)
Trioplast Landskrona AB	Flexible plastic packaging: production of mono- and co-extruded films, and printed packaging material	180	220 MSEK

Appendix 5: Data collection form

LANDSKRONA INDUSTRIAL SYMBIOSIS PROGRAMME
DATA COLLECTION FORM FOR SYNERGY ASSESSMENT

The data collected with this form will be used for the identification of potential synergy areas among the parties located in Landskrona region.

General Information

Company Name	
Sector	
Address	
Contact Person	
Title	
Tel:	
Fax:	
E-mail	

Shortcut Box
If you already have ideas regarding synergistic linkages that may involve your organization, please indicate them in this box.

Main Material Inputs
Main inputs supplied to the facility (in solid, aqueous, or gaseous form) other than the energy and water resources.

Name	Description/Composition	Amount (Appropriate unit/year)	Cost SEK/Unit	Means of supply
				☐ Produced on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
				☐ Produced on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
				☐ Produced on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea

Main Products
Products are those outputs for which the production processes are optimised.

Name	Description/Composition	Amount (Appropriate unit/year)	Means of distribution
			☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
			☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
			☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea

Energy

Electricity

Means of Supply ☐ Produced on site ☐ Purchased

Total Consumption KWh (% produced on site __%

cost Production on Site _____ SEK/kWh
Purchased externally _____ SEK/kWh

Thermal

Total Consumption _____
Kcal/MeagJoules

Fuel Type	Consumption (tonnes or m^3/year)	Cost (SEK/unit)

Steam Requirements

Pressure (bars/atm)	Quantity (tonnes/year)	Use

Hot Water Requirement

Temperature	Quantity	Use

Water

Total Amount Used	M3/year		
Means of Supply	☐ External supplier	☐ Own supply	
Cost	External Supplier	___ SEK	
	Own supply	___ SEK	
Uses			
	Quantity	Quality Requirement	Cost (SEK/m^3)
Production			
Steam Generation			
Cleaning			
Domestic			
Cooling			

By-Products

By-products represent the outputs with a commercial value that are produced during the production of the main products.

Name	Description/Composition (phase, main constituents, etc.)	Amount & Pattern (tonnes, items or m^3/year) C = continuous Se = Seasonal Sp = Spot	Market Value (SEK/tonnes or SEK/m^3)	Means of Distribution
				☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
				☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea
				☐ Used on site ☐ Road ☐ Rail ☐ Air ☐ Pipeline ☐ Sea

Wastes

Phase*	Description/composition (main constituents, temperature, etc)	Amount & Pattern (tonnes, items or m^3/year) C = continuous Se = Seasonal Sp = Spot	Means of Management	Cost (SEK/tonne or SEK/m^3)

* *Solid (S), liquid (L), or gaseous (G)*

In the following sections, please indicate if you have any surplus capacities that might be useful for any other organisation in the region (such as superior knowledge on a particular field, processing equipment that can be used by someone else, etc.) or if you need any resources that any other organisation may have in excess.

Capacity surplus

Category	Explanation
Production (e.g. goods or energy	
Processing (for material or waste)	
Storage	
Transportation	
Managerial capacities	
Human resources	
Others	

Capacity needs

Category	Explanation
Production (e.g. goods or energy)	
Processing (for materials or waste)	
Storage	
Transportation	
Managerial capacities	
Human resources	
Others	

Appendix 6: Reference groups

National Reference Group

Organisations
The Swedish Environmental Ministry (Miljödepartementet)
Swedish Environmental Protection Agency (Naturvårdsverket)
Swedish Business Development Agency (Verket för näringslivsutveckling – NUTEK)
The Swedish Environmental Management Council (Miljöstyrningsrådet)
The Confederation of Swedish Enterprises (Svenskt Näringsliv)
The Association of Swedish Environmental Managers (Näringslivets Miljöchefer)
Skåne County Government (Länsstyrelsen i Skåne län)
The Environmental Department of the Municipality of Landskrona (Miljöförvaltningen Landskrona kommun)
The Office for Trade and Industry of the Municipality of Landskrona (Utvecklings Stiftelsen i Landskrona)
Sustainable Business Hub
Local Company representatives
IIIEE representatives

International Reference Group

Organisation – Country	**Contact Name**
VTT – Finland	Allan Johansson
University of Joensuu –Finland	Jouni Korhonen
Business Council for Sustainable Development – UK	Peter Laybourn
Yale School of Forestry and Environmental Studies – USA	Marian R. Chertow
MIT Technology, Business and Environment Program	John R. Ehrenfeld
Øresund Environment	Noel Brings Jacobsen
Norwegian University of Science and Technology's (NTNU) Industrial Ecology Programme	Helge Brattebo
Institute for communication and analysis of science and technology (ICAST), Applied Industrial Ecology Programme	Suren Erkman
Erasmus Centre for Environmental Studies, Erasmus University, Netherlands	Leo Baas
Kalundborg Centre of Industrial Symbiosis	Noel Brings Jacobsen