An Adapted Approach to Industrial Symbiosis
With a case study on the northern Stockholm region

Florian Hemmer

Master of Science Thesis
Stockholm 2011
An Adapted Approach to Industrial Symbiosis
With a case study on the northern Stockholm region

Florian Hemmer

Supervisors:
Graham Aid
Nils Brandt

Examiner:
Nils Brandt

Master of Science Thesis
STOCKHOLM 2011

PRESENTED AT
INDUSTRIAL ECOLOGY
ROYAL INSTITUTE OF TECHNOLOGY
An Adapted Approach to Industrial Symbiosis

With a case study on the northern Stockholm region

Author: Florian Hemmer
Supervisor: Graham Aid
Examiner: Nils Brandt

26 June 2011
Abstract

Numerous attempts have been made to create or facilitate Industrial Symbiosis networks and self-organized networks have been uncovered. Existing networks have been studied to identify its success or failure and its context. This thesis tries to suggest and assess an adapted approach to establish successful industrial symbiosis, with a case study on the northern Stockholm region. An extensive literature review, meetings with experts and stakeholder interaction by questionnaires, interviews and a workshop were used. Potential obstructions were identified, possibilities of self-organizations and planning explored and solutions suggested. Combined with the feedback from 25 questionnaires and a workshop with local stakeholders an approach to establishing industrial symbiosis in northern Stockholm was suggested and assessed. A neutral coordinator or waste companies were concluded to have a good chance of establishing an industrial symbiosis network in the region. Using existing networks, creating awareness and providing knowledge and examples are important factors for establishing an industrial symbiosis network.

Key words: Industrial Symbiosis, Stockholm, Workshop, Network, Facilitate, Exchanges, Synergies
Acknowledgements

First of all I would like to express my gratitude to Graham Aid, who has been my supervisor during this thesis project. He provided valuable suggestions, advice and critical comments on the thesis project, the report and presentation. Besides his role as academic supervisor he was able to arrange funding for the study visits, for which many thanks to Ragn-Sells AB as well.

I would like to thank Niklas Smedberg who has been a great colleague to me. He has been checking my Swedish writing, taking care of a lot of communication with local stakeholders, and been a valuable colleague during interviews, questionnaires and the workshop. Thanks go to Nils Brandt as well, who as my examiner gave critical feedback especially in the beginning of the thesis project and during the presentation.

It is a pleasure to thank Debra Power from NISP for letting me attend the quick-wins workshop and participate in the workshop's process. Dave Berrill from NISP deserves great thanks for his insights in the functioning of NISP and advice on the case-study.

I am grateful for the advice and insight from Professor Leo Baas and Michael Martin from Linköping University and Gert Kindgren from Cleantech Östergötland. Their advice was of great help for stakeholder engagement and pointers for the research.

Great appreciation goes to all the respondents of the questionnaire, interviews and the participants to the workshop, dedicating time to the project. The valuable feedback and data are of great importance to this thesis.

Finally I would like to thank family and friends for their support during the thesis and supporting my decision to study in Stockholm for two years.
List of Figures

Figure 1. Municipalities included in the case study (colored) relative to Stockholm (striped). (modified from Wikipedia, 2006)........................................................................................................6
Figure 2. EU Waste hierarchy .............................................................................................................14
Figure 3. Response: familiarity with IS ................................................................................................19
Figure 4. Response: familiarity with EIP .............................................................................................20
Figure 5. Example of grading scale badges for industrial symbiosis .................................................25

List of Tables

Table 1. Waste treatment in Sweden over 2008 (Naturvårdsverket, 2010) ........................................15
Table 2. Success rate of sent out questionnaires ...............................................................................19
Table 3. Results feedback on Workshop .........................................................................................22

List of Acronyms

EIP Eco-Industrial Park
EU European Union
IE Industrial Ecology
IS Industrial Symbiosis
KTH Kungliga Tekniska Högskolan – Royal Institute of Technology
NISP National Industrial Symbiosis Programme
TEDA Tijanjin Economic-Technological Development Area
USPCSD United States President’s Council on Sustainable Development
WRAP Waste & Resources Action Programme
Table of Contents

Abstract .................................................................................................................................................. III
Acknowledgements ................................................................................................................................. V
List of Figures .......................................................................................................................................... VII
List of Tables ............................................................................................................................................ VII
List of Acronyms .................................................................................................................................... VII

1. Introduction..............................................................................................................................................1
   1.1. What is Industrial Ecology .............................................................................................................1
   1.2. What is Industrial Symbiosis ..........................................................................................................1
   1.3. Benefits of Industrial Symbiosis .....................................................................................................2
   1.4. Drivers of Industrial Symbiosis .....................................................................................................2
   1.5. The Future of Industrial Symbiosis Research ...............................................................................3
   1.6. Aims and Objectives ......................................................................................................................3

2. Methodology ..........................................................................................................................................4
   2.1. Scope ...............................................................................................................................................4
   2.2. Stakeholders ....................................................................................................................................4
   2.3. Expansion of case study ................................................................................................................6

3. Results ..................................................................................................................................................8
   3.1. Aspects and paradigms potentially obstructing industrial symbiosis .........................................8
      3.1.1. Geographic boundaries ...........................................................................................................8
      3.1.2. Losing Flexibility .....................................................................................................................10
      3.1.3. Lack of Trust ..........................................................................................................................11
      3.1.4. Required Awareness and Innovation Capacity ......................................................................12
   3.2. Policy and Regulation ..................................................................................................................14
      3.2.1. Waste Hierarchy .....................................................................................................................14
      3.2.2. Waste in Sweden ....................................................................................................................15
   3.3. Planned or Self-organized .............................................................................................................15
      3.3.1. Coordination ..........................................................................................................................16
      3.3.2. NISP and TEDA ....................................................................................................................17
| Appendix D. | Letter sent to other/remaining stakeholders ............................................. 55 |
| Appendix E. | Invitation to the workshop on industrial symbiosis in Sigtuna ...................... 56 |
| Appendix F. | Invitation to the workshop on industrial symbiosis in northern Stockholm 57 |
| Appendix G. | Descriptions of companies attending workshop ......................................... 58 |
| Appendix H. | “Jag har” and “Jag vill ha” papers used in workshop ..................................... 59 |
1. Introduction

Industry interacts with the environment on numerous ways. If industry were to be sketched as an abstract black box with inputs and outputs the most obvious interactions will manifest itself as raw materials that are extracted from, and waste that is inserted into its surroundings. It is the interactions between industry and the environment that result in impacts on both the environment and industry that can be studied and approached in numerous ways, of which one is industrial ecology.

1.1. What is Industrial Ecology

Industrial Ecology (IE) tries to describe how sustainability can be strived for and maintained by viewing the industrial system as interacting innumerable ways with its surrounding environment and not isolated from its surroundings. This holistic systems view enables the optimization of material flows, or rather cycles, while taking into account resources, energy and capital. (Graedel and Allenby (2003) During his presidency of the US national academy of engineering Robert White defined industrial ecology as: “the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use and transformation of resources.” (White, 1994 as cited in Ehrenfeld, 2007)

The ecology part of industrial ecology is an analogy with biological ecology. Its physical and chemical parameters can be an example; an organism uses resources and impacts its environment. Whether it is a biological or technical organisms its interactions can be restructured, and the cyclical system of material usage within biological ecology can serve as a good metaphor for the restructuring of the industrial system to achieve sustainability.

1.2. What is Industrial Symbiosis

Industrial Symbiosis (IS) can be regarded as one of the more “hands-on” concepts within the larger concept of Industrial Ecology (IE) and tries to optimize flows of material, energy and capital between actors by creating symbiotic exchanges or synergies. Symbiosis in biological terms is the intimate association between two species to the benefit of one or both; a parasitic respective mutualistic symbiotic relationship. If this definition is to be applied to an industrial system one could state IS as the sharing or transfer of resources to the benefit of those involved. Or as defined by Chertow (2000): “Engaging traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products”.

Chertow (2007) described by-product reuse, utility/infrastructure sharing and joint provision of services as the three primary opportunities for resource exchange. This expands the definition of industrial symbiosis to “Engaging traditionally separate industries in a collective approach to competitive advantage involving exchange of resources”. The definition used by Mirata and Emtairah (2005) expands the symbiotic
relationships to not just involving physical exchanges but includes the exchange of knowledge and human or technical resources as well as adding environmental benefits to the definition. The practice of industrial symbiosis within the geographical boundaries of an industrial estate it called an eco-industrial park (EIP). The U.S. President's Council on Sustainable Development (USPCSD) counts information, materials, water, energy, infrastructure and natural habitat as resources in its definition of an EIP (USPCSD, 1997 as cited in Chertow, 2007). A rule of thumb for the distinguishing of industrial symbiosis activities from simple resource exchanges has been suggested by Chertow (2007) as the “3-2 heuristic”, implying a minimum of two resources are exchanged by a minimum of three actors. This suggested rule of thumb has however been under much debate and cannot be regarded as generally accepted defining rule.

1.3. Benefits of Industrial Symbiosis

Several beneficial aspects of industrial symbiosis have been named. For example: reduced costs, increased revenues and enhanced long-term resource security as well as increased efficiency, emission reductions and waste elimination by adopting industrial symbiosis practices to comply with regulations (Chertow, 2007). EIPs have also been established in order to revitalize sites, create and maintain jobs and as an encouragement for sustainable development (Chertow, 2007; Gibbs and Deutz, 2007). It has also been linked to new business opportunities in the fields of; decomposer firms, remanufacturing, monitoring of environmental effects, transportation and environmental management (Lowe, 1997). The sharing of resources can for example reduce the spillage of by-products or waste into the environment, minimize the usage of raw-materials and is possibly a first step towards a cyclical system of material usage as it promotes the exchange of resources. Furthermore, the benefits for business caused by an improved relationship or new relationships with other stakeholders and a green image have been identified as benefits of the concept (Mirata and Emtairah, 2005).

1.4. Drivers of Industrial Symbiosis

All these motivations or reasons have led to a lot of attempts to create or facilitate industrial symbiosis, mostly by governmental bodies. But it has also led to the uncovering of existing industrial symbiosis networks and suggested policies or practices to uncover existing industrial symbioses (Chertow, 2007). Numerous case studies have been carried out on existing or planned EIPs or regions with industrial symbiosis trying to identify their success or failure and what led to it (Heeres, Vermeulen and Dewalle, 2004; Sterr and Ott, 2004; Mirata and Emtairah, 2005; Baas, 2008; Jacobsen, 2008; van Berkel, et al., 2009; ElabrasVeiga and Magrini, 2009; Chae, et al., 2010; Chertow and Miyata, 2010; Shi, Chertow and Song, 2010).

As observed by Mirata (2005 cited in Costa, Massard and Agarwal, 2010) industrial symbiosis “primarily emerges from the private sectors as a self-organizing business strategy, driven by economic advantages offered by market dynamics and/or policy requirements”. This observation is strengthened by research from Boons and Baas (2006 cited in Costa, Massard and Agarwal, 2010) which concludes that context shapes activities of industrial symbiosis, where the context can be described as having multiple
aspects: “cognitive, structural, cultural, political, spatial and temporal embeddedness”. Which leaves room for the planning, facilitating or fostering of industrial symbiosis as the embeddedness or context can be altered by stakeholders.

This influence of policies, regulation and incentives on industrial symbiosis has also been studied (Chertow, 1997; Van Leeuwen, Vermeulen and Glasbergen, 2003; Desrochers, 2004; Gibbs and Deutz, 2007; Kim and Powell, 2008; ElabrasVega and Magrini, 2009; Bain, et al., 2010; Costa, Massard and Agarwal, 2010). Furthermore the influence of organizational aspects has been studied (Gibbs, 2003; Heeres, Vermeulen and Dewalle, 2004; Wolf, Eklund and Söderström, 2007; Baas, 2008; Ashton, 2008) as have the geographical influences (Sterr and Ott, 2004) and agent base simulation as a tool (Batten, 2009). Literature research on these and other papers have for example led to the proposal of theoretical frameworks (Boons, Spekkink and Mouzakitis, 2011).

1.5. The Future of Industrial Symbiosis Research

Industrial symbiosis has received more and more attention from researchers around the globe and more symbiotic networks or EIPs are uncovered, designed or planned. Research seems to shift towards the incorporations of network theories, which could deepen the understanding of organizational and social influences on industrial symbiosis. But as opted by Szaro (1998) there might be a gap or poor relations between research, managers and the public. This gap or lack of relations is possibly illustrated by unknown symbiotic networks or EIPs uncovered by researchers and the failed attempts to successfully create these networks.

1.6. Aims and Objectives

This report tries to establish the best approach to facilitating industrial symbiosis within its context. As the context or embeddedness is very important this approach will most likely not be a ‘one-size fits all’ solution. The Sigtuna municipality and northern Stockholm region will form a case study for this research, providing input and the possibility of applying insights. Generality of the results is however discussed.

Aim: Assess the best approach to establishing Industrial Symbiosis under local conditions.

Objectives:

a) Define industrial symbiosis and related topics/subjects/methods.
b) Identify aspects and paradigms potentially obstructing industrial symbiosis.
c) Identify the influence of policy and regulation.
d) Identify the possibilities of planned or self-organized industrial symbiosis.
e) Suggest solutions to industrial symbiosis obstructions.
f) Assess the case study on industrial symbiosis feasibility.
g) Suggest an adapted method to establish successful industrial symbiosis in the case study.
2. Methodology

This study was carried out as a MSc thesis for the program of Sustainable Technology or Industrial Ecology at KTH, the Royal Institute of Technology in Stockholm. A second MSc thesis focusing on the identification and assessing of resource exchanges in the northern Stockholm region was carried out by Niklas Smedberg at the same time. Both theses use the same case study for feedback from stakeholders and therefore involved collaboration on stakeholder interaction.

An extensive literature study was carried out using the online access granted by the KTH library to search for published papers and books on the subjects of industrial symbiosis, industrial ecology and eco-industrial parks. Network theory, supply network, organizational theory and other related subjects, were found during the literature review and incorporated in the literature review. Other tools used for this research were questionnaires, interviews and a workshop.

Based on the literature study meetings were organized with actors of interest to get further insider knowledge and viewpoints. A meeting was held with Professor Leo Baas and PhD student Michael Martin at Linköping University on experiences from the EIP at Händelö (Norrköping, Sweden), research carried out on the Rotterdam harbor area and general insights related to the thesis subject. During a meeting with Gert Kindgren, chairman of the Cleantech Östergötland organization, the Händelö EIP was further discussed, as were the complications, benefits and insights based on the experiences with Cleantech Östergötland as an organization assisting local business in numerous ways. Experiences from the National Industrial Symbiosis Program (NISP) in the UK were taken note of during conversations and correspondence with Dave Berrill (NISP UK performance directors), Debra Power (NISP south east, east of England and London Region Project Manager), participants of the NISP quick-wins workshop in Harpenden the 31st of March 2011 and participation in this workshop.

2.1. Scope

Sigtuna municipality was initially designated as the case study for this thesis based on the construction of a new combined heat and power plant fueled by waste, the presence of a combined heat and power plant fueled by biomass, the presence of a waste recycling and handling station, the situation of three industrial estates, Arlanda airport, and residential areas within the municipality.

2.2. Stakeholders

Participation by local business and organizations was sought by means of interviews, questionnaires and a workshop. Stakeholders were classified in three groups: Core stakeholders, stakeholders of technical interest, and other.

Core stakeholders were identified within the original region by identifying them as potentially taking on a role of leadership, facilitation or becoming an example. These stakeholders were engaged with meetings and interviews as they could play a crucial role in engaging other stakeholders and providing continuity beyond the timeline of the thesis.
project. The identified core stakeholders in the Sigtuna region and motivation are given below:

- **SigtunaKommun**: can host or provide a networking platform and even start with knowledge exchange. As a municipality they are expected to have more opportunity in setting this up as they can more easily engage in long term investments. This platform for networking, knowledge exchange and IS can be used by SigtunaKommun to attract businesses to the region, market Sigtuna and its industry as green or environmentally friendly and promote industry in general.

- **Fortum**: Invests in a second CHP unit in Sigtuna. The current CHP unit is biofuel based and the new unit will use waste as a resource. Supplying heat and electricity to the region makes it a valuable and key actor. Energy can be supplied to regional actors in several ways and adapting its fuel source might result in it being able to process or upgrade regional by-products or low grade energy.

- **Ragn-Sells**: is a major waste handler in the region and thereby an important hub regarding waste and by-products. Investments in e.g. processing waste to a more valuable resource or providing storage capacity can enhance their position within the industrial network. Knowledge of waste and regulations can provide valuable competence.

Henrik Lilliehöök (head of refuse collection) and Ellinor Jonsson (waste officer) at SigtunaKommun gave further insight into the aspects of the municipality in relation to the study. Fortum’s viewpoints were gathered during a meeting with Per Elfving, responsible for Fortum’s business development in the northern Stockholm region. Ragn Sells’ viewpoints as owner of the waste recycling and handling station were taken from Graham Aid, working at Ragn-Sells and as a Ph.D. student at KTH.

Stakeholders of technical interest are stakeholders which’ inputs and outputs are of interest for suggesting symbiotic relationships between them. A database of companies within the region was used and 80 companies were identified. The distinction between stakeholders of technical interest and the other stakeholders was made based on a net annual turnover of minimal 10 million SEK and belonging to one of the following branches:

- Agriculture, forestry and fishery;
- Mining and quarrying;
- Manufacturing;
- Utilities (electricity, gas, heating, cooling);
- Water supply, sewage treatment, waste management, sanitation;
- Construction;
- Healthcare;
- Repair of computers, household articles and personal articles.

These stakeholders were briefly researched by checking websites prior to calling them in order to be able to explain the potential of industrial symbiosis for them. During the contact stakeholders were asked if they were willing to cooperate. If willing to cooperate
a mail was sent out to the contact with an attached letter explaining the project, including the suggestion of a future workshop within the region. A link to the questionnaire was given in both the e-mail and attached letter. This questionnaire contained questions on inputs and outputs as well as on the concept of industrial symbiosis. The questionnaire can be observed in Appendix A and the attached letter in Appendix B.

Other companies in the region were not excluded completely as opportunities could exist among them, and by showing interest in the concept follow up questions could be asked. These were companies with a net annual turnover over 10 million SEK but not part of the branches used for defining stakeholders of technical interest. Mail addresses from these stakeholders were taken from the company’s websites or websites listing company contact details. In the e-mail the thesis work and industrial symbiosis were briefly explained and respondents were requested to fill in an online questionnaire. A letter explaining the project in more detail was attached to the mail. This questionnaire only involved questions on the concept of industrial symbiosis and can be observed in Appendix C and the attached letter in Appendix D.

Core stakeholders, stakeholders of technical interest and those from the ‘other’ group that showed interest by fully answering the questionnaire were sent an invitation to a free workshop on industrial symbiosis hosted at a venue provided by Sigtuna municipality. An invitation as sent out can be found in Appendix E. This planned workshop was inspired on the quick-wins workshop from NISP as attended by the author March 31st 2011 in Harpenden, the UK. There were however not enough participants willing to take part in the workshop and the workshop was cancelled.

2.3. Expansion of case study

Due to the expectation of valuable feedback from a workshop and actual engagement of local business the case study was expanded to the northern Stockholm region, including the municipalities of: Danderyd, Järfälla, Sigtuna, Sollentuna, Solna, Sundbyberg, Täby, Upplands-Bro, Upplands Väsby, Vallentuna and Österåker, as shown in Figure 1. In the figure the municipality of Sigtuna is colored green, other included municipalities yellow and Stockholm (not included) is striped. The main purpose of the expansion was to get sufficient attendance to the planned workshop on industrial symbiosis within the northern Stockholm region. As a workshop was expected to provide interesting and valuable feedback from local business and result in practical experience the region was expanded and more companies were contacted.
These new companies were selected based on their geographical location within the given municipalities, annual net turnover over minimal 25 million SEK and the same branches as used in the selection of stakeholders of technical interest within Sigtuna municipality. In order to downsize the amount of companies to engage the healthcare branch was removed except for Danderyd’s hospital, and Stockholmslänslandsting (the province’s health care organization) was added to the list. Every third company belonging to the same branch was also removed from the list to reduce the amount of companies to contact. This measure was used to deal with time constraints of the thesis project and approaching Swedish summer holidays implied a workshop had to be hosted soon, leaving limited time for establishing contact. Companies working with ventilation, heat, sanitary and electrical installation activities were also excluded based on the expected low chance of possible resource exchanges and common subcontracting under construction companies. Companies part of the exclusion list but of interest to the project due to its size, specific products or environmental engagement as linked to the company name were however included.

The remaining group of 177 companies was contacted by phone. During contact people working with environmental issues, waste issues or the production process were explained the goal of the workshop and potential benefits for the company. An invitation to the workshop on industrial symbiosis was sent out by mail to all respondents who displayed interest in it during contact over the telephone. This invitation contained a short description of the concept of industrial symbiosis, a schedule for the three hour workshop including an hour lunch time, and a link to register. In the invitation limited availability was mentioned to attract more attendance. The invitation is included in this report as Appendix F. The workshop was held Monday 30 May 2011.
3. Results

In this section the results from the literature study, interviews, questionnaires, workshop and case study are given. First the aspects and paradigms that potentially obstruct industrial symbiosis are categorized by geographical boundaries, flexibility, trust and awareness and innovation capacity. Policy and regulation influences are then specified, followed by the questions of planned or self-organized industrial symbiosis. The results section closes with the case study description and results.

3.1. Aspects and paradigms potentially obstructing industrial symbiosis

Several aspects of industrial symbiosis or paradigms based on the concept of industrial symbiosis have the potential of obstructing industrial symbiosis. These, for example, can be grouped in technical, economic, informational, organizational and regulatory/legal aspects as done by Heeres, Vermeulen and Dewalle (2004) who described these as barriers to establishing exchange relationships between companies, this grouping covers all possible barriers but is fairly general. Technical and economic barriers are feasibility obstructions due to the exchange being e.g. too expensive. Informational and regulatory/legal barriers imply a lack of information at the involved actors or unawareness of which information applies to the situation. Organizational barriers simply imply an exchange not fitting within the organizational structure of a company.

Based on the literature study four different main aspects are used in this report to define potential obstructions to industrial symbiosis: geographic boundaries, flexibility, trust and awareness and innovation capacity. These potentially obstructing aspects are described and assessed below.

3.1.1. Geographic boundaries

The geographical boundaries of an EIP can be easily assumed as the same geographical boundaries of the industrial estate or cluster at which all participating actors are situated. Industrials symbiosis is however not excluded to single industrial estates or clusters. Reverting back to the definition of industrial symbiosis the collective approach is centered on the exchange of resources between traditionally separate industries. This requires the presence of industries with a diverse enough supply and demand for resources so that exchanges can be established among them. As geographic boundaries expand; supply and demand of resources, the chance of suitable partners and greater redundancy as the chance of more than one suitable partner increases (Sterr and Ott, 2004). The presence of a large number of actors can also make the network highly economically efficient (Bain, Ashton and Shenoy, 2009).

Six planning methods of Dutch consultancy firms as assessed by van Leeuwen, Vermeulen and Glasbergen (2003) all focus on the geographical boundary of an industrial estate for the planning of eco-industrial parks but the authors note that the exact process of achieving industrial symbiosis with these methods remained unclear even after interviewing the involved consultants. Waste management policies have influence on the success or failure of industrial symbiosis as these are part of the
context. Costa, Massard and Agarwal (2010) when discussing waste management policies provide the option of setting strong objectives on the supra national level, strong economic/regulatory instruments provided by the national level and leaving enough flexibility for stakeholder collaboration at the sub-national level. This implies a regional scale for industrial symbiosis network when it comes to policy instruments.

Close geographical proximity between actors can result in benefits for actors although it will not necessarily result in industrial symbiosis activities. Innovation and knowledge sharing for example are thought of as a result from frequent communication and cooperation between firms, as can be caused by close geographical proximity. Incentives other than economical ones for cooperation with mutual interest between managers of different actors are believed to be based on personal relationships that exist in regional economies. (Ashton, 2008). Which size of geographical boundaries is associated with these regional economies is not given. Sterr and Ott (2004) recognize that as the geographical boundaries get larger there is an increased need for an environmental management network operating inter-organizational; which can coordinate all forces and interests within the boundaries.

Larger geographical distances will also require more effort in creating the informal network between actors in the system. This is caused by an increased complexity of communication between stakeholders as the distance has to be overcome, resulting in a related increase in costs of this communication (Sterr and Ott, 2004). These increased costs will most likely not only result in higher travel expenditures but also on the necessity of allocating more time on travelling.

Transport of resources within an industrial symbiosis network will increase as the geographical size of the network increases. This is simply caused by an increased average transport distance between actors of the network. A larger network with a bigger supply and demand does however also increase the viability of recycling or re-processing activities within the network; the advantage of scale for industrial processes (Sterr and Ott, 2004).

3.1.1.1. NISP

In the UK a national organization actively practices the concept of industrial symbiosis by facilitating or organizing synergies between companies. This National Industrial Symbiosis Programme (NISP) consists of twelve regional NISP organizations; these organizations cover a region with the same geographical boundaries as the administrative area of the regional governments. The national organization develops frameworks and tools that can be used by the regional organizations of which one is a database system that is accessible for all regional organizations that can analyze the data and feed new data into it. Best practices from regional organizations are also easily shared via the national organization. (Kim and Powell, 2008)

3.1.1.2. TEDA

Results from a study on the exchanges of energy, water and material at the Tianjin Economic-Technological Development Area (TEDA) in China show interesting results on geographical proximity. 81 exchanges within TEDA or involving companies located at
TEDA were identified of which 33 exchanges took place within the boundaries of TEDA and the remaining 48 involved companies inside and outside of TEDA. Of the exchanges involving external companies 2 are based on energy exchanges and the rest on materials. Average distances of the exchanges were examined and for internal exchanges this averaged on 11.5 km while exchanges involving external companies averaged on 34 km. Exchanges of energy and water however had a maximum distance of respectively 5 and 8 km. Furthermore, it has to be noted that the building of infrastructure at TEDA was subsidized and therefore all established exchanges might not have been economically feasible without it. (Shi, Chertow and Song, 2010)

3.1.2. Losing Flexibility

Flexibility is of concern to actors within industrial symbiosis networks as partners within a symbiotic activity depend on each other. There is the fear of a partner e.g. failing to live up to the agreements, moving or going bankrupt. As stated by van Leeuwen, Vermeulen and Glasbergen (2003) one of the disadvantages of coupling production processes is the continued dependence of actors on each other and the resulting organizational process that can be complex. However, a large number of actors within a network make the network highly flexible (Bain, Ashton and Shenoy, 2009); suggesting alternatives can be easily located in a large network. Another aspect of flexibility is the migration of personal, if exchange activities are driven by personal contact the migration of key-persons can harm the exchange activities (Chertow, 2007).

Korhonen (2001) tries to apply four ecosystem principles to industrial systems and states that survival of an ecosystem is based on diversity. Diversity in the industrial system is reduced as the system is described or understood under the single denominator of monetary value. Diversity is also reduced in the current industrial system as there is a tendency of maximizing homogenous output and mass production. (Korhonen, 2009)

On the other hand similar actors are able to substitute each other within a symbiotic relationship with none or minimal change.

EIPs, which focus on industrial estates, are vulnerable for exchanges of resources that are difficult to replace as the number of companies or homogeneity of an EIP is limited; while larger regions can increase flexibility as more potential companies for exchanges can be found, argue Bain, Ashton and Shenoy (2009). It is however important to keep in mind that companies are interdependent by nature as companies for example pick sites that are beneficial based on geographical location (Clark, 1995 as cited in Lowe, 1997). Based on the industrial network approach with resources, activities and actors as the three relevant components van Bommel (2011) states that the resource structure is highly influential for a supply chain. This argues that actors and actors’ activities are partly defined by how resources are controlled, creating a certain dependency within a supply network, whether involving symbiotic relationships or not. Lowe (1997) posed that the risk of dependency can be dealt with in conventional ways as done in supplier and customer relations and gives the examples of setting up contracts on reliability and remain being in contact with alternatives.
Costa, Massard and Agarwal (2010) make a proposal for some decentralization or flexibility for local government to be able to provide tailor made policy instruments for industrial symbiosis. This tailor made approach in waste policies and regulation can increase the flexibility for industrial symbiosis networks as innovative ideas might require the adaptation of policies and regulation.

A lock-in situation can be described as minimal or no flexibility; a too high dependency on others without the possibility of establishing an alternative solution. An examination of eleven failed exchanges at the EIP of TEDA in China showed that fear of a lock-in or too high dependency on others might be unnecessary. Six exchanges ended due to cleaner production methods reducing the amount of waste possible for re-use. Two exchanges were cancelled due to increasing prices of by-products. Concerns of liability in two cases caused waste to be disposed of in more conventional manners and bankruptcy caused one exchange to end. (Shi, Chertow and Song, 2010). This illustrates that fear of a lock-in or too high dependency on other actors might be unnecessary.

Redundancy of actors providing roundput within a network, recycling matter or cascading energy (Korhonen, 2001), means there is the availability of an alternative or identical solution for matters of recycling materials and cascading energy flows. The stabilization of a network of exchanges is increasing according to Sterr and Ott (2004), if the redundancy of these roundput actors increases within the network. If a larger amount of actors is capable of roundput functions this will increase the flexibility as alternatives are present in case an exchange fails.

3.1.3 Lack of Trust

As Gibbs and Deutz (2007) noted in their paper on implementing industrial ecology a lot of previous literature emphasizes that trust is a key factor of influence on exchange activities and networking. Formation of trust can start simply by establishing travel to work arrangements, interchange in personnel and co-operative purchasing; a coordinating body can help in the process of building a community and establishing collaboration or community sense (Gibbs and Deutz, 2007). Based on their analysis of six Dutch EIP planning methods van Leeuwen, Vermeulen and Glasbergen (2003) the authors simply state that trust is important. In the Rotterdam harbor and industry complex, the Netherlands, actors have become capable of trusting each other over time which formed an important foundation for inter-organizational projects (Baas, 2008).

Two trust related risks for establishing resource exchanges are mentioned by Lowe (1997): proprietary information may come in the hands of competitors and quality concerns of the resource that is exchanged. Lowe (1997) also states the establishment or growing of an EIP needs guidance and information but it should be a self-organizing process. Part of this guidance and information are two remarks made by the author on the above mentioned risk: the exchanges or trades involve multiple actors that can easily determine what information is shared and quality can be ensured just like a contract with regular suppliers does. (Lowe, 1997)

Mutual trust among neighboring actors and stability on the demand side are described as a guarantor for a continuous material exchange by Sterr and Ott (2004). There is however
no indication given on what role the mutual trust plays for stability on the demand site or if there are other reasons for the stability. This is of concern as Sterr and Ott (2004) also state that particularly in waste related issues there is a lack of trust among companies.

Physical resource exchanges often need new infrastructure investment which potentially restricts the movement of a company as the infrastructure is in place, these exchanges might need trust in order to be maintained (Gibbs, 2003). Elabras Vega and Magrini (2009) describe the development of an EIP as a long term process which requires trust as one of the important factors and note that short term thinking of most companies forms an obstacle to creating this trust on the long term.

3.1.3.1. Establishing and Improving Trust

Role Playing Games (RPGs) can provide a simulation of multiple scenarios and changes with the actions of participants in the game. Batten (2009) suggests that RPGs and simulation models generate alternative futures that can be explored and developed based on the conditions which are influenced by the stakeholders. If different futures and development are shown within a simulation based on the participants’ actions this shows certain obstructions don’t have to be an issue, creating trust in the concept and other actors. Simulation does however have its limitations as for example the managers from Kalundborg emphasize that for building trust and business relationships their personal interactions were vital (Lowe, 1997).

This is argued by Wolf, Eklund and Söderström (2007) as well on the topic of creating or developing industrial ecosystems as personal contact with actors is of importance for building trust, company involvement and acquiring knowledge of the system. Kindgren (2011) mentions that in the case of a coordinating body or workshop the body itself or the host of a workshop needs to be trustworthy. This extends the issue of creating trust towards a coordinating body and seems logical, as a coordinating body engages in certain collaboration with the stakeholders.

3.1.4. Required Awareness and Innovation Capacity

3.1.4.1. Awareness

Industrial symbiosis as a concept is not widespread in the business world and actions undertaken that can be classified as industrial symbiosis are, with the exception of a few, not defined or communicated as such by those creating them. Many industrial symbiosis activities, or resource exchanges, have been uncovered by researchers but grew on their own; these are defined as self-organizing (Chertow, 2007). Although there is literature suggesting synergies or industrial symbiosis activity are more and more regarded as ‘business as usual’ (van Berkel, et al., 2009). This suggests a lot of industrial symbiosis activities are not reported or communicated outward either because it is regarded as common practice or because the exchanges take shape within their context but those involved are not aware of the concept of industrial symbiosis.

The Cleantech Östergötland organization (regional within Sweden) provides numerous services to local companies including training, coaching, workshops and access to knowledge on several topics like; sales, intellectual property rights, design for
environment, lawyers and procurement. It is however also marketing an EIP in the region, Händelö, to stakeholders all around the world. The organization was and is however not involved in the creation or facilitation of industrial symbiosis in Händelö but is able to use it as a green or cleantech example, attracting investment and customers for local business. As an organization funded by benefactors and ‘invested time’ of its members it is able to create awareness by marketing industrial symbiosis as innovative and functions as an important networking tool for business in the region. (Kindgren, 2011)

3.1.4.2. Innovation Capacity

For a company it is common to rely on other actors that are part of the same supply network or branch of industry when looking for resources. Strategies involving collaboration with unknown actors are usually not considered if in search for resources. But if there are no extra benefits to establishing a resource exchange between neighboring companies the most profitable solution will be chosen. (Chertow and Miyata, 2010) The search for collaboration or solutions outside of the companies’ conventional network will most likely require a certain innovation capacity as it diverts from common practices.

Within an innovative process the network holds an important function that can aid in the coordination of exchange of resources, mobilize resources and develop knowledge; innovation can therefore be seen as the product of a network (Håkansson, 1990 as cited in Mirata and Emtairah, 2004). The innovation power of a company is built up from the innovation characteristics of the company itself and the cooperative characteristics of its supply network; the level of a company’s innovation power is related to its strategy and activities that make up the strategy (van Bommel, 2011). If industrial symbiosis activities are seen as innovative it will require a company to be capable of innovation, this capability is strengthened by the innovative nature of its network. According to van Bommel (2011) transparency, leadership, adaptation capabilities, autonomy, inter-departmental cooperation and the possibilities of learning and experimenting are examples of a company’s innovation characteristics while reputation, trust, collaborative programs and knowledge sharing are examples of cooperative characteristics of a supply network.

A difference between conventional supplier and customer relations are the properties of the resource that is exchanged. If a resource is needed one can set demands and look for the most suitable supplier. In the case of sharing by-products the demands might be met only after processing of the resources in question, processing that has to be set-up by the actors involved. Or as mentioned by Chertow (2007) the use of industrial by-product in symbiotic exchanges with agriculture was a source of concern when taking into account health issues. There exists a slight fear of by-product use as it could’ve been waste for a good reason. Similarly waste regulations and policies might be unknown and pose an initial threat to symbiotic activities, but awareness of the issues and possibilities together with innovative capacity should be able to overcome posed problems.

Baas (2008) wrote that technical and regulatory capabilities are most important if starting
industrial symbiosis practices. With technical ability in this context is meant that knowledge can be mobilized and applied in order to minimize environmental impacts or develop products that are more sustainable. Regulatory ability implies the adjusting or creating of regulations so they contribute goals set by the region. (Baas, 2008) Implied a certain innovation capacity is needed from the company’s side but a network with innovation power is equally important.

3.2. Policy and Regulation

The EU waste directive defines waste as “any substance or object which the holder discards or intends or is required to discard” (EU, 2006), the holder of the substance or object has to determine whether or not it is waste. Transportation, treatment, management and use of waste are controlled by regulations as it potentially poses a threat to human health or the environment (WRAP, 2011).

3.2.1. Waste Hierarchy

The EU waste framework directive uses a waste management hierarchy to determine the best options for waste. According to this hierarchy prevention and reducing the harmfulness of waste has priority. If this is not possible reuse, recycling or energy recovery is the best option, before the final option of safe disposal by incineration or landfill sites. (EU, 2006) This hierarchy can be visualized as displayed in Figure 2.

Treatment of waste however has the goal of removing the threat to human health or the environment. An alternative goal can be the recovering of waste and turning it into a resource. This implies waste at a certain point no longer is waste, enabling recirculation after treatment. The EU is working on “end-of-waste rules”, which are intended to provide criteria that enable the determining of a material recovered from waste as not waste. The first criteria are ready and intended for metal scrap, criteria for other waste types are under development. (EU, 2011) In the UK more end of waste criteria are already in place (UK Environment Agency, 2011).

End of waste criteria developed for specific types of waste comply with four general conditions: “the substance or object is commonly used for specific purposes; a market or demand exists for such a substance or object; the substance or object fulfills the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; the use of the substance or object will not lead to overall adverse environmental or human health impacts” (JRC, 2008). This implies that the recovered material can be used as a resource within the current industrial system.
3.2.2. Waste in Sweden

Table 1. Waste treatment in Sweden over 2008 (Naturvårdsverket, 2010)

<table>
<thead>
<tr>
<th></th>
<th>Non-hazardous waste</th>
<th>Non-hazardous waste</th>
<th>Hazardous waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycling/Recovery</td>
<td>12%</td>
<td>42%</td>
<td>40%</td>
</tr>
<tr>
<td>Use as a fuel</td>
<td>10%</td>
<td>37%</td>
<td>9%</td>
</tr>
<tr>
<td>Deposit</td>
<td>76%</td>
<td>15%</td>
<td>39%</td>
</tr>
<tr>
<td>Disposal by incineration</td>
<td>0%</td>
<td>0%</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

As seen in Table 1 in Sweden a large proportion of the generated waste comes from the mining industry, waste that is deposited by the industry itself. If the mining waste is excluded 15% of waste is still deposited and 37% is used as a fuel, options that are outranked by the recirculation or recycling/recovery of materials. This implies there is room for improvement but the re-use of by-products or waste as part of industrial symbiosis activities will potentially compete with energy recovery options and landfilling. Landfill taxes or bans and incineration taxes for waste are major policies affecting industrial symbiosis in general, as are the end of waste criteria set up in the UK, concluded Costa, Massard and Agarwal (2010). Increasing landfill taxes in the UK (£ 56 per tonne in 2011 (CEWEP, 2011) have been and are a great driving force for the National Industrial Symbiosis Programme (NISP) as it forces companies to find different solutions for their waste, according to Berrill (2011).

A ban on landfilling exists in Sweden. The ban includes sorted combustible waste and organic waste with some exceptions. The exceptions on organic waste are: burned ashes with less than 18% (mass) organic carbon, composted sewage sludge, green liquor (originating from kraft process pulp and paper mills), certain types of animal waste, homogeneous waste with less than 10% (mass) carbon and heterogeneous waste with less than 10% (volume) combustible waste (Naturvårdsverket, 2011a). Landfill tax in Sweden is € 43 per tonne (CEWEP, 2011). Taxes on the incineration of municipal solid waste have been abolished after not achieving the desired effect (Avfall Sverige, 2010). Value of the major product from waste incineration in Sweden, district heating, is however higher than in countries like the Netherlands and Germany due to the taxation on CO₂ and energy derived from fossil fuels (Olofsson, 2005). This creates an incentive for the use of waste as a fuel as it competes with taxed fossil fuels or biofuels and might hinder the creation of by-product or waste exchanges between companies.

3.3. Planned or Self-organized

A planned eco-industrial park (EIP) involves the identification of companies suitable for resource exchanges and locating them together to enable the exchanges. A self-organizing model is however based on decisions and interactions of private actors. The Kalundborg EIP, in Denmark, was self-organized by the companies involved, once established the role of coordination became of help in the developing of more
exchanges or advancing existing exchanges. Self organization has the benefit of facing a market viability test and pose as a good example for other private actors. It is however recognized that coordination and encouragement after initial self organization can benefit the success of an industrial symbiosis network. (Chertow, 2007) An ‘anchor tenant’, two or more large companies engaged in a physical resource exchange, is suggested to function as a role model from whom other exchanges can be initiated more easily (Chertow, 1998).

3.3.1. Coordination

If industrial symbiosis does not come natural to stakeholders and has to be introduced it will require an approach with new types of capabilities (Baas and Boons, 2005 as cited in Baas, 2008). In the Rotterdam harbor area industry came to the universities for help on implementing industrial ecology practices, this was possibly caused by a history of environmental concerns (Baas, 2011). Actors from the industry, government, port authority, universities and an environmental advocacy organization were part of a new platform that was set up for strategic decisions and has come to function as a sustainability conscience for those involved (Baas, 2008). Workshops were carried out at the Rotterdam harbor area, starting with an initial workshop to brief project managers and later a two day workshop for involved engineers (Baas, 2011). The organization representing industry in the area has grown to be a knowledge broker for industry relying on its personal networks (Baas, 2008). Furthermore Baas (2008), based on the reflections on the Rotterdam harbor complex, concludes that stimulation of industrial symbiosis activities and the monitoring thereof requires professional facilitation and that contributions from relevant stakeholders is part of the key to successful facilitation.

Gibbs and Deutz (2007) indicate the importance of local collaboration and partnership and suggest that coordinating bodies can take up this role. The coordinating role can be as broad as creating and sustaining relationships between other actors, knowledge and the identification of interesting partners. They also state the importance of community in the sense of networking and collaboration, as cooperation cannot be simply made mandatory and used to establish exchanges (Gibbs and Deutz, 2007). In a paper on Dutch EIP planning methods the collective learning process is identified as key to the development of an EIP (van Leeuwen, Vermeulen en Glasbergen, 2003).

Facilitation of by-product exchange could also be taken care of by brokers dealing with surplus resources. There is however a risk brokers will only put effort on finding possibilities for high value resources if working on commission. A benefit for smaller companies on working with or along a coordinating body or broker is the increased possibilities of competing with large companies due to the collaboration. (Lowe, 1997) This is also suggested by Kindgren (2011): “compete in the foreground but collaborate in the background”, and backed by the range of services and collaboration possibilities the organization of Cleantech Östergötland offers it members who thereby enjoy benefits otherwise costly or only viable for larger companies.

The formation of inter-company networks that generate and share knowledge and thus innovation is suggested to be encouraged by institutions. This voluntary encouragement
or the use of existing governance structures in the formation of these networks and the success of these networks is debatable (Gibbs, 2003).

3.3.2. NISP and TEDA

The National Industrial Symbiosis Program (NISP) in the UK uses a broad definition of resources to stimulate more collaboration, is demand based and emphasizes the need for a management tool. Commitment of companies and organizations within a region is sought after which industrial symbiosis thinking is part of trainings while resource data is collected. This data is for example used on giving a “heads-up” call to other companies on possibilities for collaboration. Resource exchanges, synergies in NISP language, are then identified by all involved and only implemented if commercially viable. An important step afterwards is the monitoring and maintaining of projects, which can also be used as good examples and to create trustworthiness. (Kim and Powell, 2008 and Berrill, 2011)

An independent environmental protection bureau was set up for the Tianjin Economic-Technological Development Area (TEDA) in 1990. It created and uses environmental programs to assess new projects, monitoring and emission control. In 2000 the TEDA achieved ISO 14001 certification, partly due to the believed competitive advantage of certification. During its existence this has led to the creation of several industrial symbiotic activities including by-product exchange and utility sharing. Partnership with external innovation centers was necessary due to a lack of innovation capacity in TEDA. (Shi, Chertow and Song, 2010)

3.3.3. Planning

The analysis of six Dutch EIP planning methods included several methods or incentives used for the planning. A requirement to take part in a park management organization, the park is based on three sets of options which are based on; obligations from the authorities, criteria used to select companies and other rules that come to apply to the involved companies are part of the ‘environmental grading system’. ‘The sustainability scan’ is based on information and data gathered by a consultant which is expressed in possibilities, the motivation of companies to act and the carrying capacity of proposed measures. The method called ‘the helping hand’ strives to develop carrying capacity by going through phases of initiation, orientation, decision making, design and finally implementation. At each phase the participants are guided and supporting tools are available. None of the planning methods however are based on participation of just companies, the authorities are always included. (van Leeuwen, Vermeulen and Glasbergen, 2003)

In order to successfully develop an eco-industrial park active participation from numerous stakeholders is necessary according to Heeres, Vermeulen and Dewalle (2010), which are: “public sector stakeholders from local, regional and national government agencies, representatives of local companies and potential future tenants in the EIP, leaders in the industrial and financial community, local chamber of commerce, labor representatives, educational institutions, education and training, community and environmental organizations and practitioners with all capabilities needed: architecture,
engineering, ecology, environmental management” Thus enabling the gathering of all necessary data, viewpoints and interests from all stakeholders for the development of an EIP. It is however not describing how the interaction of all stakeholders should take place and how all stakeholders can be aligned.

3.4. The case study: Sigtuna and northern Stockholm

A case study was used to gather feedback from local stakeholders. The municipality of Sigtuna was chosen on first hand and during the study the case study was expanded to the northern Stockholm region. Meetings with stakeholders, questionnaires a workshop and phone- conversations were carried out to establish stakeholder engagement and gather feedback.

3.4.1. Case description

Sigtuna municipality is located north of Stockholm and has a little over 40,000 inhabitants and is part of greater Stockholm (Wikipedia, 2011). The three towns of Märsta, Sigtuna and Rosersberg are part of the municipality, as is Stockholm’s main airport: Arlanda. The five industrial estates of: Arlanda, Mårstaarbetsområde north, Mårstaarbetsområde south, Arlandastad and Rosersberg are part of Sigtuna municipality. Because of the proximity to Arlanda airport a lot of warehouses for transport to, from and within Sweden are located in the municipality. Other interesting aspects of the municipality in relation to this study include the construction of new combined heat and power plant fueled by waste, the presence of a combined heat and power plant fueled by biomass, and the presence of a waste recycling and handling station.

Engagement was especially sought at the core stakeholders: Sigtuna municipality, Fortum and Ragn-Sells. Sigtuna municipality was willing to provide a venue for the workshop and sponsor lunch that could be organized at the workshop. In correspondence and conversations with local business involvement of Sigtuna municipality could however not been mentioned as the municipality felt it might get the image of being too actively involved with local business as several questionnaires for other studies had been sent out already. Fortum showed interest in the concept of industrial symbiosis and the study but was not willing to get actively involved by for example being mentioned in correspondence as actively supporting the project. Ragn-Sells was actively involved in the project as the thesis supervisor is part-time employed at Ragn-Sells and showed interest in the concept. Furthermore, Ragn-Sells were willing to host a venue for the workshop and sponsored the attendance of the author to the NISP workshop in Harpenden.

Due to a lack of participation for a planned workshop on industrial symbiosis, based on the NISP quick-wins workshop as attended by the author March 31st 2011 in Harpenden, the region was expanded. Feedback from the workshop is therefore based on the northern Stockholm region, defined as the municipalities of: Danderyd, Järrolla, Sigtuna, Sollentuna, Solna, Sundbyberg, Täby, Upplands-Bro, Upplands Väsby, Vallentuna and Österåker. Figure 1 in the methodology section gives a quick overview of the included municipalities and their situation in greater Stockholm.
3.4.2. Results from questionnaire

These results only reflect upon Sigtuna municipality.

A questionnaire containing input/output related questions, used in another thesis but not part of this thesis, and questions on the concept of industrial symbiosis was sent out to 48 respondents. These 48 respondents resulted from calling 80 companies that were identified as stakeholders of technical interest. During the phone-conversation the study was briefly explained, the respondent was asked if he/she wanted to cooperate and for a direct mail address. Of these 20 respondents filled in the questionnaire.

To all other stakeholders in the Sigtuna region a questionnaire was sent with only questions on the concept of industrial symbiosis. This questionnaire, the accompanying letter and mail was the first contact with these stakeholders and generic mail addresses gathered from company websites, people were not directly contacted. 63 questionnaires were sent out, resulting in 5 completed questionnaires.

Table 2. Success rate of sent out questionnaires

<table>
<thead>
<tr>
<th>Questionnaire type</th>
<th>Contacted by phone</th>
<th>Sent out</th>
<th>Completed</th>
<th>Success rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input/output + industrial symbiosis</td>
<td>80</td>
<td>48</td>
<td>20</td>
<td>25% / 42%</td>
</tr>
<tr>
<td>Industrial symbiosis</td>
<td>-</td>
<td>63</td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td>Both / Total</td>
<td>-</td>
<td>111</td>
<td>25</td>
<td>23%</td>
</tr>
</tbody>
</table>

The overall success rate of the questionnaire was 23%. Without prior contact and generic mail address the success rate was only 8% while the success rate of phone contacted participants indicating cooperation was 42%. Table 2 gives an overview of the amount of questionnaires sent out and completed.

Questionnaires were formulated and answered in Swedish but the results are translated to English for the purpose of this report and based on the 25 completed questionnaires.

3.4.2.1. Are you familiar with or have you heard of Industrial Symbiosis

Respondents could choose between the options:

- I know exactly what it is
- I understand it but don’t know exactly how it works
- I have heard of the term/concept
- I have never heard of industrial symbiosis until now

Figure 3 shows the results, no respondents new exactly what industrial symbiosis is.

Figure 3. Response: familiarity with IS
3.4.2.2. Are you familiar with or have you heard of Eco-Industrial Parks (EIP)

Respondents could choose between the same options as in the question on familiarity with industrial symbiosis, replacing industrial symbiosis with EIP, the results are visible in Figure 4.

As with industrial symbiosis no respondent knew exactly what EIPs are. Familiarity with the concept of industrial symbiosis seems to be better than with EIPs, as more respondents indicated never to have heard of EIPs and only 4% indicated to understand it.

3.4.2.3. Open questions

Before the open questions industrial symbiosis and EIPs were briefly explained in four sentences. These questions were asked:

- What opportunities do you foresee?
- What obstructions do you foresee?
- Say an opportunity of collaboration by by-product sharing exists, what help do you feel is most wanted or needed?
- What role should the municipality or authorities take on this subject?
- Room for comments, suggestions and/or ideas.

Only one respondent answered negative on the question of opportunities, several respondents briefly described possibilities for their companies’ waste or what services they could offer. One respondent warns for high developments costs which can be shared if a right platform is created by “politicians who understand the possibilities of industrial symbiosis”.

Costs associated with the exchange of resources transport and related storage and diversity of actors within the direct neighborhood are foreseen obstructions by the respondents. Two respondents noted not to foresee any obstructions and there was one mentioning of the complications that arise in dealing with contagious waste.

Information, education, good examples and contact with people who have participated in a similar project or a role for authorities to help find solutions indicates companies predominantly prefer help in the form of knowledge. Low costs and flexibility in policies and regulations were also mentioned as preferred help.

Sixteen respondents shared their viewpoints on the role that the municipality or other authorities should take on. Only two would like the authorities to have no role or one as small as possible. Twelve, the majority, see a role for the municipality on advising companies and controlling set rules because they are most likely to have insight in all companies’ by-products, can keep oversight over the larger system and start discussion among companies. Two respondents suggested municipalities to take care of transportation and storage space.
3.4.3. Results from the workshop

The workshop took place Monday March the 30th from 10:15 to 13:00 in the conference room of the department of industrial ecology at KTH. The workshop was held in Swedish but comments from participants and text from the presentation are translated to English for this report. Of the 177 companies contacted ten registered as attending, three cancelled a few days prior to the workshop and one did not show up without notice, leaving six participants:

- Kristina Elliot (Enebybergs Plåtslageri),
- Tomas Svankvist (Marketer at Kriminalvården),
- Kathryn Arnborg (Managing director and owner of Tre Well Emballage AB),
- Per Elfving (Asset manager at AB Fortum Värme),
- Erik Petersson (Quality and Environmental manager at Inrego AB),
- Richard Lundgren (Owner of A Lundgren Smide AB).

A short description of the companies as given by the participants is translated and given in Appendix G.

3.4.3.1. Introduction and Presentation

A ten minute presentation explaining industrial symbiosis was the start after a very brief explanation of the theses work and intentions. This presentation began by explaining industrial symbiosis with a headline: “Collaboration and Sharing to achieve better Results”, followed by a why, how and what:

- Why?
  - Because industries/organizations can do better with their resources
- How?
  - Create a network between otherwise separate industries
- What?
  - Exchange by-products, share utilities, share services
  - Establish contact

Industrial symbiosis was then approached from a supply chain or network perspective. The presentation began by sketching out the situation of a current linear system from raw material extraction via production, use, wasting, and treatment to landfill or incineration. Then explaining companies wish to establish control on their supply chain, e.g. by supplier contracts and mentioning that several developments like; scarcity of resources, efficiency of recycling, environmental concerns and dependency make it harder to efficiently add value as a company. This was followed by the image of every company in a supply network having a product to sell and by-products or waste, which can end up in the supply chain of a recycling or waste company.

By made-up examples of by-product sharing within an industrial state or region and utility sharing the question was asked whether or not these practices are different from a traditional supplier relationship. The follow up slide answered negatively, mentioning the difference was that solutions can be found outside the common or own networks.

Results from 5 years of the NISP program in the UK were used to show benefits on the
economic, environmental and social side. Six examples of industrial symbiosis taken from NISP’s website were presented very briefly to show practical applicability. After which the actual workshop took place.

3.4.3.2. Workshop

The workshop was based on the NISP quick-wins workshop as observed by the author 31 March 2011 in Harpenden, UK. Each participant was asked to give a very short introduction or presentation to their company. These presentations were simple short speeches but two participants used a short company film on the projector to further illustrate company activity. After these presentations every participants were asked to note the resource they wanted and those they had. Special papers were used for this and based on the one used by NISP. “Jag har” and “Jag vill ha” papers (I have and I want), printed on blue and yellow papers. These enable the specification of resources to simple details like the location, quantity and current solutions, as can be seen in Appendix H.

All “I have” and “I want” resources were read out loud to the table by the table host, giving those interested a chance to respond or ask for more details. This resulted in some short fruitful conversations between participants on possible other solutions or the gathering of more details on the resource. During the workshop 37 “I have” and 21 “I want” resources were noted, ranging from waste and by-products to labor services and work. This led to 35 potential possibilities of cooperation.

3.4.3.3. Feedback

A list of all resources and possibilities of cooperation resulting from the workshop was sent out to all participants the same day. A check on the success-rate of these possibilities was due to the deadline of the thesis not possible. Feedback on the workshop was however achieved by sending out an online feedback form to all participants, of which five filled in the form. Six questions asked for a grading from one to five, one being the lowest. Results from these questions are given in Table 3.

<table>
<thead>
<tr>
<th>Question</th>
<th>Grade (1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the organization of the workshop was good?</td>
<td>4.6</td>
</tr>
<tr>
<td>Do you think the presentation was useful for you?</td>
<td>4.2</td>
</tr>
<tr>
<td>Do you think the workshop was useful for you?</td>
<td>3.4</td>
</tr>
<tr>
<td>Was the workshop as you expected it to be?</td>
<td>3.8</td>
</tr>
<tr>
<td>How would you rate the networking opportunities?</td>
<td>4.0</td>
</tr>
<tr>
<td>In your opinion, can the workshop stimulate industrial symbiosis in the Stockholm region?</td>
<td>4.6</td>
</tr>
</tbody>
</table>

On the question “What can be improved on the “I want” and “I have” papers” respondents stated:

- Specify better what is useful for “symbiosis” products and services.
- Tempo in the reading out of resources. Maybe every participant can read his own papers out loud and note the possible collaboration partners, like speed dating.
- More time is needed for the reading out of resources.

On the question: "How can we improve the workshop" respondents stated:

- Create large networks or use existing local networks.
- Make sure there are participants of which you know beforehand synergies are possible. And there might be an advantage in setting geographical boundaries as this can be an obstruction to cooperation.
- Involve more companies/organizations
- More companies are obviously better. It was good that reviewing of companies was possible beforehand as it can take while before you get in the right thoughts of what others can offer. Include a company using waste as a resource as many noted a waste as a resource, this is also good for the discussion. Control of the discussion can be tougher in terms of both time and the right topic at the right level.
4. Discussion

The results will be discussed in this section based on the set objectives for the study:

a) Define industrial symbiosis and related topics/subjects/methods.

b) Identify aspects and paradigms potentially obstructing industrial symbiosis.

c) Identify the influence of policy and regulation.

d) Identify the possibilities of planned or self-organized industrial symbiosis.

e) Suggest solutions to industrial symbiosis obstructions.

f) Assess the case study on industrial symbiosis feasibility.

g) Suggest an adapted method to establish successful industrial symbiosis in the case study.

4.1. Definition of industrial symbiosis

The concept of industrial symbiosis is subject to many interpretations and practical implementations. This might be caused by the naturalness of the concept of collaboration, which is a very common act to many. In industrial symbiosis however the collaboration is sought among those who might not meet or discuss topics of collaboration while doing business; traditionally separate actors.

4.1.1. Definition

Sharing or exchanging resources is the goal of the collaboration but the definition of these resources is not carved in stone. Some definitions of industrial symbiosis have delimited resources to physical materials and substances and energy. Other definitions broadened the resources to include the sharing of services or utilities. During the workshop participants used a very broad definition of resources, including not only by-products or waste but also shared labor and overcapacity in production.

A participant however also noted a request for “structuring the organization”. This can be regarded as a request for a service, and thereby resource but can be requested on the normal market and does not need industrial symbiosis. If a company or organization’s services and products it offers are defined as resources an industrial symbiosis network could easily turn into a regular marketplace which can overshadow the initial goal. The example of the prison services offering a workforce with workshop however is benefiting the collaboration between traditionally separate actors, but is not the core service or product of the organization. One of the comments from a participant of the workshop was that the definition needed clarification.

Purpose of the collaboration, exchange and sharing is however increasing resource efficiency. Industrial symbiosis should therefore be defined as bringing together actors from traditionally separate companies and organizations with the aim of establishing collaboration by exchanging resources and the sharing of services and utilities. Resources can be defined as physical materials, energy and water. The core services and products a company or organizations delivers should be excluded from the resources, services or utilities.
Eco-industrial parks can use the same definition but are delimited to the geographical boundaries of the industrial estate, as it is the implementation of industrial symbiosis within these geographical boundaries. Exchanges from actors within the EIP with companies or organizations outside the EIP could however be accounted to the EIP as its involvement is required. This could have potential in expanding from an EIP to a broader industrial symbiosis network.

4.1.2. Industrial symbiosis grading scale

The defining of industrial symbiosis activity by defining it as a minimum of three actors involved in at least two different resources will exclude start-ups of industrial symbiosis network or activities and not help in the dissemination of the concept. A grading scale of industrial symbiosis could however give better insight in the type of exchange and number of actors involved. Such a grading scale cannot be linked directly to economic, environmental or social performance. It can however aid the dispersion of the concept of industrial symbiosis as it can typify industrial symbiosis activity and thereby used as examples or even marketing instruments.

A grading scale could have four classifications:

A. Physical exchange (material, waste, by-product, water)
B. Energy exchange (cascading, upgrading spillage)
C. Shared utilities (water treatment, steam generation)
D. Shared services (transportation, fire suppression)

The amount of exchanges taking place with the actors is identified by a number after the letter; the number of actors involved in the exchange will add another number after a dash. For example: one company is able to exchange its by-product to another company and a third actor is reprocessing the by-product to the required standards, resulting in an A1-3 class industrial symbiosis. A B3-10 indication implies the involvement of ten actors and three energy exchanges. Figure shows an example of how the badges identifying the class of exchange could look like.

![Image of grading scale badges for industrial symbiosis]

Figure 5. Example of grading scale badges for industrial symbiosis

Colors of the badges could be used to create an increase in the achievements made, as in general the physical exchange of materials or energy cascading will be higher achievements than the sharing of utilities or services. If the company is part of an industrial symbiosis network or EIP the name or logo thereof could be inserted into the
badge. A short description of the exchange should be part of the classification for full clarification. Grading industrial symbiosis activities like this will also enable clarification between collaboration achieved in an industrial symbiosis network between that what is meant to be achieved and side activities aiding business not part of the original concept.

4.2. Aspects and paradigms potentially obstructing industrial symbiosis

Several aspects and paradigms are identified in the results section that potentially obstruct industrial symbiosis practices. This section discusses the implementations of these aspects and paradigms and suggests solutions to these obstructions.

4.2.1. Geographic boundaries

Large or small geographical boundaries each have their own benefits. If industrial symbiosis is established within small geographical boundaries the main advantage will be short transportation distances for the exchanges, which is especially important for physical and energy exchanges. Results from a study on Tianjin Economic-Technological Development Area (TEDA) in China have shown that average distances of physical exchanges within TEDA were 11.5 km and those involving outside actors 34 km. Maximum distances of energy and water exchanges were considerably shorter with 5 respectively 8 km, indicating distance are mainly an issue for resources that are difficult to transport or have to flow continuously.

Personal ties are more likely to form or be maintained when those involved operated within close geographical proximity. These personal ties have been identified as important for the creation of for example trust. One can also expect collaboration in general is benefited by personal ties. Collaboration and frequent communication is also believed to be very beneficial for innovation and improved knowledge sharing.

4.2.1.1. Supply and Demand

Larger regions however have other benefits for the concept of industrials symbiosis. A larger region incorporates a larger supply and demand which at the same time leads to a higher redundancy as similar actors are more likely to exist within the network and higher economic efficiency due to competition. Larger regions are also more likely to comprise of more diverse actors which increases the chances of finding suitable partners or solutions.

The larger supply and demand, number of actors and diversity will however make a network, especially an informal one, between actors more difficult to establish and use for the purpose of industrials symbiosis. Larger geographical distances between the actors will further complicate the process of networking due to increased travel times and complexity of other personal contact solutions. A coordinating body is therefore more needed in a larger region or network than in a smaller one.

4.2.1.2. Coordination

It seems like the advantages of personal ties or communication have to be overcome by a coordinating body. Advantages of a larger and more diverse supply and demand are most
likely outweighing the disadvantage of transportation distances. This is because of transportation distances being larger only on average and the fact that a smaller region with possible synergies depending on short transportation distances can easily function within a larger region.

In the UK the National Industrial Symbiosis Programme (NISP) functions as a coordinating body on the regional and national level at the same time. This is an example of increasing efficiency by scaling up as general tasks and frameworks can be set-up nationally and used by all regions while best practices from regions can be shared over the national network. The risk of creating a ‘one size fits all’ solution that reduces efficiency or adaptability may however not be overlooked.

The regions chosen by NISP are the same as those used by regional authorities so that regional policies, incentives or collaboration can be easily sought or developed. Setting a region size to the same delimitation as authorities use can make involvement of these authorities easier and excluded overlap and conflicts of interests between authorities to certain extent. The risk of favoring a certain company or industry by the authorities, e.g. due to its large social and economic influences, exists but is marginal. A coordinating body can however use several tools to counteract favoritisms, e.g. by involving other companies or the media.

A larger region with the same size as delimited by the authorities seems most promising for the establishment of an industrial symbiosis network or activities. Prior research in the diversity and size of supply and demand are however key to determining the geographical boundaries. Setting up an EIP will severely limit the possibilities for industrials symbiosis in general as it depends on a limited supply and demand or re-locating of companies. It does increase possibilities for exchanges that are hard to transport or require continuous flow. An EIP however should never be seen in isolation, actors situated in e.g. neighboring industrial estates, residential areas or the region can provide valuable opportunities for industrial symbiosis exchanges.

4.2.2. Flexibility

Fear of losing flexibility or ending up in a lock-in situation is a concern for companies when engaging in resource exchanges, which is especially true for physical or energy exchanges. These exchanges can lead to the coupling of a production process to another actor and should therefore be stable. Results from TEDA however showed that several physical resource exchanges were cancelled for numerous reasons but this had no bigger consequences for the companies depending on them than in a conventional supplier relation.

If the resource exchange is seen as a supplier relationship similar contracts and agreements can be made to ensure e.g. stability, quality and quantity of the resource. A high diversity and large supply and demand of the resources and actors within an industrial symbiosis network provide the flexibility of changing the ‘supplier’. In case of a failing resource exchange a company could simply switch back to the original or conventional state as well. The relatively low number of companies or homogeneousness of an EIP can severely lower the flexibility as alternatives are not possible.
Loss of flexibility can however also be created due to made investments in infrastructure for the resource exchange or adaptation of the production process. Switching back to the original or conventional state can then imply taking a loss on investment. This is hard to overcome but methods of assessing a company’s credibility in supplying the goods are used in traditional supplier relationships and can be used for symbiotic relationships. If trust between the actors is not sufficient a simpler solution requiring lower investments or a gradual change of supply can be implemented.

Exchanges of physical resources can be under the influence of policies and regulations. Flexibility and transparency from the authorities can increase the feasibility of options and provide a way-out for companies in case the exchange fails. For example by allowing proposed solutions with lower initial investment due to not demanding new high-tech equipment but the adjusting of existing equipment, even if not most environmentally friendly.

4.2.3. Trust

Trust is a key factor in industrial symbiosis. Exchange activities and networking require the trust among those involved. It is however not easy to build trust and it can take time. Using existing platforms or network that have earned trust from its members or users can speed up the process as long as full collaboration of the platform or network is in place and able to motivate its trust in the concept.

The problem with using existing networks and platforms however is that these are not random, there is a shared value or action that unites the actors. This can pose a problem for engaging traditionally separate companies or organizations that are key to industrial symbiosis (and the diversity of actors it requires). Setting up a resource exchange between actors part of the same network will benefit from the trust, if an outside actor is involved trust will have to be created. Existing networks and platforms can however be used to introduce and disseminate the concept and acquire interest and engagement prior to merging or mixing the networks to achieve diversity.

A simple start of collaboration and a slow pace can foster trust among actors. Physical exchange of materials which require investments might be possible on the long run but collaboration could start with for example shared transportation. Coordinating bodies can facilitate the creation of trust by creating a community that actors wish to be part of, for example by offering services that don’t have to be focused on industrial symbiosis. This will also create trust in the coordinating body.

Role Playing Games (RPGs) can give insight in scenarios that are shaped by the participants. This will give insight in the possibilities of collaboration but also in the actions, although virtual and hypothetical, of other participants. As personal contact is of key importance for the creation of trust discussion and reflection between participants are of major importance when using RPGs.

Local business contacted for the questionnaire and workshop showed a low willingness to participate. This might have been caused by the combination of unfamiliarity with the concept, potentially sensitive questions about company’s waste and by-products and the unknown students carrying out the study.
4.2.4. Awareness and Innovation Capacity

Industrial symbiosis is a fairly new concept and is not widespread within the business world as a concept or practice. Results from the questionnaire illustrate this lack of awareness of industrial symbiosis as only 28% said to understand it but not know exactly how it worked, and only 4% mentioned the same on EIPs. The uncovering of industrial symbiosis network or EIPs shows that even if companies are engaged in industrial symbiosis activities they do not label or market it as such. A grading scale of industrial symbiosis activities as mentioned in the section of the grading scale on page 25 can help with the dissemination of the concept and create awareness on its possibilities.

The Cleantech Östergötland organization is not engaged in the creation or stimulation of industrial symbiosis but creates awareness of the concept globally and can thereby attract investments to its members. This illustrates the power of a network and collaboration of multiple small actors in creating awareness and the attracting of investment in innovation offered by the actors. Awareness of the concept is of major importance to establish engagement from all stakeholders.

Innovation capacity can be seen as the product of a network. The innovation power of a company is not only dependent on company specific characteristics but also on the networks in which it operates and the support this network can offer. It is important to note that the authorities are part of these networks and can provide incentives for innovation and create or adapt regulation to foster innovation and its products.

This innovation capacity is of major importance as resource exchanges might require the changing of production processes, solutions for transporting the resource or technology for the processing or upgrading of a resource before use. Required solutions can be found within the company or network, where external actors can provide valuable services and knowledge.

4.3. Policy and Regulation

The waste hierarchy of the EU directive on waste determines which option is best when it comes to waste. Currently in Sweden 37% of waste is used as a fuel (energy recovery) and 15% is deposited. Recirculation of waste is has a higher position within the hierarchy and is therefore preferred, which implies about half of Swedish waste can benefit from industrial symbiosis practice if resources are not used as a fuel.

New end-of-waste criteria are set up by the EU and can be used to remove the label ‘waste’ of certain materials after treatment. This will lift the potential regulations on the handling, transportation and treatment of waste as it is no longer waste. These criteria however are more likely to benefit actors simply treating the waste and processing it into a resource than direct material exchanges. These reprocessing actors can however stimulate the roundput of material within the system but will most likely create business opportunities for separate entities that can be deemed decomposers, collecting what’s left from industry and injecting it in the system as a normal resource.

Landfilling in Sweden is taxed and is thereby discouraged in relation to other waste treatment options. The incineration of waste however is not taxed. Furthermore, CO₂
taxes and higher energy taxes on energy from fossil fuels have led to the using of other fuel sources. In combination with large district heating networks in Sweden this creates an incentive to use waste as a fuel. Waste sent to be used as a fuel for e.g. district heating can be labeled ‘recycling’ in environmental reports. Resource exchanges of sorted but combustible waste will therefore have to compete with energy/heat producing companies.

Very important is the collaboration of local authorities by publicly supporting the concept and providing good examples by for example finding unconventional solutions for municipal waste. As the concept is unknown or new, certain skepticism can be expected.

4.4. Planned or Self-organized

Eco-Industrial Parks can be planned; companies can be selected based on their resource requirements and by-products or waste generated after which incentives can be used to locate all within geographical proximity. Industrial symbiosis networks can also be planned as actors can be selected on numerous identifiers with potential collaboration or exchange in mind. Self-organized EIPs or industrial symbiosis networks however come into existence without a plan but are shaped by decisions and actions of the actors involved.

4.4.1. Responsibility

Planned industrial symbiosis has more potential in setting up collaboration and exchanges as it enables the selection of actors. A planning entity can however not cover all aspects, options and possibilities. Furthermore the planning of resource exchanges can move the responsibility of projects towards the planning entity and away from those potentially benefitting and engaged in the actual exchange, thereby increasing the potential of incomplete commitment and possibly missing a market test.

Self-organizing has the benefits of responsibility being taken by those actually engaged in the collaboration as no third party is involved and of regular market mechanisms controlling the feasibility. But for self-organization to begin the need or problems must be present and communicated to move beyond the status quo, if conventional or common solutions exist these are more likely to be used. Awareness of industrial symbiosis and its possibilities could mitigate the degree of need or problems before action is taken.

4.4.2. Selection and Encouragement

Selecting actors suitable for resource exchanges and collaboration or simply selecting a diverse and large group of actors and putting them together can spark the required awareness of possibilities. The however requires convincing of actors, requiring the acquisition and usage of knowledge of their actions which will lead to the prioritizing of actors and making a selection after all. A certain degree of self-organizing has to be part of the process though as the planning or selecting entity cannot cover all aspects, options and possibilities. Actors should be engaged in the process and not be an idle chess piece
waiting for command, the results will benefit them so full commitment can be demanded.

A coordinating body can initiate an industrial symbiosis network by starting with planning but mimicking self-organizations to achieve benefits from both. The planning can ensure all stakeholders are represented within the network, aware of the concept and committed to action. Viewpoints and interests of stakeholders can also be communicated to others via the coordinating body to ensure it is communicated clearly and to all involved; this also enables the gathering and sharing of knowledge that is of importance for a new concept.

Encouragement and providing the right contacts and information is a role suitable for a coordinating body with the sole interest of assisting actors by using industrial symbiosis. Information on established collaboration and exchanges can be easily made accessible via a coordinating or umbrella body and used for motivational purposes as well as the sharing of knowledge, contacts and best practices.

Data collected from actors, established resource exchanges and institutions can be used to provide initial sparks for new collaboration by simply attending an actor on a possibility. Services not directly related to industrial symbiosis could be given to members of the network; these can be services from partner networks and can secure commitment and trust in the organization.

Funding for a coordinating body is a difficult topic. Acting as a broker taking commission over established resource exchanges requires planning of the exchanges and a role with certain responsibility over the exchange but is possible. Brokers will however most likely focus solely on the physical and energy resource exchanges as services or other forms of collaboration are hard to take a commission on. A membership fee for a coordinating body has been tried by NISP in the UK but proved unsuccessful as it hinders smaller companies in joining and creates a sense of bias. Operating without charging members or taking commission is however only possible with benefactors supplying funds or subsidies from governments.

A coordinating or facilitating body that stimulates the self-organizing but purposely engages all important stakeholders seems the best way to establishing an industrial symbiosis network. It can be deemed ‘planning lightly while mimicking self-organization’. An unbiased and free organization is most trustworthy to members as it will not favor certain actors or provide a financial threshold for joining.

4.4.3. Existing Networks and Waste Companies

Although existing organizations could expand by applying, coordinating and facilitating industrial symbiosis it is their ‘members’ that can hinder success as diversity is needed. A special industrial symbiosis organization combining the network of other organizations is possible and potentially fundable by these other organizations as it offers a new and valuable service for its members.

Waste collectors and processors can play the role of coordinator or broker as they have a diverse client base which gives indirect access to diverse types of waste, production
processes and activities. This gives a good opportunity for waste handling or consulting companies to discover synergies, given the company structure is not too diversified on waste types. Successful industrial symbiosis resource exchanges might not require the services of waste companies as the resource exchanges seek to make use of the waste or by-products but their services and expertise can be of use. Reprocessing, upgrading or cleaning are examples of services a waste company can offer to resource exchanges.

Of key importance for waste companies is that expertise, availability of equipment or flexibility needs to be better and remain better than in the scenario of the involved actors taking matters into their own hand. For example the leasing of necessary equipment can provide flexibility to the company by lowering the required investments while expertise can comprehend the understanding of the properties of the exchange and how to alter it to the desired quality. Concepts like design for environment or design for disassembly is expertise that can lead to the simplification of exchanges or reprocessing of materials, lowering the risks of the exchange itself. Active implementation of industrial symbiosis is however expected to make a part of their conventional treatment and collection services obsolete, entailing a shift in the business model.

4.5. The case study

Engagements with local stakeholders, experiences and the literature study have given a good foundation to assessing the feasibility of industrial symbiosis in northern Stockholm. But it has also left room for suggesting improvements to the approach that has been taken in e.g. the method of involving stakeholders.

4.5.1. Feedback from questionnaires

A large portion of the respondents was unaware of the concept of industrial symbiosis or EIPs with 56 % respectively 76 % answering never to have heard of it. Only 28 % (industrial symbiosis) and 4 % (EIP) said to understand it but not know exactly how it works. It is remarkable though that in general industrial symbiosis was better known than EIPs for unknown reasons.

Foreseen opportunities and obstructions were given from the point of view of the respondent but are all previously described in literature. Knowledge, information and examples were most requested as help. So although several respondents warned for high costs or investments financial aid is not a priority, access to knowledge and experience is. A suggestion that stood out is the hosting of a storage place by the municipality to ease transportation, which could be free or low cost and turn into a marketplace but is in risk of becoming a dumping ground without anyone picking up the resources.

Municipalities or authorities should advise and exercise control. It shows that solutions should be driven by business itself but advice is requested as to where the possibilities can be found, which is no real surprise as it involves traditionally separate industries. Control on rules on the other hand implies there is a certain fear of certain resource exchanges not following the rules and creating an unbalance in competition.

In general the respondents’ answers fitted with the results from the literature study but suggested interesting possibilities for industrial symbiosis in the region.
4.5.2. Suggested improvement for the taken approach

4.5.2.1. Stakeholders

Differentiating in stakeholders is in essence a bit of planning in industrial symbiosis but important as there is limited time and interest from stakeholders. More core-stakeholders should have been selected and could have been brought together once commitment with some of them was secured. Several municipalities could for example have been involved and a selection of the most engaged is possible, a workshop for municipalities could than spark ideas and lead to a discussion among municipalities with the potential of competition or distilling the most suitable partners in industrial symbiosis facilitation.

Core stakeholders that were missed are existing networking organizations, although these are hard to find. These networks can be used to disseminate the concept among a wider range of companies relatively easy in comparison to phone conversations by for example given a short presentation at a network meeting. Skepticism and ‘I don’t think that’s useful for me’ are more easily counteracted during presentations and workshops than over the phone or by e-mail. A big drawback of this study is the student profile. A thesis has a very limited time scope and securing commitment takes times and often requires a commitment on the longer run from the study itself.

An issue with trying to engage the stakeholders of technical interest is that the concept often has to be described as beneficial for the specific company. This requires knowledge and insight in the company, its resources, products and by-products or waste. Knowledge that is hard to acquire prior to contacting a company. Specific examples however proved to be successful to secure a good conversation with companies to get some insight and securing interest, this is however no guarantee for engagement. Questionnaires or interviews can both be used were the latter is more time consuming but fruitful. If interest is awakened and the company sounds above average promising for industrial symbiosis actions an interview should be opted, a questionnaire can be the alternative but will require follow-up if not filled out.

Questionnaires have the issue of taking up time without providing direct valuable feedback for the respondent. Only a few questions can therefore be asked but will not give the complete picture needed. Phases of questionnaires can possibly solve this problem but require a longer time frame for the study and will most likely see a decline in respondents per phase. Social ties for example were excluded from the questionnaire but could provide valuable insight in existing networks and personal ties among actors. Snowball sampling, were respondents can nominate other respondents, could be used to extend the pool of respondents and moreover give insight in the level of engagement of actors.

4.5.2.2. Workshop

The number of attendees at the workshop was low, only six participants. This hindered the amount of possibilities as diversity and size of supply and demand were low. The short presentation from the supply chain/network perspective proved to be successful. It was rated with a 4.2 on usefulness while the workshop itself was rated 3.4 on a scale of 1 to 5. Moderation at the workshop should be stricter in order to give all noted resources a
chance of finding partners; of-topic discussions or of too great detail should be cancelled.

No breaks were part of the workshop, from 10:15 to 12:00 the presentation was given and the workshop held. A break could however create a more relaxed atmosphere beneficial to the openness and interest in each other’s resources. A short presentation of a company engaged in industrial symbiosis can create trust in the subject and bring practical experience to the workshop. As there are many types of exchanges or collaboration possible the exemplary company should be chosen wisely.

As collaboration is sought by mean of a workshop more interaction between the company delegates might aid the process of fostering trust, personal bonds and collaboration. In general more creativity or play is expected to increase interaction between participants. An active presentation explaining the concept, its benefits and successful examples can benefit from interaction between presenter and audience. For example by polling how many are familiar with the concept, what they think are the benefits and examples they can think of.

Instead of a host reading out the resources noted down by participants a sales pitch by the companies or a speed dating concept could prove more helpful and create more interaction, selling their left over resources. This could be taken a step back by letting participants prepare a short presentation or pitch. Risk is the length of pitches and unawareness of possibilities by participants. And although neutral, a host can see more synergies and steer discussions by looking at the right people when reading out resources applicable to their situation.

Other means of creating more play and creativity to increase interaction could be a method of browsing the resources available and requested by participants, for example by laying the resources out on a table grouped by type of resource. Visualizing the outcome of the workshop; possible synergies, with an online network node model for later review can indicate the numerous possibilities. Examples can be made more insightful by interactively building them with blocks representing the actors and wires the exchanges, this can also stimulate out of the box thinking.

4.5.3. Industrial symbiosis feasibility in northern Stockholm

A set of indicators to determine the industrial symbiosis feasibility of a region could assess the regions potential and determine the required resources for a successful network. The complexity and number of actors however renders this impossible, especially if it needs to be determined quickly.

If indicators on for example diversity of actors, size of supply and demand, flexibility of policies and an indicator for the level of present networking in the region could be developed the checking of these indicators will be time consuming. It will for example involve the acquiring of knowledge on company’s activities, types and amount of resources required, waste and by-products produced. This data is not available in a database and generalization on company types is not precise enough.

Investing time and effort into gathering the required information will have the desired
side effects of creating a network, may it be in very early stages, spreading awareness and interesting actors in the concept. A major drawback of this approach is that its character is short term; there is no guarantee for continuity even if a few exchanges are possible. If the conclusion of such a preliminary study however were positive a good start for creating a network, community, awareness or trust has been made.

4.5.3.1. Region

Sigtuna municipality is too small for an industrial symbiosis activities network as supply and demand of resources suitable for exchanges is low, as is diversity. Although the number of companies is not small a lot of them are warehouses and transportation. The northern Stockholm region however has a more diverse company base and supply and demand of resources should be large enough.

Presence of the Royal Institute of Technology, Stockholm School of Economics, Stockholm University and Karolinska Institute means there are plenty of possibilities for help on problem solving and innovation. Technical solutions, economic incentives and constructions, social studies and even medical-technical solutions can be aided by the institutions. Companies in Sweden are not unfamiliar with education/institution cooperation and in general do not lack the capacity to innovate.

District heating within the region and general acceptance of using waste for generating heat on a large scale can however pose as a status quo that has to be broken. The region’s or Stockholm city’s focus on sustainability and cleantech on the other hand might provide valuable opportunities of involving local authorities and specialist knowledge or companies on clean or high-tech technologies.

4.5.4. How to continue / best approach

Although the northern Stockholm region seems large enough for the establishment of an industrial symbiosis network expansion over the whole Stockholm region can be recommended. This will include the city of Stockholm and its ambitions on sustainability. It’s larger and denser residential areas providing different opportunities than the lower density areas around Stockholm, and the opportunities that come with the rapid growth of Stockholm. At the same time this will enable the complete involvement of Stockholm’s länsstyrelse, the county administrative board. This board is responsible for the implementation of environmental objectives set by the government and regional growth. Potential environmentally hazardous activities require permits from either the municipality or county board depending on the degree of pollution; the county board however has an advising role to the municipalities.

4.5.4.1. Coordinating body

A coordinating body will be necessary to gather, share and store knowledge and stakeholder specifics like viewpoints and offerings. Although this can start with very few people, funding by neutral investors like a municipality or generous benefactors will be required. Given workshops could be sponsored by other networking organizations introduced to the concept or by companies, as long as the organization or body itself remains neutral. Introduction to the concept can be achieved by simple workshops that
should provide tangible options for sharing resources and collaboration, as low diversity of actors can be expected when using existing network organizations role playing games or data from real, but anonymous, companies could be used.

Most likely performance of the concept will have to be tracked to justify the funding. This will not only require the tracking of increased economic performance but of the more difficult to track environmental performance. Existing lifecycle assessment studies on the exchanged resources can be used to determine its mitigated environmental impact, as can for example relatively simple carbon content calculation when compared to using the resource as fuel. Institutions like the Royal Institute of Technology and Stockholm School of Economics can be asked to aid in finding the right accounting or tracking methods. Verification or selection of the methods used and data verification should be carried out by external auditors.

The suggested grading scale will not aid in the tracking of performance for funding but does provide an upwards path for stakeholder involved and distinction between the offered and given opportunities. Sharing services is good but actually sharing physical resources will make someone stand out. At the same time it can be used as a marketing tool for companies; communicating sustainability or greenness with the side effect of creating awareness.

All municipalities within the region will have to be engaged, resulting in a workshop for all municipalities where awareness can be created; commitment secured, and proactive municipalities uncovered. Institutions like the universities can provide useful input by supplying thesis or Ph.D. students focusing on a specific task, or aiding the coordinating body. Existing networks have to be contacted and where possible used to reach local business and other stakeholders. If possible industrial symbiosis should be regarded and labeled as one of the pathways to achieve the Swedish miljömål; sixteen targets of environmental quality in 2020 including decreased climate impact and emissions of heavy metals, NOx, SOx, ozone and phosphorus.

4.5.4.2. Broker and Private Facilitator

As expertise will have to be gathered by a neutral coordinator, and is most likely expected to be shared for free, funding is a problem. Other actors like waste or recycling companies and resource traders can take on the role of brokers or private facilitators. An active role in industrial symbiosis by waste or recycling companies and resource traders will most likely entail a change in their business model. Interaction can be initiated and industrial symbiosis facilitated by using their knowledge and data on resources and actors. Waste or recycling companies can start by acting as a consultant but move towards providing technical, organizational and logistical support and equipment to facilitate the exchange. This could go as far as providing a service were the resource giving and receiving party only deal with the broker.

Acting as a broker will bypass the need for funding. It is however expected that in the broker approach by waste/recycling companies or resource traders will lessen the chances of energy exchanges and collaboration on services. The first as it is not part of their expertise and the latter can be the start of complicated exchanges which involves
smaller companies, therefore deserving attention. Energy or utilities companies could act as a broker by offering for example the upgrading of waste heat on site. It is recommended for waste/recycling companies or resource traders to cooperate with networking organizations to broaden the client base by collaboration on the service level, planting the seeds for future exchanges.

All data originating from workshops, interviews and other means of contact should be stored and easily searchable. This is especially important for the resources companies wish to share and note during a workshop or interview. These should be used to initiate new contacts on establishing resource exchanges. Once successful exchanges have been established or discovered these should be made visible to others by giving for example their grade, transport distance, short resource description and the actors involved. Contact on these examples should initially run through the coordinating body so all activities can be logged for follow-up and data-gathering, enabling tracking of performance and providing the right examples.

4.5.4.3. Internet based

Some respondents of the questionnaire and participants of the workshop opted for an online system to link actors to each other. However, once asked if they were likely to put their by-products, waste or required resources online the overall response was negative. Anonymity however can be a way to overcome this problem, as long as the coordinating body is trusted.

Data gathered on available wastes, by-products and requested resources can be stored in an internal database only visible by the coordinating body. This data can be used to facilitate exchanges by tipping involved actors on a possibility of exchange. A web based platform can be used to gather the required data, besides by using for example workshops and interviews.

An external database, visible to all on the internet, can then be used to search for possible synergies and examples by interested actors. All data is however anonymous, only a short description of the resource, quality and quantity will be visible. If contact is requested this can be arranged via the coordinating body which could make initial contact and make sure the requester is serious. This check can involve a minimum of three resources registered in the internal database, tax registration number and using a service checking the financial credibility of an organization.

This can increase the speed of gathering data on resources and thereby increase diversity and the amount of supply and demand that can be used to suggest resource exchanges. At the same time data on potentially sensitive waste, by-products and resource requirements is only shared with the coordinating body and not with competitors or the general public.

4.5.4.4. Step by step

These steps give an indication of how an industrial symbiosis network can be established by a neutral coordinator or facilitator. Waste and recycling companies or resource traders can start with material exchanges based on their clientele but creating a larger and more
diverse network beyond their own expertise and core business can foster future exchanges and possible attract public investments.

<table>
<thead>
<tr>
<th>Involve Stockholmslän</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Gain interest, commitment, spreading</td>
</tr>
<tr>
<td>• Interest: familiarity with the concept, tips from their side</td>
</tr>
<tr>
<td>• Commitment: Letter of intent or covenant, member of network, information/knowledge shared, contact person established.</td>
</tr>
<tr>
<td>• Spreading: concept is part of their advice, concept is part of policy or regulation, concept is used for promotional purposes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Involve municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Municipalities within Stockholmslän</td>
</tr>
<tr>
<td>• Gain interest, commitment, spreading</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Workshop for municipalities and län</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is industrial symbiosis</td>
</tr>
<tr>
<td>• Benefits: economical, environmental, social, marketing, attracting investment (concept + cleantech)</td>
</tr>
<tr>
<td>• Possible roles for municipalities/län and preferred role</td>
</tr>
<tr>
<td>• What information and knowledge can the municipalities and län provide</td>
</tr>
<tr>
<td>• Stimulate discussion and competition to prioritize municipalities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Website + database operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is industrial symbiosis: why, how and what</td>
</tr>
<tr>
<td>• Goals</td>
</tr>
<tr>
<td>• Involved groups/networks, authorities, companies, institutions, organizations</td>
</tr>
<tr>
<td>• What is offered</td>
</tr>
<tr>
<td>• Examples and work in progress</td>
</tr>
<tr>
<td>• Contact</td>
</tr>
<tr>
<td>• Non-public database of resources (available and requested) to enable initiating of exchanges</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Involve networking organizations and promotion to attract companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 'Conventional' networks (chambers of commerce, employers organizations, etc)</td>
</tr>
<tr>
<td>• Snowball sampling to discover other networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Involve knowledge institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Knowledge and research aiding the organization + input on currently creating resource exchanges</td>
</tr>
<tr>
<td>• KTH (Royal Institute of Technology): how to map/track environmental performance, material flow analysis of regions, suggested exchanges</td>
</tr>
<tr>
<td>• Handels (Stockholm School of Economics): How to map/track economical and environmental performance, possible incentives for industrial symbiosis</td>
</tr>
<tr>
<td>• Stockholm University and Karolinska Institute: map social ties, possibilities for medical waste or products</td>
</tr>
</tbody>
</table>
4.6. Generalization and Limitations

Due to the start of the study with a case-study only focused on the municipality of Sigtuna the number of respondents from the questionnaire was low. An initial start with the bigger region of northern Stockholm would have increased the number and diversity of respondents to the questionnaire. Time constraints and the low response from Sigtuna municipality rendered follow-up interviews with interesting actors impossible.

The number of attendees at the workshop was small and not representative for the diversity of companies in the northern Stockholm region but did provide valuable insight. Due to the limited time frame a follow-up within this thesis was not possible. A follow-up can give an indication of the rate of success of possibilities of exchange, collaboration and networking offered by the workshop. Participants of the workshop should be contacted one to two months after the workshop to enquire the status of discovered possibilities, their level of engagement in these and what help might be needed in the process.

Although business networking and personal ties are different for each culture the described approach for northern Stockholm should fit most situations. A lack of existing networks or the possibility of unbiased funding will however not be possible in every situation. Innovation capacity might be the major threshold for successful facilitation or coordinating of self-organizing industrial symbiosis as this is required for the understanding and implementation of a new concept. Innovation is further required to solve the technical and organizational challenges that exist in establishing resource exchanges.
5. Conclusions

Traditionally separate companies and organizations establishing collaboration by resource exchange and the sharing of services and utilities should be the definition of industrial symbiosis. Core services and products of a company or organizations should be excluded from the definition. Differentiating resources from services and utilities in combination with the grading scale will provide different classes of industrial symbiosis and favor physical or energy exchanges but not alienate other collaborations. This enables a broad base of participants and aid in the dissemination of industrial symbiosis as a concept or strategy.

A diverse and large supply and demand of resources and company types defines the minimal needed geographical boundaries. Flexibility is in general no concern; redundancy of suppliers and clients can provide an alternative, leasing constructions and companies providing the exchanges as a service can further benefit flexibility. Contracts and agreements can safeguard proper operation but trust between actors is essential for the resource exchanges. Innovation and awareness among stakeholders are required for problem solving and a quick dissemination of the concept.

Self-organization can yield better results than planning due to full commitment, grown trust and a test under market conditions. Unawareness of the concept and its possibilities require facilitation or coordinating by providing a spark to start the process and gather data. Keys of successful facilitation lie in using existing networks to gather trust, spread awareness, gather knowledge/information and secure commitment. Brokers can take on a biased version of the role of coordinator to initiate exchanges but are expected to serve only a part of what industrial symbiosis can offer.

Industrial Symbiosis in the northern Stockholm region is feasible although a long term perspective will have to be adopted. For a neutral coordinator funding can pose a problem. Waste/recycling companies or resource traders can take on the role of brokers for resource exchanges but should initiate a broader network to further disseminate the concept by e.g. service sharing, potentially creating future markets for material exchanges.
References


Appendices

Appendix A. Questionnaire sent to stakeholders of technical interest ................. 46
Appendix B. Letter sent to stakeholders of technical interest .................................. 51
Appendix C. Questionnaire sent to other/remaining stakeholders .......................... 52
Appendix D. Letter sent to other/remaining stakeholders ........................................ 55
Appendix E. Invitation to the workshop on industrial symbiosis in Sigtuna .......... 56
Appendix F. Invitation to the workshop on industrial symbiosis in northern Stockholm 57
Appendix G. Descriptions of companies attending workshop ......................... 58
Appendix H. “Jag har” and “Jag vill ha” papers used in workshop ..................... 59
Appendix A. Questionnaire sent to stakeholders of technical interest

Frågor gällande energi, material och industriell symbios

Tack för att ni tar er tid till att läsa och förhoppningsvis även fylla i uppgifterna i enkäten.

Den informationen som ni lämnar kommer att användas för att ta reda på hur förutsättningarna ser ut för industriell symbios i Sigtuna. Tanken med våra två examensarbeten är att ta reda på hur företagen i regionen skulle kunna samarbeta för att minska avfallsmängderna och därmed deras miljöpåverkan, men att det även skulle skapa ekonomiska fördelar för alla parter.

Vid frågor eller eventuella synpunkter på enkäten är ni välkomna att kontakta oss:

Niklas Smedberg: nsm@kth.se eller 073-3941747
Florian Hemmer: hemmer@kth.se eller 073-0340284

Med vänliga hälsningar
Niklas Smedberg och Florian Hemmer

Kontaktuppgifter

Vi är tacksamma om du lämnar dina kontaktuppgifter, så att vi kan nå dig om det är något som vi undrar över. Det kan även i vissa fall bli aktuellt med en intervju för att följa upp svaren.

Var vänlig ange företag, namn, telefonnummer och e-postadress. Om möjligt ange även arbetsuppgifter/titel.

Sekreteress

Vilka fär ta del av uppgifterna som ni har lämnat i samband medundersöknningen och/eller under en eventuell intervju?

☐ Alla fär ta del av uppgifterna i samband med examensarbetet.
☐ Uppgifterna ska skyddas och fär endast användas i en skyddad bilaga. Detta innebär att bilagan endast är tillgänglig för de som arbetar med examensarbetet.
Frågor om energi

Vilket energibehov har ni?
Ange vad det är och vilken mängd det handlar om. Det kan exempelvis vara elektricitet, fjärrvärme, ånga eller någon form av bränsle.

Har ni eventuellt något överflöd av energi som skulle kunna användas av andra företag? Ange vilken form av energi det handlar om, annars ange "Inget överflöd". Om det är något alternativ som saknas, välj då "Övrigt" och specificera vad det är.

- □ Värme
- □ Ånga
- □ Bränsle
- □ Inget överflöd
- □ Other: __________________________

Frågor om material och kemikalier

Vilka är de vanligaste resurserna gällande material som används vid anläggningen/processen? Ange om möjligt även vilka kvantiteter handlar det om?

Vilka kemikalier använder ni i processen eller inom anläggningen? Ange om möjligt även vilka mängder handlar det om?

Ge exempel på de vanligaste kemikalierna som används, det kan antingen vara de med störst kvantitet eller de med störst miljpåverkan.
Biprodukter och avfall

Vilka är de viktigaste biprodukterna/avfall som bildas i samband med processen eller från anläggningen? Vilka kvantiteter handlar det om och vad gör ni med dessa produkter i dagsläget? Ge exempel på de viktigaste biprodukterna som uppstår och ange kortfattat vad ni gör med dessa i dagsläget.

Har ni något existerande samarbete med andra företag gällande erts avfall, biprodukter, resurser, eller övrigt.

☐ Ja
☐ Nej
☐ Inte i dagsläget, men vi har planer på att göra det.

Frågor gällande industriell symbios (IS)

Vet du vad industriell symbios handlar om eller har du hört talas om det?
Var vänlig och välj det förslag som stämmer in bäst på dig.

☐ Jag vet exakt vad det är.
☐ Jag vet ungefär vad det handlar om.
☐ Jag har hört talas om det.
☐ Jag har aldrig hört talas om det förrän nu.

Känner du till begreppet Eco-Industrial Park (EIP) eller har du hört talas om det?
Var vänlig och välj det förslag som stämmer in bäst på dig.

☐ Jag vet exakt vad det är.
☐ Jag vet ungefär vad det handlar om.
☐ Jag har hört talas om det.
☐ Jag har aldrig hört talas om det förrän nu.
Industriell Symbios (IS) och Eco-Industrial Park (EIP)

Industriell symbios (IS) handlar om att ta vara på avfallet/biprodukterna från ett företag och utnyttja det som en resurs för ett annat. Det gäller inte bara att ta vara på de synergeri som uppstår då man tar vara på avfallet, utan även användandet av gemensamma resurser och service. Det kan beskrivas som ett försök att sluta kretsloppet kring materialanvändningen inom industri och andra områden, öka energieffektiviteten och uppnå en högre effektivitet genom samarbete. Eco-Industrial Parks (EIP) är industriella områden där IS tillämpas inom systemgränserna för området.

Vilka möjligheter kan du förutse när det gäller IS?

Vilka hinder kan du förutse?

Om det skulle finnas en möjlighet till ett utbyte av biprodukter, vilken form av hjälp anser du mest önskvärd/nödvändig?

Vilken roll borde kommunen och/eller andra relaterade myndigheter ha när det gäller det industriell symbios?
Övriga kommentarer/förslag eller ideer gällande IS.

Tack för din medverkan!
Vid frågor eller eventuella synpunkter på enkäten är ni välkomna att kontakta oss:

Niklas Smedberg: nsm@kth.se eller 073-3941747
Florian Hemmer: hemmer@kth.se eller 073-0340284

Submit

Powered by Google Docs
Report Abuse - Terms of Service - Additional Terms
Appendix B. Letter sent to stakeholders of technical interest

Stockholm, 2011-03-21

Florian Hemmer:
hemmer@kth.se - 073-0340284
Niklas Smedberg:
nsm@kth.se - 073-3941747

Anm: Examenarbeten på KTH gällande industriell symbios i Sigtuna.

Hej,

*Industriell symbios: Samarbete och gemensamma resurser för att uppnå bättre resultat.*

Ett flertal nationella och regionala program har initierats i olika delar av världen med mål att anordna eller genomföra projekt som handlar om industriell symbios. Det här har resulterat i att industrinområden har satsat på ett utökat samarbete mellan de olika närbelägna aktörerna genom att exempelvis använda sig av gemensam service och utrustning men även samarbeta kring biprodukter och avfall. Dessa industrinområden tituleras Eco-Industrial Parks. Det finns även andra projekt som exempelvis handlar om att förändra råvarukedjan genom att involvera aktörer inom regionen och att dela med sig av kunskaperna till företag inom landet. Alla förändringar har genomförts med målet att uppnå större ekonomiska och miljömässiga vinstar, exempelvis kostnadsbesparningar, nya affärsmöjligheter och hantering av biprodukter och avfall.

Vi, Florian och Niklas, arbetar för tillfället med våra examensarbeten gällande industriell symbios i Sigtuna kommun. Florian arbetar med att undersöka hur man skulle gå tillväga för att underlätta industriell symbios i en region, medan Niklas arbetar med att undersöka vilka flöden av biprodukter som existerar i Sigtuna och om det finns en potential för att genomföra ett samarbete kring biprodukter och en gemensam användning av olika resurser. För att vi ska kunna lyckas med våra examensarbeten behöver vi lite hjälp ifrån företagen i Sigtuna.

Resultatet från våra examensarbeten kommer att inkludera en genomgång av möjligheterna för biprodukter och avfallshantering samt möjligheterna för samarbeten och även en workshop. Syftet med workshopen är att kortfattat beskriva industriell symbios, fördelarna och påverkan från och om regionen följa av möjligheten till att knyta kontakter genom aktiviteter där samarbeten och gemensamma resurser kan identifieras. En officiell inbjudan kommer att skickas ut senare. Om ett stort antal aktörer deltar i projektet så kan det vara början på en regional organisation som arbetar med att underlätta för aktörerna att skapa kontakter genom olika nätverk, arbete med frågor gällande symbios och hantera förmedlingen av bästa praxis eller kunskap för att uppna ekonomiska och miljömässiga fördelar.

Vi skulle vara väldigt tacksamma om ni kunde svara på frågeformuläret via följande länk:

Vid ytterligare frågor gällande projektet eller andra exempel på industriell symbios är ni välkomna att kontakta oss.

Med vänliga hälsningar,

Florian Hemmer och Niklas Smedberg
Appendix C. Questionnaire sent to other/remaining stakeholders

**Frågeformulär gällande Industriell Symbios**

Tack för att ni tar er tid till att läsa och förhoppningsvis även fylla i uppgifterna i enkäten.

Den informationen som ni lämnar kommer att användas för att ta reda på hur förutsättningarna ser ut för Industriell symbios i Sigtuna. Tanken med våra två examensarbeten är att ta reda på hur företagen i regionen skulle kunna samarbeta för att skapa ekonomiska fördelar för alla parter och minska avfallsmängderna och därmed deras miljöpåverkan.
Vid frågor eller eventuella synpunkter på enkäten är ni välkomna att kontakta oss:

Niklas Smedberg: nsm@kth.se eller 073-3941747
Florian Hemmer: hemmer@kth.se eller 073-0340284

Med vänliga hälsningar
Niklas Smedberg och Florian Hemmer

**Kontaktuppgifter**

Vi är tacksamma om du lämnar dina kontaktuppgifter, så att vi kan nå dig om det är något som vi undrar över. Det kan även i vissa fall bli aktuellt med en intervju för att följa upp svaren.

Var vänlig ange företag, namn, telefonnummer och e-postadress. Om möjligt ange även arbetsuppgifter/titel.

**Sekreteress**

Vilka får ta del av uppgifterna som ni har lämnat i samband med undersökningen och/eller under en eventuell intervju?

- [ ] Alla får ta del av uppgifterna i samband med examensarbetet.
- [ ] Uppgifterna ska skyddas och får endast användas i en skyddad bilaga. Detta innebär att bilagan endast är tillgänglig för de som arbetar med examensarbetet.
Frågor

Vet du vad industriell symbios handlar om eller har du hört talas om det?
Var vänlig och välj det förslag som stämmer in bäst på dig.

○ Jag vet exakt vad det är.
○ Jag vet ungefär vad det handlar om.
○ Jag har hört talas om det.
○ Jag har aldrig hört talas om det förrän nu.

Känner du till begreppet Eco-Industrial Park (EIP) eller har du hört talas om det?
Var vänlig och välj det förslag som stämmer in bäst på dig.

○ Jag vet exakt vad det är.
○ Jag vet ungefär vad det handlar om.
○ Jag har hört talas om det.
○ Jag har aldrig hört talas om det förrän nu.

Industriell Symbios (IS) och en kort beskrivning av EIP

Industriell symbios (IS) handlar om att ta vara på avfallet från ett företag och utnyttja det som en resurs för ett annat. IS handlar inte bara om att ta vara på de synergie som uppstår då man tar vara på avfallet, utan även användandet av gemensamma resurser och service. Det kan beskrivas som ett försök att sluta kretsloppet kring materialanvändningen inom industrin eller andra områden, öka energieffektiviteten och uppnå en högre effektivitet genom samarbete. Eco-Industrial Parks (EIP) är industriella områden där IS tillämpas inom systemgränserna för området.

Vilka hinder kan du förutse?


Om det skulle finnas en möjlighet till ett utbyte av bliprodukter, vilken form av hjälp anser du mest önskvärd/nödvändig?


Vilken roll borde kommunen och/eller andra relatade myndigheter ha när det gäller det industriell symbios?

Ovriga kommentarer/förslag eller ideer gällande IS.

Tack för din medverkan!
Vid frågor eller eventuella synpunkter på enkäten är ni välkomna att kontakta oss:

Niklas Smedberg: nsmi@kth.se eller 073-3941747
Florian Hemmer: hemmer@kth.se eller 073-0340284

Submit

Powered by Google Docs

Report Abuse · Terms of Service · Additional Terms
Appendix D.  Letter sent to other/remaining stakeholders

Stockholm, 2011-03-30

Florian Hemmer:
hemmer@kth.se - 073-0340284

Niklas Smedberg:
nsm@kth.se - 073-3941747

Ämne: Examensarbeten på KTH gällande industriell symbios i Sigtuna.

Hej,

Industrid-symbios: Samarbete och gemensamma resurser för att uppnå bättre resultat.

Vi, Florian och Niklas, arbetar för tillfället med våra examensarbeten gällande industriell symbios i Sigtuna kommun. Florian arbetar med att undersöka hur man skulle gå tillväga för att underlätta industrisymbios i en region, medan Niklas arbetar med att undersöka vilka födelen av biprodukter som existerar i Sigtuna och om det finns en potential för att genomföra ett samarbete kring biprodukter och en gemensam användning av olika resurser. För att vi ska kunna lyckas med våra examensarbeten behöver vi lite hjälp ifrån företagen i Sigtuna.

Resultatet från våra examensarbeten kommer att inkludera en genomgång av möjligheterna för biprodukter och avfallsshantering samt möjligheterna för samarbeten och även en workshop. Syftet med workshopen är att kortfattat beskriva industriell symbios, fördelarna och påverkan från och om regionen följt av möjligheten till att knyta kontakter genom aktiviteter där samarbeten och gemensamma resurser kan identifieras. Om ett stort antal aktörer deltar i projektet så kan det vara början på en regional organisation som arbetar med att underlätta för aktörerna att skapa kontakter genom olika nätverk, arbeta med frågor gällande symbios och hantera förmedlingen av bästa praxis eller kunskap för att uppnå ekonomiska och miljömässiga fördelar.


Vid ytterligare frågor gällande projektet eller andra exempel på industriell symbios är ni välkomna att kontakta oss.

Med vänliga hälsningar,

Florian Hemmer och Niklas Smedberg
Appendix E. Invitation to the workshop on industrial symbiosis in Sigtuna

Inbjudan till workshop gällande

Industriell Symbios i Sigtuna

10 maj 2011 – 10:15 till 13:00 – Forum, Mästa

Industriell symbios handlar om att förbättra organisationers effektivitet och kompetens genom samarbeten mellan organisationer. Det kan exempelvis handla om att använda material och energi från varandra, hyra ut lager, dela erfarenheter/kunskap eller arbetskraft, etc. Kort sagt: att dela resurser. Flerta organisationer gör det redan idag men söker efter lösningar från deras egna nätverk. Målet med workshopen är att försöka upptäcka möjligheterna för ett samarbeta mellan organisationer som kanske inte vanligtvis möts som kund och säljare, men verkar inom samma region.

Workshopen baserad på KTH:s forskning och ett framgångsrikt koncept från Storbritannien där organisationer från olika branscher upptäcker ett flertal samarbetsmöjligheter för resurser under workshops. Deltagarna behöver bara anteckna de resurser som de har, samt vad de vill ha. Under workshopen upptäcker man sedan synergie och möjligheter. Antecknade synergie och möjligheter kommer därefter att skickas som en excel-fil till alla deltagare som har deltagit i workshopen och som därmed har ytterligare en möjlighet att granska de synergie som har uppkommit under workshopen.

Tidsplanering:

10:00 – 10:15: Registrering

10:15 – 10:30: Introduction och inledning
Vad är industriell symbios, några exempel och vad det kan innebära för er.

10:30 – 12:00: Workshop
Notera alla resurser du har kvar samt vad du vill ha. Under workshopen kommer alla synergie och möjligheter att upptäcka

12:00 – 13:00: Kaffe och smörgås
Knut kontakter med t.ex. de som är en del av de upptäckta synergie/möjligheter.

Anmäl dig senast den 3:a maj via: http://tinyurl.com/workshop-IS
Deltagarlistan och vägbeskrivning kommer att skickas ut 4:e maj.

Med vänliga hälsningar,

Niklas Smedberg    Florian Hemmer
073 – 394 17 47    073 – 034 02 84

Vi arbetar med våra examensarbeten inom Industriell Symbios på KTH: Skolan för Industriell teknik och management – Enheten för Industriell ekologi
Appendix F. Invitation to the workshop on industrial symbiosis in northern Stockholm

Inbjudan till workshop gällande
Industriell Symbios i norra Stockholm

30 maj 2011 – 10:15 till 13:00

Industriell symbios handlar om att förbättra organisationers effektivitet och kompetens genom samarbeten mellan organisationer. Det kan exempelvis handla om att använda material och energi från varandra, hyra ut lager, dela erfarenheter/kunskap eller arbetskraft, etc. Kort sagt: att dela resurser. Målet med workshopen är att försöka upptäcka möjligheterna för ett samarbete mellan organisationer som kanske inte vanligtvis möts som kunder och säljare, men verkar inom samma region.


Begränsat antal platser (60 deltagare), anmäl snarast. Se nedan.

Tidsplanering:

10:00 – 10:15: Registrering

10:15 – 10:30: Introduktion och inledning
Vad är industriell symbios, några exempel och vad det kan innebära för er.

10:30 – 12:00: Workshop
Notera alla resurser du har kvar samt vad du vill ha. Under workshopen kommer alla synergier och möjligheter att upptäcka

12:00 – 13:00: Nätverkslunch (valfritt)
Knyt kontakter med t.ex. de som är en del av de upptäckta synergier/möjligheter.

Anmäl dig senast den 20:e maj via: http://tinyurl.com/workshop-IS
Deltagarlistan och vågbeskrivning kommer att skickas ut 23:e maj.

Med vänliga hälsningar,

Niklas Smedberg Florian Hemmer
073 – 394 17 47 073 – 034 02 84

Vi arbetar med våra examensarbeten inom Industriell Symbios på KTH: Skolan för industriell teknik och management – Enheten för industriell ekologi
Appendix G. Descriptions of companies attending workshop

Kristina Elliot (EnebybergsPlåtslageri)

AB EnebybergsPlåtslageri (Enebybergs Sheet Metalwork) has been active since 1943 and today has 22 employees and an annual turnover of 34 MSEK. Our target groups are real estate managers, housing associations, private persons, construction companies, industries, etc.

Tomas Svankvist (Kriminalvården)

(Prison services)

“From Haparanda to Ystad”

Over a 100 production facilities with spacious rooms, modern machinery, good logistical properties, trained chefs and a good access to labor. A powerful resource, partner and supplier of products, services and production capacity. With clients in the industry and public activities in Sweden and other northern countries. Production areas: metalwork, wood, surface treatment, assembly, packaging, plastics, washing/cleaning and nature

Kathryn Arnborg (Tre Well Emballage AB)

Packaging factory for customized cardboard boxes, certified boxes, folding walls, folding screens, corrugated plastic and foam plastic.

Per Elfving (AB Fortum Värme)

[No company description given by participant]

Author’s short description: Production and distribution of district heating and cooling, and electricity production.

Erik Petersson (Inrego AB)

Re-use of computers. Inrego purchases IT equipment from companies and organizations, removes data, refurbishes and sells it. This is a win-win for both seller and supplier but especially for the environment. Inrego was founded 1995 and has an annual turnover of 125 MSEK with 60 employees within the Nordic region. Inrego won the Swedbank Sustainability Award in 2010 as Sweden’s most sustainable and profitable business.

Richard Lundgren (A Lundgren Smide AB)

A Lundgren Smide (forging) manufactures glass walls, facades and construction forgings and interior forgings. Our customers are construction companies and property owners. At the moment we’re working on weather guards for the tram lines, glass sections at the central station and kiosks. We have 32 employees and the workshop is located in Sundbyberg.
Appendix H. “Jag har” and “Jag vill ha” papers used in workshop

<table>
<thead>
<tr>
<th><strong>Jag har:</strong></th>
<th><strong>Bord:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Företag/Organisation:</td>
<td></td>
</tr>
<tr>
<td>Namn:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Jag har:</strong></th>
<th><strong>Kvantitet/Volym:</strong></th>
<th><strong>Plats:</strong></th>
<th><strong>Krav:</strong></th>
</tr>
</thead>
</table>

**Vad gör ni av resursen idag? (kryssa för alla som passar)**

<table>
<thead>
<tr>
<th>Lagras</th>
<th>Förbränns</th>
<th>Återvinns av externt företag</th>
</tr>
</thead>
</table>

**Jag har en lösning men söker efter alternativ: (kryssa för alla som passar)**

<table>
<thead>
<tr>
<th>Billigare</th>
<th>Övrigt:</th>
<th>Närmare</th>
<th>Miljövänligare</th>
</tr>
</thead>
</table>

**Match**

<table>
<thead>
<tr>
<th>Bord nr.</th>
<th>Namn:</th>
<th>Företag/Organisation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bord:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jag vill ha:</td>
<td>Bord:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Företag/Organisation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Namn:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jag har:</td>
<td>Kvantitet/Volym:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plats:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Krav:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Match**

<table>
<thead>
<tr>
<th>Bord nr:</th>
<th>Namn:</th>
<th>Företag/Organisation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bord</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>