Summary of Second International Industrial Symbiosis Research Symposium: Stockholm, Sweden, June 11, 2005

Sixty-two researchers from seventeen countries convened in Stockholm in June 2005 to discuss the state of research in the field of industrial symbiosis. Industrial symbiosis is principally concerned with the cooperative management of resource flows through a network of businesses as a means of approaching ecologically sustainable industrial activity. The event was sponsored by the Nordic Council of Ministers and organized through IIIEE at Lund University, Roskilde University and the Norwegian University of Science and Technology, in collaboration with Øresund Environment Academy.

The objective of the symposium was to identify and discuss on-going theoretical and empirical research, as well as current trends, and to continue the dialogue in light of the agenda from the first symposium held at Yale University in 2004. Key issues for discussion included the definition of symbiosis, the most effective means of implementing symbiotic relationships, the quantification of benefits, and the role of other disciplines in research and practice.

INTRODUCTION

Introductory remarks by Dr. John Ehrenfeld, Executive Director of the International Society of Industrial Ecology, challenged his colleagues to address many of the questions surrounding industrial symbiosis. He described a new framework that envisions industrial ecosystems as SOHO systems: self-organizing holarchic open complex systems, based on research by Canadian ecologist James Kay. Properties emerge from the system, and sustainable development is a measure of the health of the system. Key questions include: How do eco-industrial networks evolve? What are the barriers to and key characteristics of effective development? Which models work? What role should the market or government play in this evolution? How does local culture effect development of networks? What is unique about IS/EIN compared to industrial development in general? To the industrial supply chain? Given that managing a complex system over time is very difficult, how best should IS/EIN be considered? Who shares risk and how should it be allocated?

Professor Stefan Anderberg followed these remarks by making a case for increasing the breadth and depth of IS research in Nordic countries. In general, IS is still not a well-known concept in the region except in Denmark. The use of the IE concept is primarily confined to academic circles; however, IS-like activities under various names have been carried out by both municipalities and some industries. There are an increasing number of initiatives to adopt IS in local community development. Forest and metal industries have traditionally undertaken IS activities and remain at the vanguard of implementing IS within industry.

FRONTIES WITHIN CONTEMPORARY INDUSTRIAL SYMBIOSIS RESEARCH

A two-part panel discussion gave presenters the opportunity to talk about cutting-edge research being done in industrial symbiosis at universities. Ramesh Ramaswamy moderated Part I, and the first speaker was Professor Marian Chertow, who discussed the frontiers of industrial symbiosis research thematically (what frontiers are being explored), methodologically (how are we examining questions), and geographically (where are significant efforts underway). She stressed the importance of exploring multiple temporal, spatial and organizational scales in analyzing industrial ecosystems, especially as we come to understand them more as complex adaptive systems. She noted the first sketch of a collective action model proposed by Boons and Janssen, the "natural history" approach her team is using in Puerto Rico to investigate industrial and social networks, and techniques for adapting industrial ecology tools to study IS in developing countries (e.g. Erkman and Rameswamy). Professor Pierre Desrochers offered a perspective on the economic and geographic factors that have led, historically, to by-product linkages. He discussed earlier related concepts including joint production, agglomeration economies, and long distance trade.

Professor Leo Baas provided an historical view of the process by which the industrial ecosystem has evolved in Rotterdam. Development of the project occurred in multiple phases and was directed by a decision-making group consisting of stakeholders from industry, government, academia, and environmental advocacy groups. The phased implementation took into consideration sociologically relevant elements of community, including the existence of informal and formal networks and eventually the adaptation of networks as contexts for learning. The project has been successful in capturing waste heat: the district expects to increase the number of homes being heated from the project to increase from 3,000 in 2006 to 52,000 in 2020. The key factors for the success of IS efforts as observed over the last ten years in Rotterdam include: mutual understanding and recognition between government and industry; good communications and strategic dialogues among major stakeholders; incremental development of complex social networks as the platform of IS, and a sufficiently long time horizon to make it happen.

Discussion covered the importance of coordination, including how much and how little could be coordinated in a market setting. Also, confidence building was discussed as key to reducing transaction costs in network formation. Common

instruments for comparing and assessing data are also important in exchange networks and may help to reduce defections from those who are satisfactorily receiving services but may not wish to continue the obligations of a network.

Professor Matthias Ruth moderated Part II of the panel discussion. First, Professor Rene van Berkel discussed the great progress that has been made in Australia in developing IS in mining and other resource processing sectors. Analytical and diagnostic tools that allow for more systematic understanding of the inter-industry, inter-sectoral material and energy flows have been further developed in Australia, which has been helpful in recognizing benefits which are usually undervalued and underestimated. Successful projects have been found to be a mix of technology, license to operate, and a compelling business case; but if any of these are missing, there is likely to be a failure. IS has been increasingly adopted as industrial development and as a key platform for technological innovation rather than narrowly as an environmental and recycling strategy.

Prof. Yong Geng discussed the increasing resource and environmental pressures that have impeded China's efforts to rapidly improve the quality of life of its population, while protecting its environment from being degraded. Industrial ecology has been promoted as a potential means of breaking the impediment. He stressed that China has to explore its own way of implementing IE, by planning eco-industrial parks, developing appropriate technologies, and, eventually, through the development of a circular economy – a national strategy for future economic development.

Professor Allan Johansson focused on the need for large-scale change, and how most of the efforts to focus on sustainability have focused too much on material and energy issues and not enough on social and soft sciences. He described an alternative strategy to drive sustainable industrial development – that of distributed economies, a strategy to combine sustainable development with knowledge of innovation and entrepreneurial behavior, with a focus on small and medium sized enterprises and communities.

Discussion centered on the role of self-organization in industrial symbiosis and the relative importance of exchange in driving the types of environmental changes needed. In addition to environment, industrial symbiosis should also be seen as a means of achieving competitive advantage. Professor Ruth stressed the importance of studying failures in addition to successes as a means of increasing knowledge

PH.D THESIS RESEARCH: CASE STUDIES AND THEORETICAL IMPLICATIONS

Three Ph.D. students presented their thesis research, giving participants the opportunity to hear from the next generation of leaders in the field of industrial ecology. Weslynne Ashton from Yale described her IS research on industrial clusters in Puerto Rico over a timeframe of about fifty years. This enables the use of tools and criteria from different fields to characterize succession patterns and how the systems adapt to change, and to examine the role of social networks of the actors in the systems more carefully. Murat Mirata from Lund University discussed the action

research he has been conducting that increases flexibility in addressing a complex system from different dimensions. His research has focused on Landskrona, Sweden, where it is necessary to confront the extent to which IS might be helping some firms stay in business that will not be there in the long run when more radical changes must occur. Olli Salmi from Helsinki University of Technology has been researching different views of eco-efficiency and eco-effectiveness in relation to a study of the industrial Kola Peninsula region in Russia. This has led to a comparison between market socialism and market liberalism in understanding what has happened and what should happen in the future.

GROUP DISCUSSION SESSIONS

In the afternoon, conference participants broke out into groups to discuss one of three topics.

The first group, moderated by Professor Jun Bi, conducted a comparative analysis of the ways in which policy and planning effect industrial development in the East vs. the West. The group compared central planning, prominent in Asia, with more self-organized or market-based approaches to development as experienced in Europe and North America. The group agreed that the role of planning was important, but how it is done is a key part of the outcome and can differ widely.

Professor Stefan Anderberg moderated the second group on the role of social systems in industrial symbiosis. Discussion stressed that beyond a tool or physical relationship, industrial symbiosis is also a social network of people so must also focus on organization, processes, and governance.

The third group, moderated by Peter Lowitt, looked at the complexity of developing metrics to evaluate the success of IS projects in light of the different needs of different stakeholder groups. Several efforts to develop indicators were noted at the State Environmental Protection Administration in China, Curtin University in Australia, and Waterloo University in Canada.

PLENARY DISCUSSION ON RESEARCH DIRECTIONS

To wrap up the conference, there was a plenary session on research directions for the future, moderated by Suren Erkman, and a discussion of next steps, led by Mikael Backman, Marian Chertow, Peter Laybourn, and Noel Brings Jacobsen. Dr. Erkman stressed that industrial ecology is a hybrid – not a science but a transdisciplinary concept. Since industrial symbiosis is embedded in other ecosystems, it raises the questions of the limits and relevance of industrial symbiosis and what it can contribute to sustainability.

While the participants stressed the multidisciplinary approach inherent in industrial ecology (and the increasing trend in this direction), there was also some concern that perhaps the field was getting too broad and needed to retain a narrower focus. There were also discussions of the need to broaden the scale of research (spatially, temporally, and organizationally) and to address social sustainability issues in addition to the current focus on technology.

A challenge for industrial symbiosis research is the volatility of companies – internal and external – and the challenges that poses to managing industrial ecosystems. Some expressed the idea that there is still a large opportunity to develop the engineering part of industrial symbiosis and that perhaps research in this area had been neglected.

The potential clash of self-organization and modeling systems theory was raised. Perhaps an iterative approach could be developed as a more fundamental view of these issues is taken. It is important not only to look at the output side (the waste that is a problem that needs to be solved) but also on the input side.

The view that many IE/IS principles go against traditional business school logic was raised. IS even has some enemies, such as those favoring simulation or those in the camp that "we can't bring all the stakeholders together all the time." Finding ways to identify people who will trigger change is key.

Looking ahead to the future of research in the field, symposium participants noted that better tools are needed to evaluate the economic and environmental performance of IS. In addition, participants stressed the importance of drawing on the knowledge and tools of other academic disciplines, while maintaining a distinct identity for the field. Some participants were interested in finding more ways to apply IS knowledge to real world business scenarios—essentially bringing IS out of the classroom and into the corner office. All participants agreed that research is changing to incorporate new tools and approaches, as new discoveries and insights continue to emerge.

Special thanks to Noel Brings Jacobsen for organizing the initial note-taking on which this summary is based.

Stockholm Industrial Symbiosis Research Symposium Schedule
June 11, 2005

09.30 - 09.45: Coffee and registration
Welcome by *Noel Brings Jacobsen*, Roskilde University, *Mikael Backman*, IIIEE at Lund University and *Marian Chertow*, Yale University

09.45-10.15: Introduction
Industrial Symbiosis in Industrial Ecology – Introductory remarks by *Dr. John Ehrenfeld*, Executive Director, International Society of Industrial Ecology (ISIE) **Industrial Symbiosis in a Nordic Perspective** by Prof. Stefan Anderberg, University of Copenhagen

10.15-12.10: Frontiers within contemporary Industrial Symbiosis research
Part I

Systems thinking and industrial symbiosis by *Prof. Marian Chertow*, Yale University, US;

System boundaries and industrial symbiosis by *Leo Bass*, Erasmus University, Netherlands;

From industrial waste to wealth: Past economic and geographical perspectives on the development of by-product linkages by *Prof. Pierre Desrochers*, University of Toronto, CA;.

Questions and plenary discussion
Moderator: Mr. Ramesh Ramaswamy, Resource Optimization Initiative, India

Part II

From industrial symbiosis to distributed economies by *Prof. Allan Johansson*, IIIEE, Lund University, Sweden;

Industrial symbiosis in Australian heavy industrial areas: issues and opportunities by *Prof. Rene van Berkel*, Curtin University, Australia

Potentials and barriers in Chinese eco-industrial development by *Prof. Geng Yong*, Dalian University, China

Questions and plenary discussion
Moderator: Dr. Matthias Ruth, University of Maryland, USA

12.10-13.10: Lunch

13.10-14.10: PhD thesis research – case studies and theoretical implications
Industrial symbiosis in Puerto Rico: preliminary results by *Weslynne Ashton*, Yale University;

Industrial symbiosis in Landskrona, Sweden by *Murat Mirata*, IIIEE, Lund University;

Efficiency and effectiveness in industrial symbiosis by *Olli Salmi*, Helsinki University of Technology;

Questions and plenary discussion
Moderator: Mikael Backman, IIIEE at Lund University

14.10-14.40: Coffee break

14.40-15.40: Group discussions
Focusing industrial symbiosis agenda in:

Group A **Policy and planning: East and West**
Moderated by *Prof. Jun Bi*, Nanjing University, China.

Group B **Social systems and Industrial Symbiosis**
Moderated by *Prof. Stefan Anderberg*, University of Copenhagen

Group C **Performance evaluation**
Moderated by *Peter Lowitt*, Devens Enterprise Commission, Massachusetts

15.40 - 16.55: Plenary discussion on research directions
Interactive session facilitated by: *Suren Erkman*, ICAST, Switzerland

16.55-17.15: Symposium Wrap-Up and Next Steps
Mikael Backman, IIIEE at Lund University, *Marian Chertow*, Yale University, *Peter Laybourn*, NISP and *Noel Brings Jacobsen*, Roskilde University