6th Annual Industrial Symbiosis Research Symposium

Industrial Symbiosis –
Contribution to CO_2 Reduction and Sustainability

Symbiosis Team in front of Asnæs Power Station in Kalundborg

June 18 – 20, 2009

Kalundborg, Denmark

YALE UNIVERSITY
School of Forestry
& Environmental Studies

INDUSTRIAL SYMBIOSIS
Sharing of resources

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INTRODUCTION – OPENING REMARKS

Welcome from Claus Steen Madsen, Kalundborg Kommue, Denmark

I'm very pleased to open this research symposium. On behalf of the Board of Directors of the Industrial Symbiosis Institute of Kalundborg, I welcome you and I hope you find this to be an inspiring situation. Especially, we are pleased that this symposium is held in Kalundborg in 2009, the year when Denmark will host the 15th Climate Summit in Copenhagen in December.

Representatives of the Danish government often visit Kalundborg. These official guests are very impressed when we introduce them to the results of industrial symbiosis. They suggested that these Kalundborg initiatives be used in a greater context, for example, for export. To the question of whether the industrial symbiosis in Kalundborg can be used as a model in Denmark as well in other countries, the answer is yes. The concept can be used any place provided that sufficient conditions are present.

The Kalundborg model is a bottom-up model driven by a will to cooperate. To spread industrial symbiosis as a concept, companies should integrate the ideas and carry them through development. The Kalundborg municipality is very aware of our role as a facilitator for development and innovation within the climate and energy sector. Industrial symbiosis is one of the opportunities to showcase this and an annual conference on this issue is one of the possibilities.

By the end of this month, we no longer have a director of this institute. Mr. John Kryger has been chairman of the organizing committee of this institute. I'd like to thank him and also Prof. Marian Chertow from Yale University who has taken the initiative for a number of the symposia.

Welcome from Marian Chertow, Yale University, USA

I want to welcome you and also thank you and John, both from Kalundborg, for this wonderful meeting. It seems like there are a lot of people who are interested in industrial symbiosis. Going back to 2004, we sponsored the first Industrial Symbiosis Research Symposium in New Haven at Yale. Every year, the meeting is growing. The second year we were in Stockholm and the third year we were in Birmingham in the UK. We finally made it to Canada—Toronto—two years ago, and last year Peter Lowitt bought us to Devens, Massachusetts. Now finally, we have an Industrial Symbiosis Research Symposium (ISRS) in Kalundborg, the "Center of the Universe."

We always hold the meeting around the time of the ISIE meeting or the Gordon Research Conference. Many of you have been to one of these famous industrial ecology meetings. A characteristic of these meetings is that many papers are presented, but there is not a lot of time to talk and interact. In contrast, one of the goals of the Symposium is to create more time for discussion and reflection so we have shorter talks and fewer papers just to stimulate our thinking and to make sure that we're taking on the mission of interacting. Here, we try to be very egalitarian: Ph.D. students are equal to senior professors and everyone should participate on an equal basis. That is an important value we share because it is an important part of building a community.

So with those ground rules in place, let me say that something exciting will happen this year to build more community. We created a new section of the International Society of Industrial Ecology, specifically devoted to members who are interested in industrial symbiosis and eco-industrial development. Peter Lowitt, the chair of the section, will talk about this more later in the meetng.

COUNTRY AND REGIONAL REPORTS – AROUND THE WORLD

Report from Guillaume Massard, Switzerland

There are 4 separate IS projects ongoing; a tool has been developed for planning—related to material flows—as a way to help determine where to locate new plants. Industrial ecology (IS specifically) is being used as a strategy for regional development.

Report from Andreia Minulescu, Czech Republic

Her group looks at industrial parks as social systems and is working to find the quantifiable added value for industries—measured in knowledge. The group is currently combining autopoiesis and industrial ecology as a field of study.

Report from Albena Bossilkov, Australia

Gladstone, Queensland – industries do not show much commitment to keeping the project going.

Port Melbourne – needs water synergies; have potential to expand development; may adopt the Kwinana model.

Geelong, Victoria – synergy identification tool applied; since 2007, two large companies have closed; the remaining firms are unable to meet the government requirement for 50% matching funds.

Brisbane, Queensland – in 2008 investors showed interest in establishing a Greenfield EIP and using the CRSP tool to analyze the mix of companies that would be needed to achieve zero waste objectives; funding ceased but there are hopes for further development.

Whyalla– the largest industrial area in southern AU has suddenly put all projects on hold.

Kwinana - is now 10 years old. There are 18 completed pre-feasibility studies in the hands of the companies for evaluation; 3 of these projects look very promising. At present the major focus in on water and one of the projects is investigating the application of evaporative and desalination technologies to treat industrial effluent.

Centre for Sustainable Resource Processing (CSRP) - funding will cease in June 2010. The inorganic project has stopped and only the evaporative water technology pre-feasibility study is currently ongoing.

Report from Pauline Deutz, United Kingdom

Pauline attended the symposium with Qiaozhi Wang, a PhD candidate at the University of Hull, working on research on how industrial symbiosis contributes to sustainable development via eco-industrial park developments.

Peter Lowitt, USA
Alabama, Texas, Chicago and Kansas City all have ongoing projects; the economic stimulus plan holds some promise of further funding. News from Pennsylvania will be given during the later presentation by Matthew Eckelman.

Leonard Mitchell, USA
USC Center of Economic Development – working on the design of zero-waste industrial parks - one for California and one for the east coast.

Megha Shenoy, India
Just finished research where she found 11 symbiotic networks during interviews; many people use agricultural residues as a fuel source; she will follow-up with a study of the consequences of swapping coal by agri-residues. Recycling networks are very informal, which makes it difficult to trace the flow of materials once they leave the factory; there is also a need to investigate the health implications.

Inêz Costas, Portugal
Currently a PhD candidate. Working to develop some eco-industrial networks made up primarily of SMEs, oriented toward waste management. Later she plans to follow-up with EU waste directives. Her goal is to help government create instruments that motivate the creation of industrial symbiosis, for example, an organized waste market.
Inêz also is working on a database that is tracking waste management and will be used to track potential synergies. RESIST is a program applying IS concepts to the study of urban resilience.

Leo Baas, Erasmus and Linköping
From Rotterdam (NL), Leo reports ongoing IS projects including shrimp farms. There is a coupling of CO_2 emissions to greenhouse production from the Shell refinery; eventually all greenhouses will be connected. Another project on district heating systems, also dependent on Shell, is not going well due to lack of support. The greenhouse project has taken precedence and this has disrupted the IS network and partners for the past two years. In March 2009, a biomass network was started.
From Linkoping (S), Leo reports that he will start in the autumn as a professor of industrial ecology for the department of Environmental Technology and Management and that he is becoming acquainted with the well-connected people there. At the regional level, he would like to achieve renewable energy systems; convert household waste to energy with plants that make biomass and bio-energy products; the university is promoting regional stations that pump bio-diesel fuel.

Professor Hung-Suck Park, South Korea

Professor Park reported on the EIP initiatives taking place in South Korea – for more background see http://www.indigodev.com/korea_eip.html. He presented slides of the Ulsan and Onsan national industrial parks. He reported that South Korea is treating EIP development as a business model.

Gemma Cervantes, Mexico

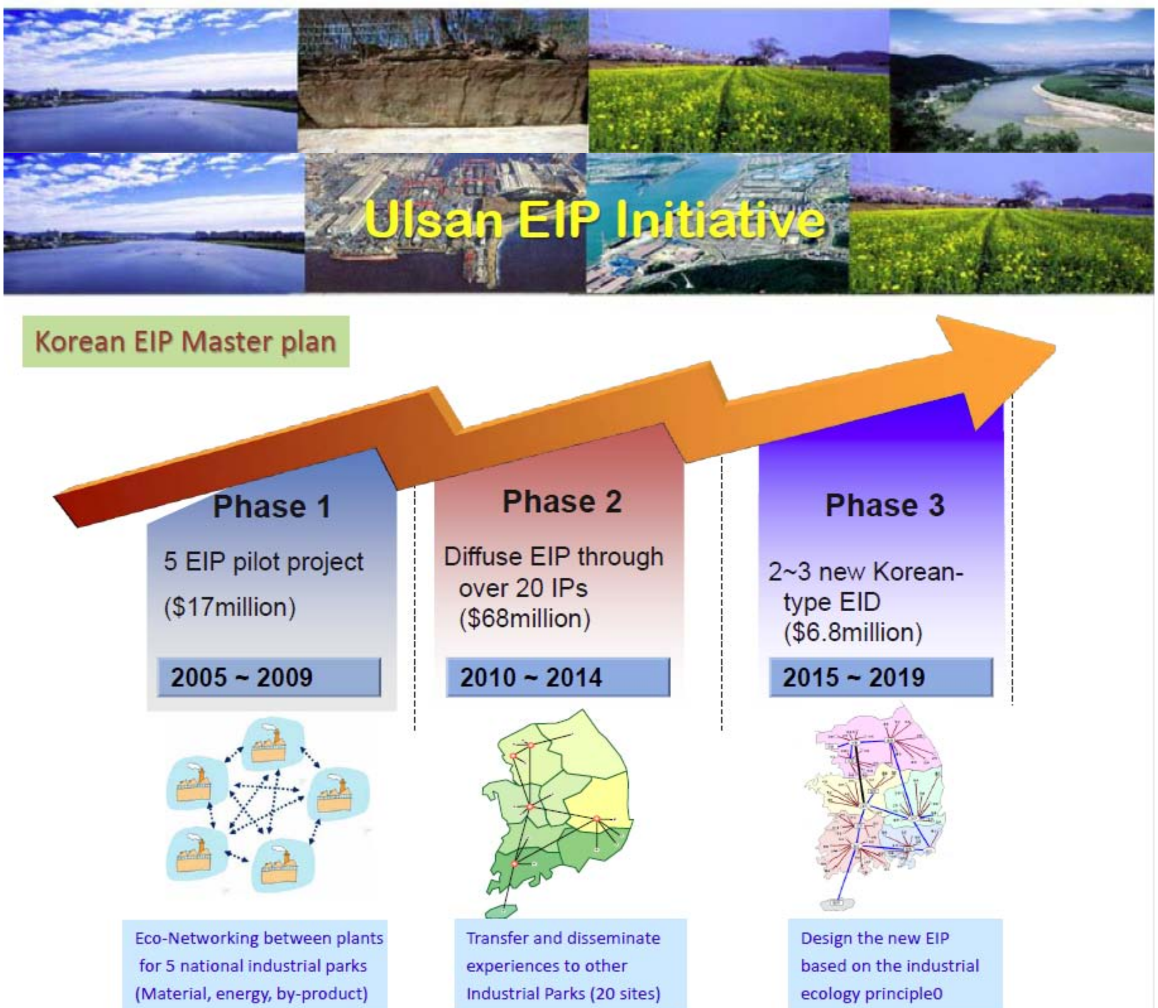
Gemma reported that IE in México started with an IS initiative (a By-Product Synergy demonstration Project) in Tampico (Tamaulipas) and now there is an IS development and also some Eco-industrial initiatives. IE and IS actors in México now are mainly: CESPEDES (The Centre for Sustainable Development of the private sector), AISTAC (the Industrial Association that developed the BPS in Tampico), IPN (National Technical Institute) and NISP-Mx (National Industrial Symbiosis Program in Mexico). Thirty-two research projects were identified. The first two students who developed final projects in IE and that have finished their degree are working in the field, one in NISP Mexico and the other one in CESPEDES. A website from the research group (IERG) on IE, called GIEI, has been created with IE contents in Spanish (www.giei.org). Every year one or two eco-industrial workshops are organized by IPN and AISTAC. In 2008, the 4th eco-industrial workshop in Mexico was held in Tampico in November with assistance from industry, government and academia.

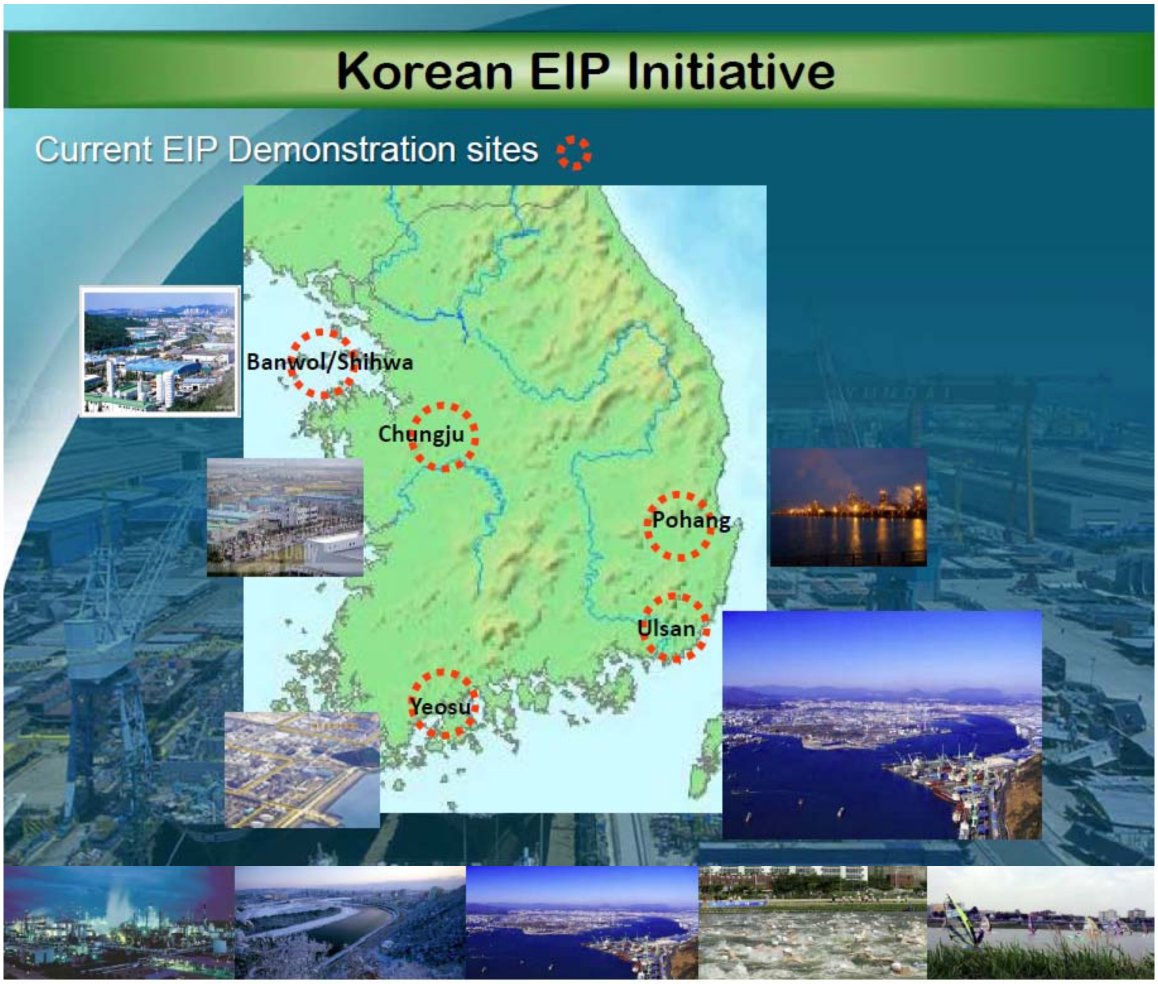
Recent developments in Ulsan Eco-Industrial Park initiative

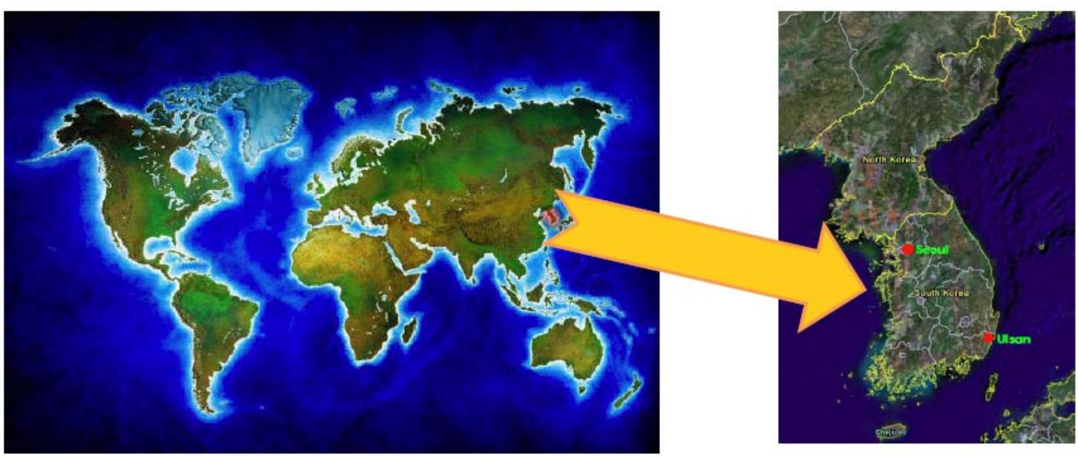
Hung-Suck Park [1,2]

[1] Director, Yeongnam Industrial Complex Infrastructure Innovation Center, Ulsan

[2] Professor, Dept Civil and Environmental Eng., University of Ulsan, Ulsan, 680- 749, South Korea







Population

South Korea: 49,268,000

Ulsan Metropolitan City: 1,095,000 (As on 2006)

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Overview of Ulsan National industrial Parks

Category	Ulsan-Mipo	Onsan	Total
Food Products	8	-	8
Textile Products	5	1	6
Wood/Papers	15	3	18
Petrochemicals	121	65	186
Non ferrous	29	10	39
Steel	13	20	33
Machinery	188	61	249
Electrical, Electronics	70	7	77
Transport Equipments	104	41	145
Others	18	7	25
Services	86	32	118
Total	657	247	904

Source : KICOX (As on Dec.2007)

Overview of Ulsan National industrial Parks

Item		Ulsan/Mipo	Onsan
Area	Total (Km²)	46.185	17.283
	Plant (Km²)	34.619	15.391
Number of companies	Move-in	752	283
	In operation	657	247
Capacity of water supply (㎥/day)		641,000	340,000
Capacity of wastewater treatment (㎥/day)		250,000	150,000
Production (Billion USD$)		80.70	25.78
Export (Billion USD$)		41.69	15.15
Number of Employees		85,530	10,237

Source : KICOX (As of Dec' 2007)

Major industries in Ulsan National industrial Parks

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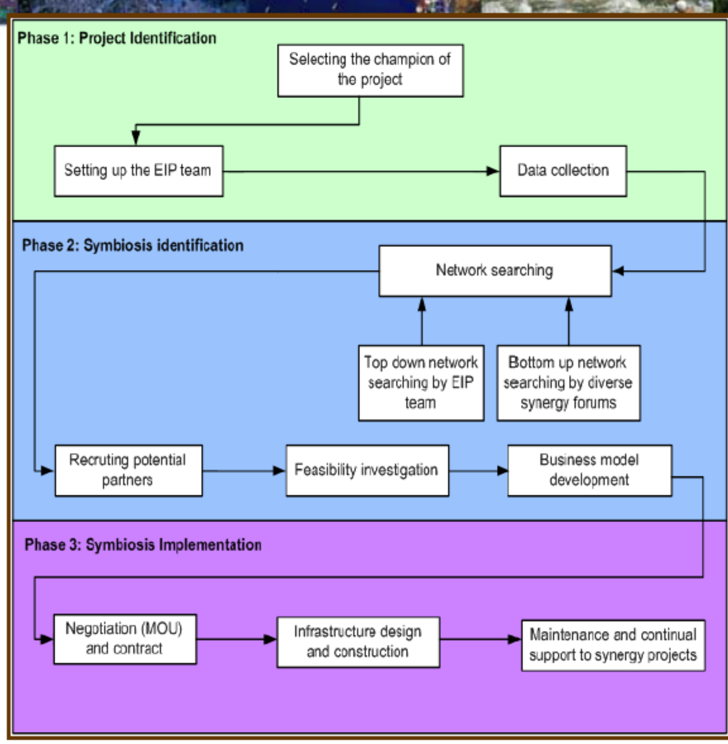
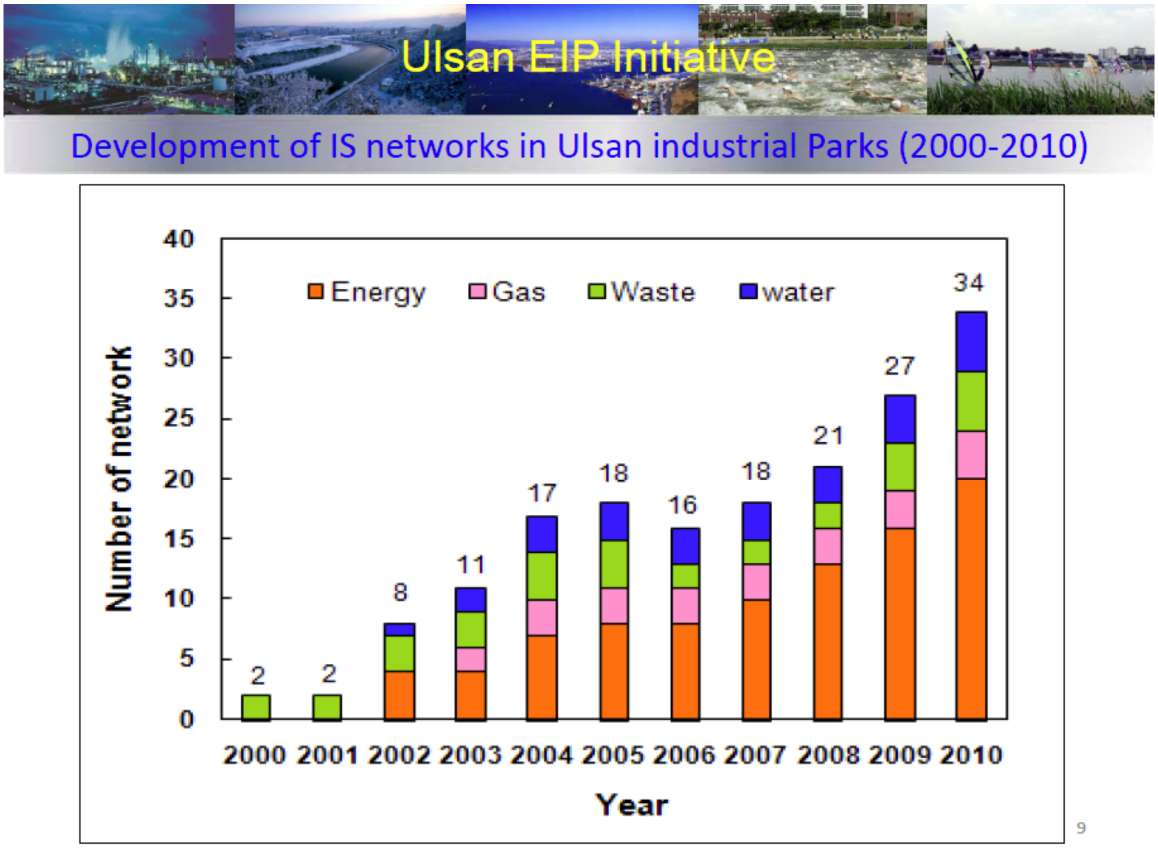
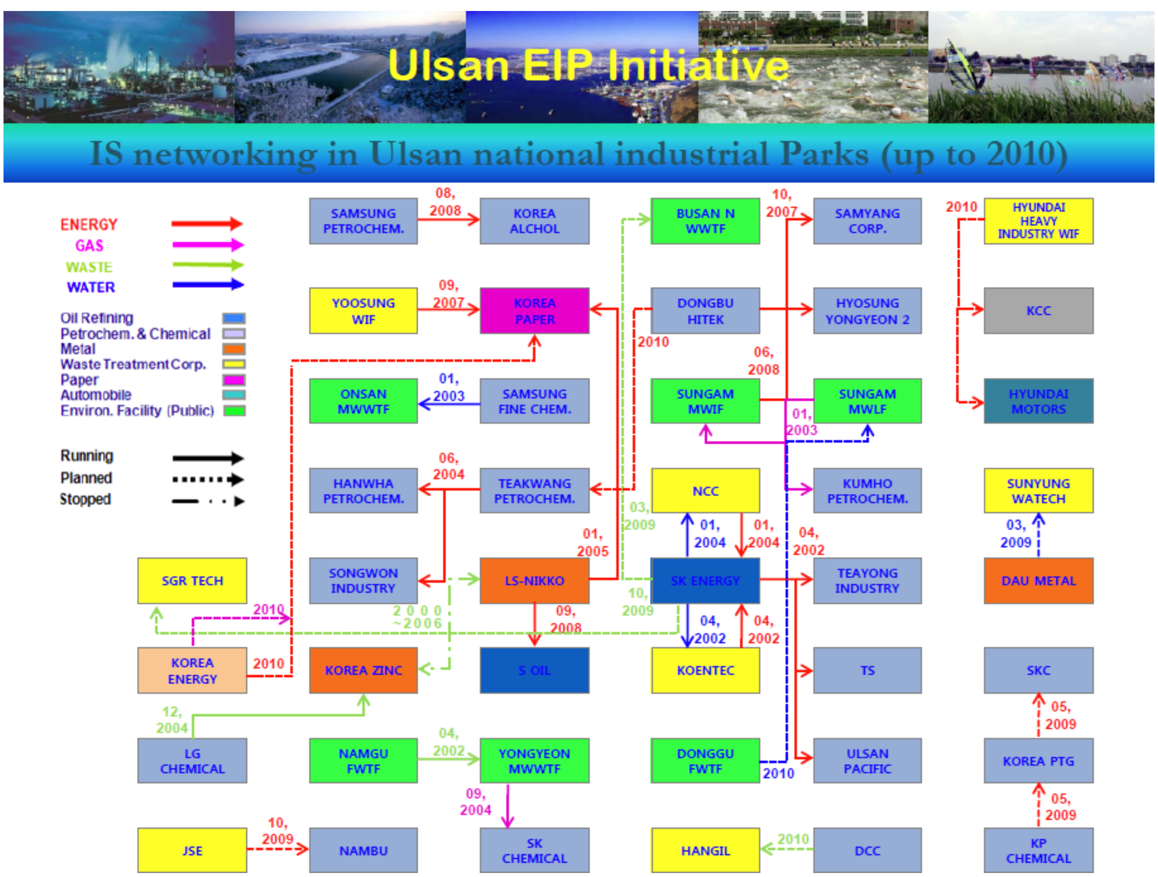
Ulsan Eco-center's Strategy




Ulsan EIP Initiative
Development of IS networks in Ulsan industrial Parks (2000-2010)
Energy
Gas
Waste
water
Number of network
Year
40
35
30
25
20
15
10
5
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
2
2
8
11
17
18
16
18
21
27
34
9


Ulsan EIP Initiative
IS networking in Ulsan national industrial Parks (up to 2010)
ENERGY
GAS
WASTE
WATER
Oil Refining
Petrochem. & Chemical
Metal
Waste Treatment Corp.
Paper
Automobile
Environ. Facility (Public)
Running
Planned
Stopped
SAMSUNG PETROCHEM.
KOREA ALCHOL
BUSAN N WWTF
SAMYANG CORP.
HYUNDAI HEAVY INDUSTRY WIF
YOOSUNG WIF
KOREA PAPER
DONGBU HITEK
HYOSUNG YONGYEON 2
KCC
ONSAN MWWTF
SAMSUNG FINE CHEM.
SUNGAM MWIF
SUNGAM MWLF
HYUNDAI MOTORS
HANWHA PETROCHEM.
TEAKWANG PETROCHEM.
NCC
KUMHO PETROCHEM.
SUNYUNG WATECH
SGR TECH
SONGWON INDUSTRY
LS-NIKKO
SK ENERGY
TEAYONG INDUSTRY
DAU METAL
KOREA ENERGY
KOREA ZINC
S OIL
KOENTEC
TS
SKC
LG CHEMICAL
NAMGU FWTF
YONGYEON MWWTF
DONGGU FWTF
ULSAN PACIFIC
KOREA PTG
JSE
NAMBU
SK CHEMICAL
HANGIL
DCC
KP CHEMICAL
08, 2008
10, 2007
2010
09, 2007
2010
06, 2008
01, 2003
01, 2003
06, 2004
03, 2009
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2010
12, 2004
04, 2002
09, 2004
2010
05, 2009
05, 2009
10, 2009
2010

Ulsan EIP Initiative

Economic and Environmental Benefits

Economic and environmental benefit from IS implementation in Ulsan EIP transition

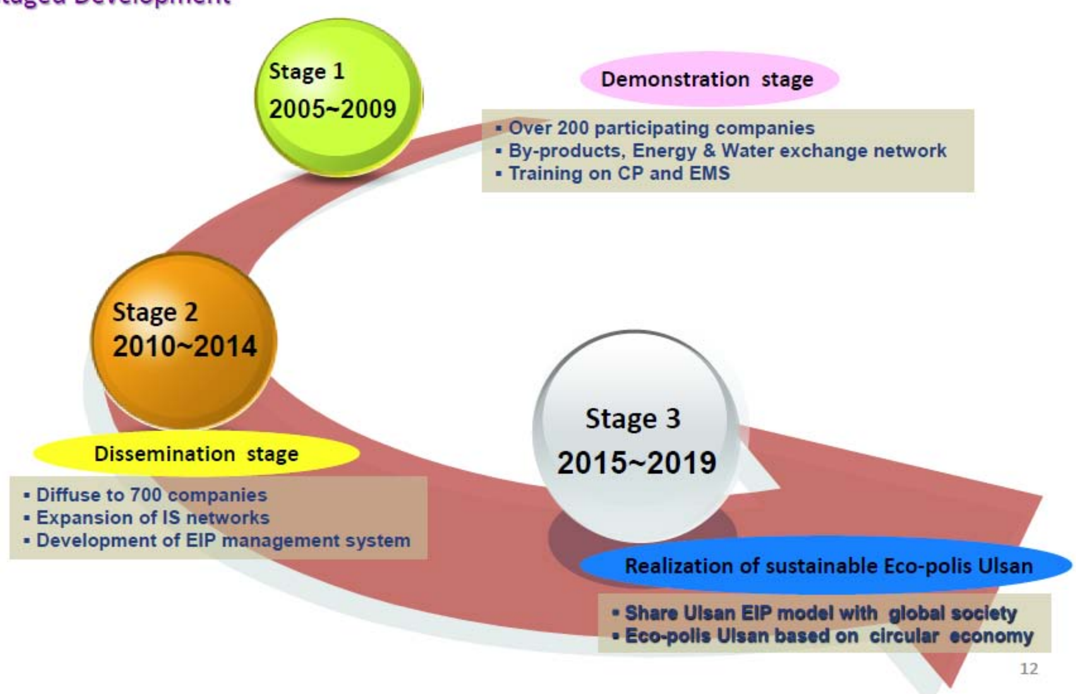
No.	Status	Material	From	To	Period	[1]Investment (0.1 billion KRW)	[2]Profit (0.1 billion KRW/year)	CO_2 reduction (ton/year)
1	Running	Steam	Yoosung Company	Hankook Paper	Since Sept' 07	8.5	23.2	19,058
2	Running	Steam	Sungam MWIF	Hyosung Company	Since May 08	50	71	24,515
3	Running	Steam	Korea PTG KP Chemical	S K C	Since Jan' 09	140	64	44,468
4	Running	Aldehyde wastewater	S K Energy	Noksan MWWTF	Since Mar' 09	1.3	19.8	-
5	Running	Nutrient for microorganism	Sunkyuong Watech	Tongsuh Petrochemical	Since Feb' 09	1	36.9	-
6	Under design	Steam	Hyundai Heavy Industry	KCC Company Hyundai Motor Company	From Nov' 09	60	35	19,058
7	Under design	Steam	Dongbu Hitek Taekwang Industry	Samyang Corp. Songwon Company	From Oct' 09	160	144	47,644
8	Under design	Steam	Korea Zinc Company	Hankook Paper Donghae Pulp	From Dec' 09	120	92	119,908
9	Under design	Recycled oil by pyrolysis	J S E	Nambu Bomyung	From June 09	2	14.6	-
10	Under design	Oil degradation material	S G R Tech	Soil remediation site	From Aug' 09	2	3.6	-
			SUM			544.8	504.1	274,651

[1]Currency conversion:
1000 KRW(Korean Won) ~ 1USD $

[2]Profit is the summation of both supplier and recipient

Ulsan EIP initiative - Vision

Staged Development




Thank you
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PRESENTATIONS AND DISCUSSIONS

1. The Clean Development Mechanism and Industrial Symbiosis (Kristian Brüning, Climate Wedge Ltd., Helsinki, Finland)

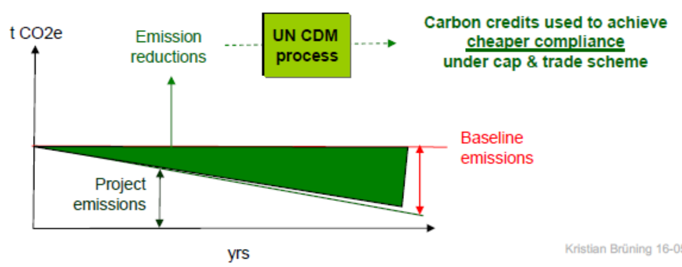
Kristian Brüning is a founding executive of Climate Wedge Ltd, an independent firm providing carbon finance and emissions trading related advisory and asset management services, and pursuing principal investments and project development in the carbon markets. Kristian is a seasoned carbon market expert who has built a very strong understanding of energy corporate finance, carbon finance and emissions trading during the last 10 years through positions in corporate climate change strategy consulting, emission reduction project development and carbon fund advisory. He has worked with numerous industrial and financial sector clients such as BP, Rio Tinto, Toyota, Wärtsilä, Cheyne Capital Management and CalPers, as well as with McKinsey & Company and CSIRO on carbon-related issues. Prior to founding Climate Wedge Kristian was an assistant director at PricewaterhouseCooper's climate change team in its energy corporate finance practice in London. Kristian holds an M.Sc (Intl. Econ) from Hanken in Helsinki and is certified financial analyst by the European Federation of Financial Analysts' Societies (EFFAS).

Agenda

- What is the Clean Development Mechanism?
- How do you structure and manage a CDM project?
- Is the CDM working? Pros and cons
- Snapshot of CDM in industrial processes
- Transposing CDM onto Industrial Symbiosis – some observations

Carbon Credits

- *A verified reduction* of CO2e against a project baseline
- Measured against the *baseline* - - representing the *emissions in the absence of the project activity*
- From projects certified against a UN protocol to generate Certified Emission Reductions (CER) under the Clean Development Mechanism (CDM) [or voluntary protocols].
- Carbon financing helps projects overcome barriers that would have prevented the project from happening anyway
- Provides a cheaper way of compliance for entities under cap

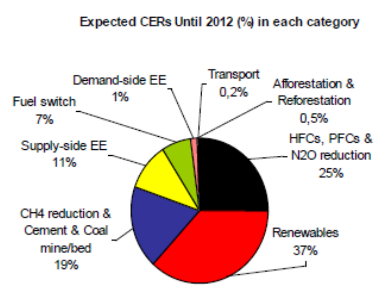


The Clean Development Mechanism

- **One of the three *flexibility mechanisms in the 1997 Kyoto Protocol:***
  - Emission trading (between nations)
  - Clean Development Mechanisms (CDM)
  - Joint Implementation (JI)
- **Introduced to reduce cost of abatement of GHG emissions:**
  - As a cheaper source of abatement
  - Technology transfer to developing countries
  - Leap-frogging over
  - Sustainable development benefits
  - Push a price of carbon into a very diverse range of sectors
- **Novel combination of central enforcement and outsourced implementation**
  - CDM Executive Board, legislative/administrative power with mandate from COP
  - Expert panels – providing technical advice to the board
  - Designated Operational Entities
  - Bottom up methodology development

Clean Development Mechanism

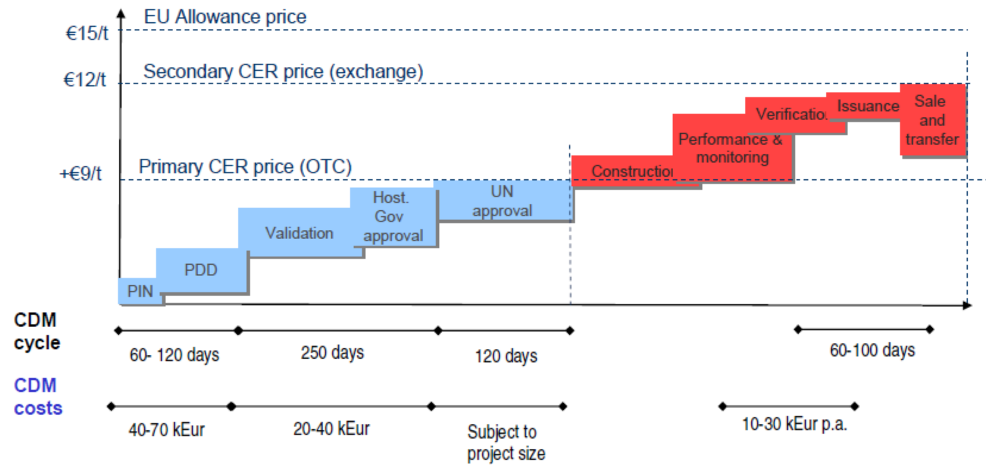
- Largest CO_2 offset system in the world
  - 1650 registered projects in 51 countries
  - 3000+ projects in the pipeline
  - 290 million CERs issued
  - 2.7 billion CERs in pipeline by 2013
  - 1.5-2 billion likely to materialize



- China, India, industrial gas and methane projects dominate
- ”Low-hanging fruit” already gone – larger volumes needed:

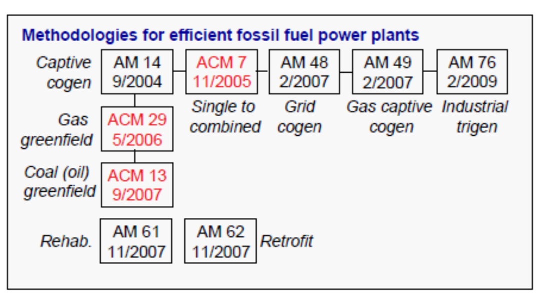
Total in the CDM Pipeline	Number		kCERs	2012 kCERs	
Latin America	791	17,9%	76080	391718	14,3%
Asia & Pacific	3432	77,7%	498449	2224722	81,0%
Europe and Central Asia	46	1,0%	4605	18487	0,7%
Africa	100	2,3%	17689	79762	2,9%
Middle-East	48	1,1%	7238	33449	1,2%
Less developed World	4417	100%	604061	2748139	100%

Development cycle and cost for Certified Emission Reductions



Baseline and monitoring methodology at the heart of CDM

- A CDM project is developed, validated and verified according to a UN-approved "project design and monitoring methodology"
- There are app. 130 approved methdologies specifying the CDM project to high level of detail
- *Methodolgies are developed for public use.*
- UN maintains a roster of available methodologies
- Example, power sector:



CDM project design – the devil is in the details

Term	Description
Project boundary	Processes and procedures included in the project and for which emissions are calculated
Baseline scenarios	*All available alternative processes and procedures for the project developer that provide similar outputs or services as the proposed project activity.*
Baseline	*Likely baseline scenario (~ "what would have happened in the absence of the project")*
Additional	*It must be proven that the project would not have happened in the absence of CDM -> CDM alleviates operational, financial or technological barriers*
Baseline emissions	The amount of emissions in the identified baseline scenario calculated
Project emissions	The amount of emissions after implementing the project activity
Leakage emissions	Increases in emissions outside the project boundary resulting from the project activity
Emission reductions	Baseline emissions – project emissions + leakage emissions

Pro's and con's of CDM

- \+ Hugely successful in mobilizing emission reduction projects from private sector
- \+ On track to reduce 1.5-2 Gt of CO2e
- \+ Highly diverse pipeline of project types – enormous public pool of information
- \+ "Unbiased" in terms of sector – carbon price can be applied in almost any project type
- \+ Bottom-up process for methodology development – active pull from private sector
- – Administrative capacity has not been up to market demand (validation, registration)
- – Claims of unpredictability and lack of transparency on part of the CDM Executive Board
- – Revisions and improvements take very long to push through
- – Based on proving a counterfactual argument – "what would have happened"
- – Proving the need for CDM income prone by mixed incentives, transparency and verification problems

Results of CDM and industrial projects in the pipeline

CDM projects in the pipeline	All CDM projects in Pipeline				CDM project with CERs issued		
Type	Projects	1000 CERs	2012 kCERs	2020 kCERs	Projects	Issued kCERs	Issuance success
Afforestation	4	26	160	7050			
Agriculture	178	7596	45189	101901	39	3903	45%
Biogas	283	14238	61752	168573	11	1234	66%
Biomass energy	645	40235	194824	542259	108	12215	87%
Cement	30	5758	32007	85455	7	1103	66%
CO2 capture	3	29	167	396	1	43	191%
Coal bed/mine methane	67	30102	130974	358841	3	733	45%
Energy distribution	5	2009	8234	21002			
EE households	13	883	3627	9624			
EE industry	158	5946	28661	70976	23	994	84%
EE own generation	398	55940	248879	701635	30	11377	90%
EE service	14	192	798	2106	1	4	61%
EE supply side	49	15523	30985	179668	6	360	78%
Fossil fuel switch	122	40581	178161	504360	18	2376	85%
Fugitive	23	10967	54356	154739	3	5153	112%
Geothermal	15	3433	17179	43574	2	318	29%
HFCs	23	82498	479243	1108036	17	159928	106%
Hydro	1200	125799	464368	1579073	99	10493	90%
Landfill gas	322	43305	220251	625126	36	5929	33%
N2O	67	47850	249872	634735	12	59003	122%
PFCs	10	2911	9914	29777			
Reforestation	44	2364	12202	39973			
Solar	28	583	1968	8363	1	1	18%
Tidal	1	315	1104	3631			
Transport	10	988	4779	14012	2	132	47%
Wind	705	63991	268483	761226	92	12521	85%
Total	4417	604061	2748139	7756111	511	287819	97,5%

Examples of CDM project types for industrial processes (not exhaustive)

BIOFUELS
- *Waste oils & fats for biodiesel*

COGEN & ENERGY
- *Captive or gas-based*
- *Trigen*
- *Chillers / chilling*
- *Waste heat for industrial pre-heating*
- *Waste heat/gas recovery (cement/refinery)*

BIOMASS WASTE
- *In cement production*
- *Grid power*
- *Heat (captive)*

CEMENT
- *Increasing blend (reducing clinker) with fly ash, slag etc*
- *Altenative raw material for clinker production (EX)*

WASTE
- *Wastewater treatment*
- *Composting*
- *Biogenic methane to grid or to town gas*
- *Biomass as feedstock for pulp & paper*

INDUSTRIAL GASES
- *SF6 replacement in magnesium industry with other cover gas*

CO2 CAPTURE
- *Switch to renewable CO2 (ethanol distillery) in production of chemical salts*
- *Tail gas recovery of CO2 to replace industrial CO2*

Does not include several methodologies that deal with the destruction/final decomposition of a industrial material/waste stream (e.g. HFC23 and N2O)

Example of applicability requirements: Clinker production (ACM 15)

- Use of alternative raw materials that do not contain carbonates for clinker production e.g - waste ash from fuel combustion in power plants, blast furnace slag, gypsum and fluorite etc.
- Permits only use of materials that are not used in normal production conditions as input material to the cement kiln for the purpose of production of clinker for full or partial replacement of carbonates.
- Use of alternative materials shall increase neither the capacity of clinker production nor the lifetime of equipment;
- Type and quality of clinker must remain the same in both baseline and project case;
- Alternative raw materials have never been used in the clinker production facility prior to the implementation of the project activity;
- The available quantity of alternative materials, within a 200km radius, shall be at least 1.5 times the quantity required for meeting the demand of all existing users
- New cement varieties are excluded from the emission reduction calculations
- Energy and transport emission from sourcing alternative material must be included as emissions leakage

Observations: CDM/Industrial symbiosis (I)

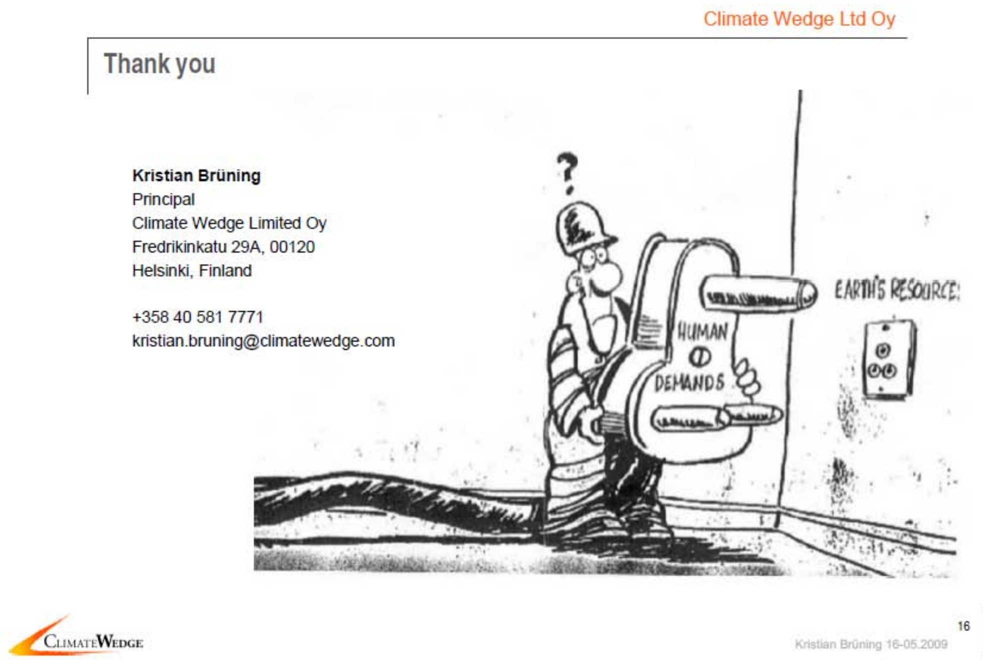
- TBC

Observations: CDM/Industrial symbiosis (II)

- TBC

Company overview

- Climate Wedge Oy is an independent carbon management and investment advisory firm providing carbon finance and emissions trading related advisory and asset management services.
- Climate Wedge helps clients maximize the value of financial- or physical assets or business strategies by developing and executing carbon management strategies.
- Our aim is to drive and support novel market-based solutions to reducing greenhouse gas emissions through carbon finance and emissions trading.
- Founded in 2005 by former senior members of PricewaterhouseCoopers' Climate Change Services team in London with strong backgrounds in carbon finance, corporate climate strategy, carbon markets/ transactions, and climate science and policy.
- Utilizing a deep pool of real market experiences from a diverse set of projects with a blue-chip clients ranging from McKinsey & Company, NEFCO, California Public Employees Retirement System (CALPERS), Cheyne Capital, Wärtsilä and News Corporation.
- Climate Wedge has co-developed and financed emission reduction projects and platforms through a principal or advisory role on transactions for tens of millions of tons of CO2eq reductions.
- Operates from offices in Helsinki and San Francisco, and representation in Shanghai



Discussion

Matthew Eckelman, Yale University, USA – Almost none of the industrial symbiosis projects have been approved as CDM. One of the big issues is how you share credits among different companies whereas most of the applications of climate change credits are on the basis of a single company and implementation of the project.

Kristian Bruning, Climate Wedge Ltd Oy, Finland – U.S. is a different case, but I would not use Chicago Climate Exchange as the current driving force. There are projects outside of the Chicago Climate Exchange using recognized methodologies either from the UN, California Climate Action Registry, Voluntary Carbon Standard or Gold Standard. As for the issue of sharing credits, there can be several project developers if they want to and they gets credits from the UN whatever sharing scheme they agreed upon.

Jørgen Christensen, JC consult, Denmark – Industrial symbiosis is a bilateral activity. How can a donor and a receiver agree on trying to apply for a CDM project together? We know how difficult it is to achieve an industrial symbiosis project and it seems to be even worse to achieve CDM projects.

Kristian Bruning, Climate Wedge Ltd Oy, Finland – The UN is not interested in how credits are shared or maybe even developers. There is no requirement of having everyone in the process to be involved in the registration. The project developer can be a third party.

Gary Foster, NISP, UK – How do you capture the value of substitution to calculate the carbon footprint?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – That is challenging. A contract requirement between sellers and buyers can guarantee that buyers are not going to monetize the reductions. This technology can somehow be applied to those contexts. Contractual effect can be one approach for suppliers to get rights.

Megha Shenoy, Resource Optimization Initiative, India – What is a methodology to monitor the realized benefits?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – First, you validate your project and then usually you need to verify it every year. You need to have a third party to do that. Once the credits are issued to the owner, there is no follow-up. It is purely left to the contractual arrangements. There are high sustainability methodologies under the Gold Standard. They have specific requirements that you need to follow up on, for example, sustainable development indicators. However, this does not apply to the CDM.

Gemma Cervantes, Nat. Tech. Inst., Spain/Mexico – Do you know why the number of success cases is low?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – The collection system has not been effective.

____________ - In one of the initial slides, you showed the diagram including some numbers. What is it, is it grace period or period extension? Is it some kind of limitation how many credits you can get?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – At the time of application, you have a choice of crediting period for 1 time in 10 years or 3 times in 7 years. What happens after 7 years is that the baseline is reviewed. It is not an automatic review. That is the theoretical crediting period, but the real crediting period right now is up to 2012. So, if you start a project today, you know that you can get the credits until 2011

Marian Chertow, Yale University, USA – How much money is earned in a project at such as the Ulsan eco-industrial park?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – As a rule of thumb, in the case of a CO_2 project, you would probably get 1 to 5% of the project returns. The price of CO_2 today is 13 euros per ton. Who gets the money is according to the financial arrangement between the parties involved. You can get the money upfront, but the price would be much lower. The money comes from industrial companies who are forced to meet the caps. Marginal abatement cost in Europe is on average 35 euros per ton; Denmark probably 100 euros since a lot is already done; 10 euros from Brazil.

Hung-suck Park, University of Ulsan, South Korea – One of the projects in Ulsan EIP reduces 100,000 tons of CO_2 per year and they're trying to increase investments to verify. Is it possible to register it as regional policy CDM?

Kristian Bruning, Climate Wedge Ltd Oy, Finland – Yes, and that would change the landscape completely. Everything in the policy would be credited. A sectoral policy-based CDM certainly simplifies things a lot. In fact, JI [Joint Implementation] already works that way. National governments determine what is additional and they take credits out of the national cap. I hope the system is going to move towards that.

2. Measurement of CO_2 Emission Reduction from Industrial Symbiosis in Japanese Eco Towns (Tsuyoshi Fujita, National Institute for Environmental Studies, Tsukuba, Japan)

Tsuyoshi Fujita is head of the Environmental Technology Assessment System Research section in National Institute for Environmental Studies (NIES). He is also a professor in the Environmental Planning and Management Faculty of Engineering at Toyo University as well as a visiting professor of the Chinese Academy of Science's Institute for Applied Ecology. He received a Master's degree of city planning at University of Pennsylvania and Ph.D. in urban engineering from Tokyo University.

Research Presentation for International Workshop
June 19th, 2009, Kalundborg, Copenhagen

Quantitative Assessment of CO_2 Emission Reduction Effects of Industrial Symbiosis in Japanese Eco-towns

Prof. FUJITA, Tsuyoshi
Head of Environmental Evaluation System Research Section, National Institute for Environmental Science, Japan
Professor for Graduate School of Engineering, Toyo University
Visiting Professor, Chinese Academy of Science, Institute for Applied Ecology
fujita77@nies.go.jp

1

Research on quantification of CO_2 emissions from IS

- Definition of environmental and social benefits of Industrial Symbiosis
  - Define the community of interests, reduce environmental impacts, maximize energy efficiency, conserve materials, network companies, continuously improve the environmental performance, etc (Cote & Cohen-Rosenthal, 1998)
  - Creating jobs, foster new enterprises, reduce environmental Impacts, addressing waste management, and saving resources (Chertow, 2007)

- The reduction of CO2 and GHG emissions is one of the environmental impacts, which has not been the focal point of research on EIP and IS.

- Low carbon effects of IS , EIP and IS&EIP networks, need to be quantified in order to have the reasonable return and benefit to symbiotic stakeholders through carbon credits in the Post-Kyoto World after 2013.

HOW?

Agenda

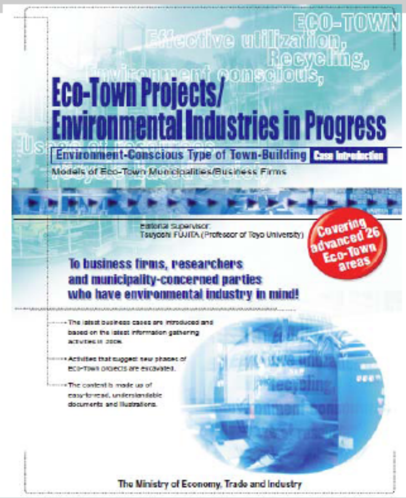
1)Background of quantitative assessment methodologies for industrial symbiosis

-Present and future targets of Japanese industrial symbiosis or eco-towns

2) Quantitative assessment methods of CO2 emission reduction through industrial symbiosis in Japan

Eco-town Areas as demonstration projects of circular technologies

The Ministry of Economy, Trade and Industry and the Ministry of Environment approved Eco-Town Plans for 26 areas as of the end of January 2006, and they provided financial support to 62 facilities located within the appropriate areas.



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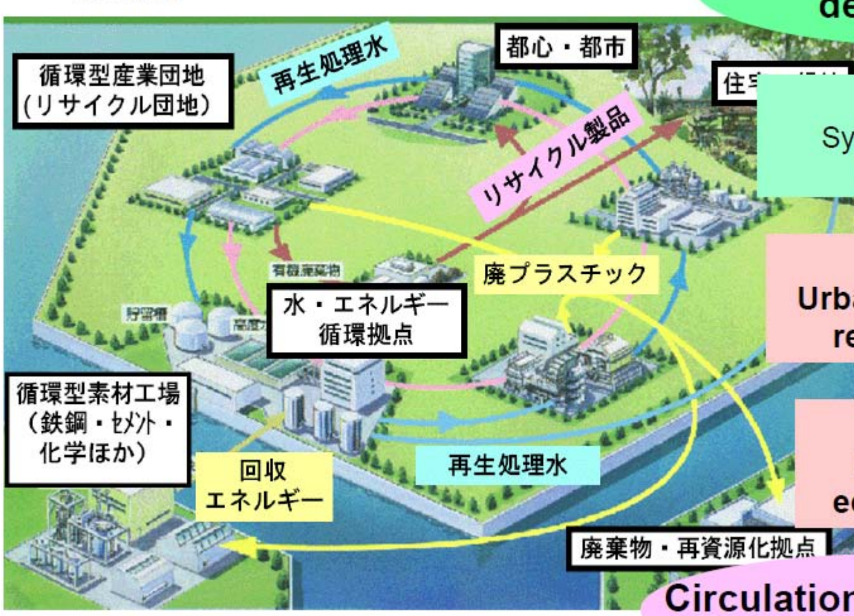
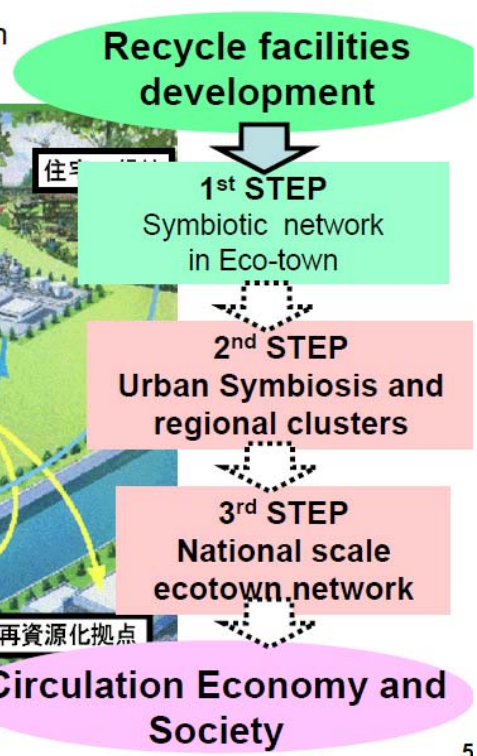
Eco town development and network

Circular industrial network around eco-town facilities





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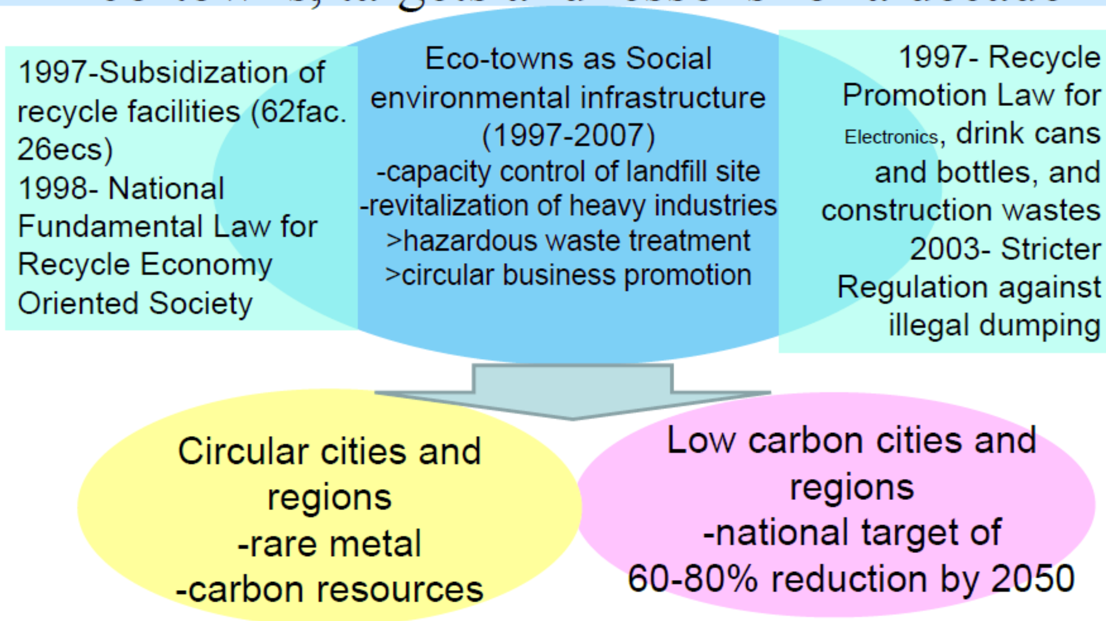
Eco-towns, targets and lessons for a decade



Eco-tows as driving engines for the sustainable urban regional management
-low carbon industrialization –regional material circulation
-urban and industrial revitalization

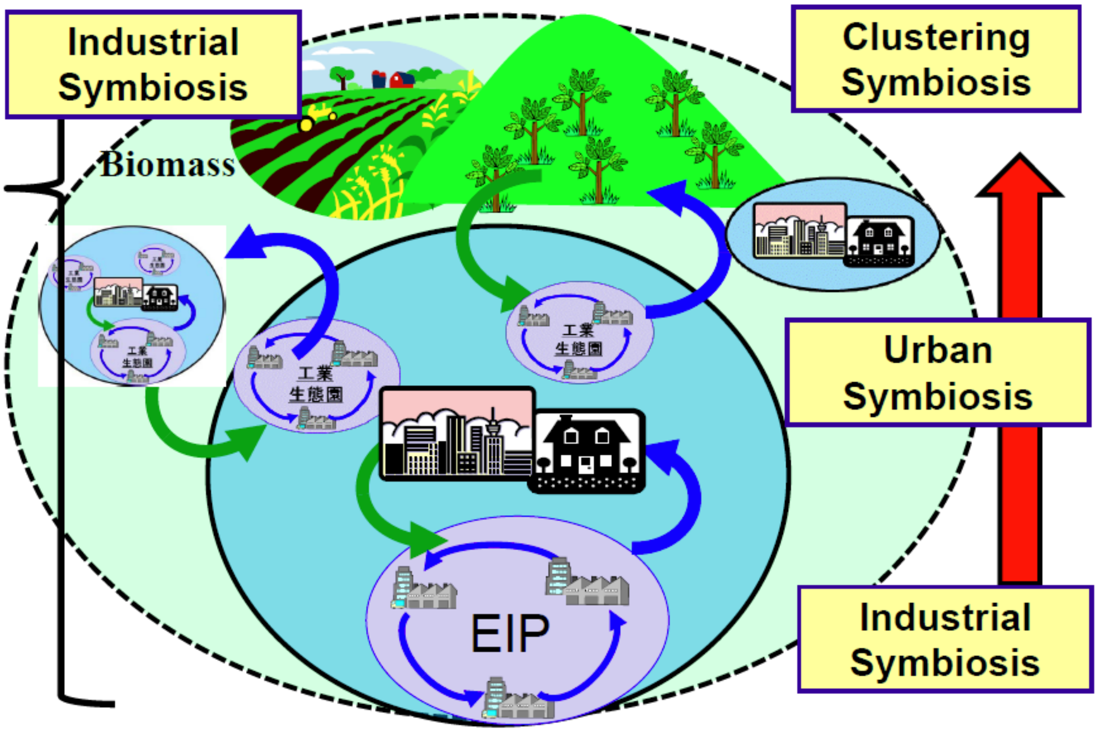
6

Challenges for Measuring the CO2 Reduction Effects of Industrial Symbiosis

- Data for technologies and material flow are limited
  - –EIPs came for the bottom up and company oriented collaboration
  - –Technology data base including alternative production and waste management
- Indirect and invisible effects of CO2 reduction of industrial symbiosis
  - – Baseline with alternative technologies
  - – Project boundaries are diversified for EIPs particularly for urban and regional symbiosis
  - –Substantial effects are from substituting crude

7

Industrial symbiosis, urban symbiosis, and clustering symbiosis



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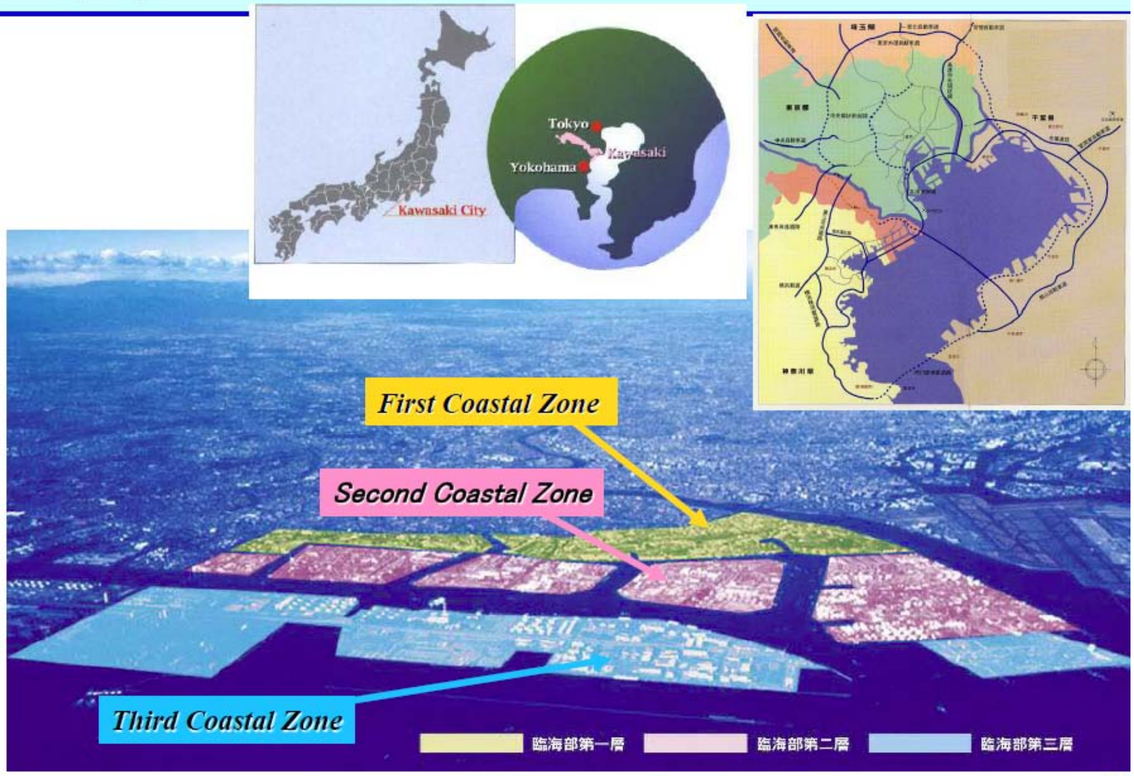
Kawasaki Eco-town as Urban Eco-industrial Parks

9

Geographical Conditions of Kawasaki Coastal Area



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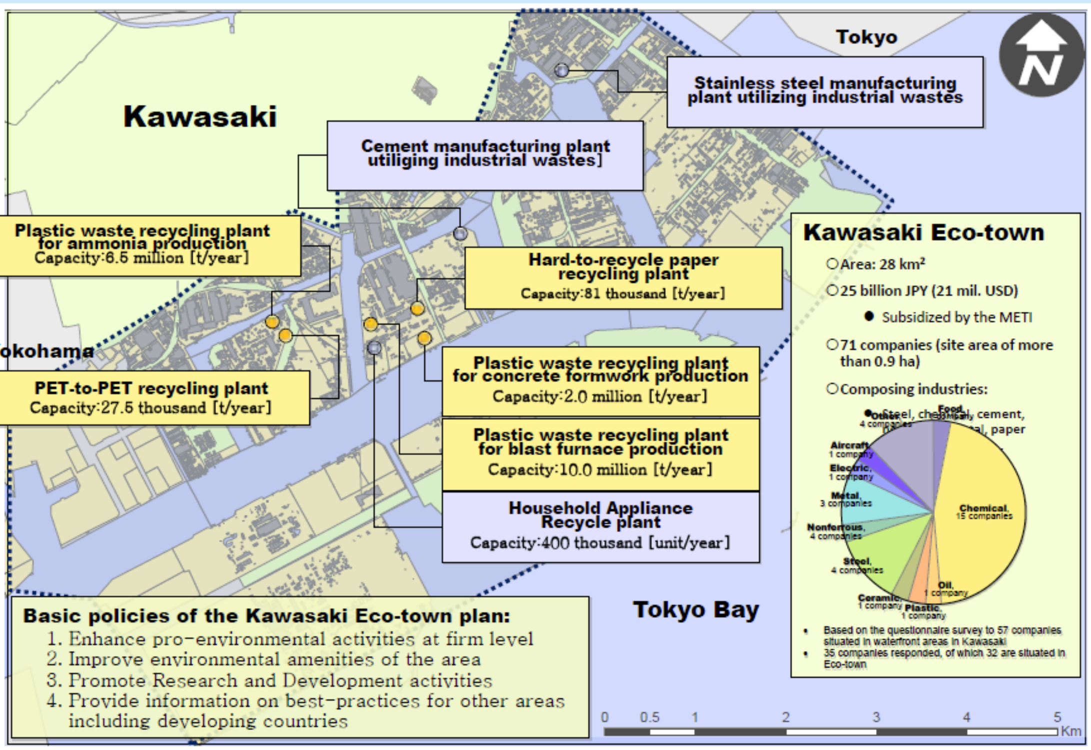
Major manufacturing/recycling plants of the Kawasaki Eco-town



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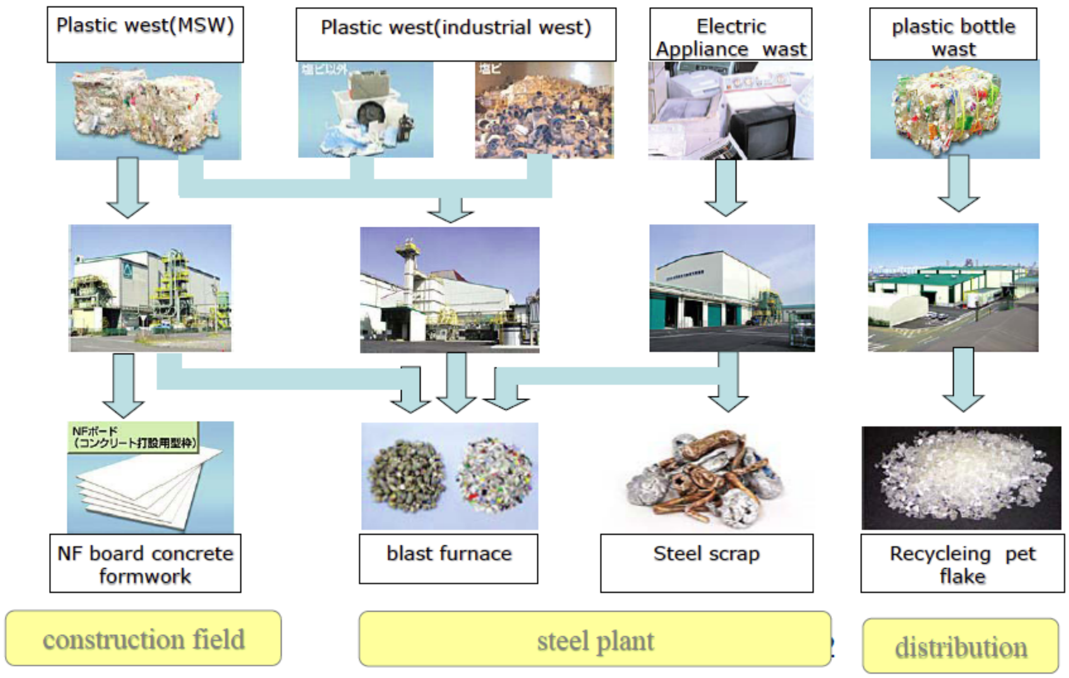
Symbiotic Technologies of Recycle Efforts by JFE-Group in Kawasaki



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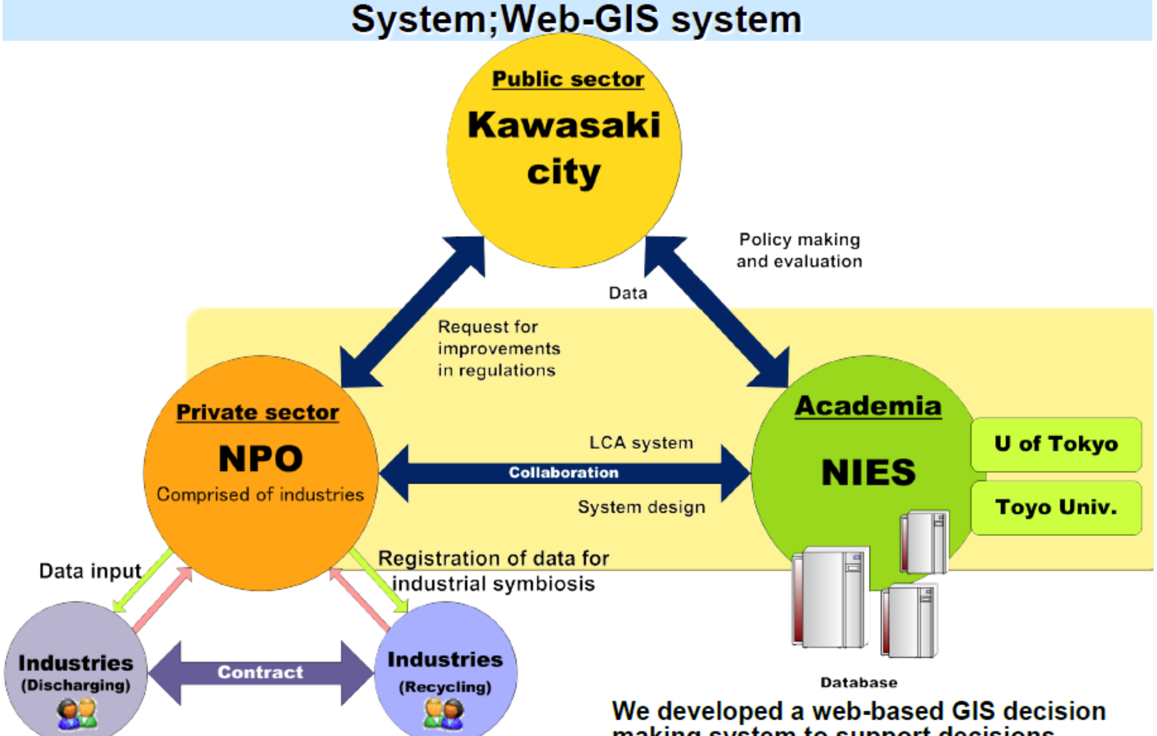
Cooperation scheme for the Environmental Information System;Web-GIS system



We developed a web-based GIS decision making system to support decisions made by corporate staffs who take charge of the management of production process

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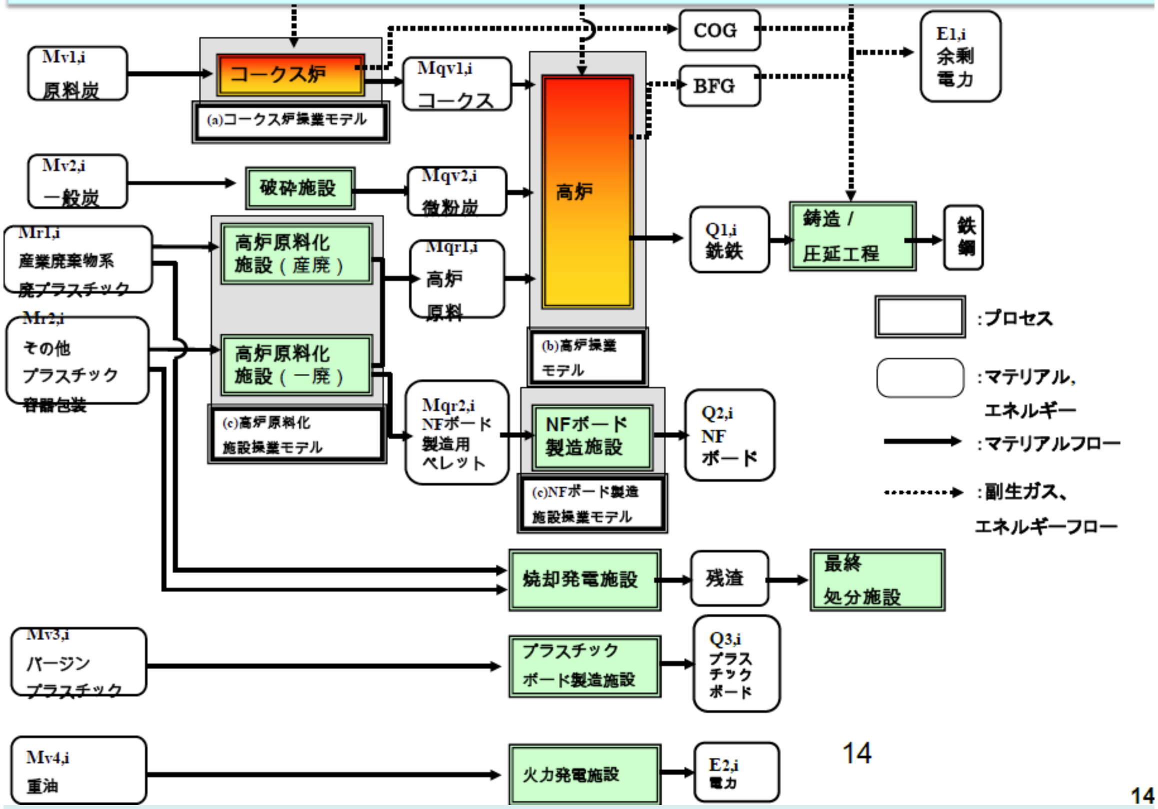
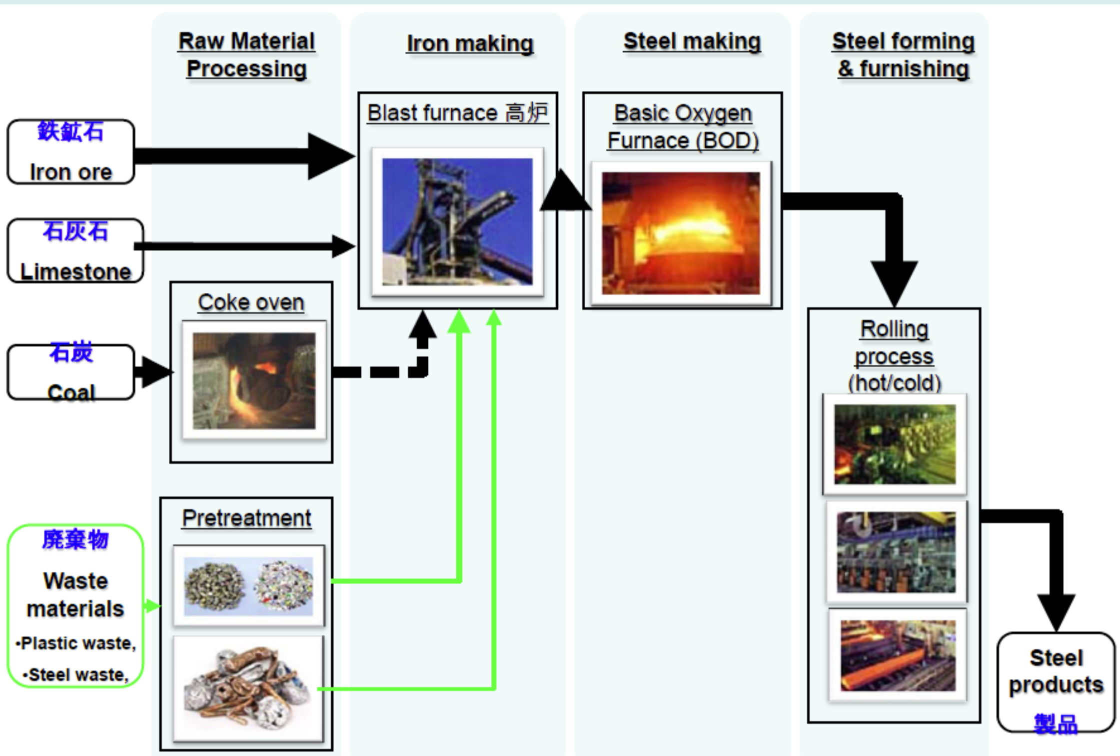
Quantitative information of recycling waste plastics



Manufacturing process of circular steel industry

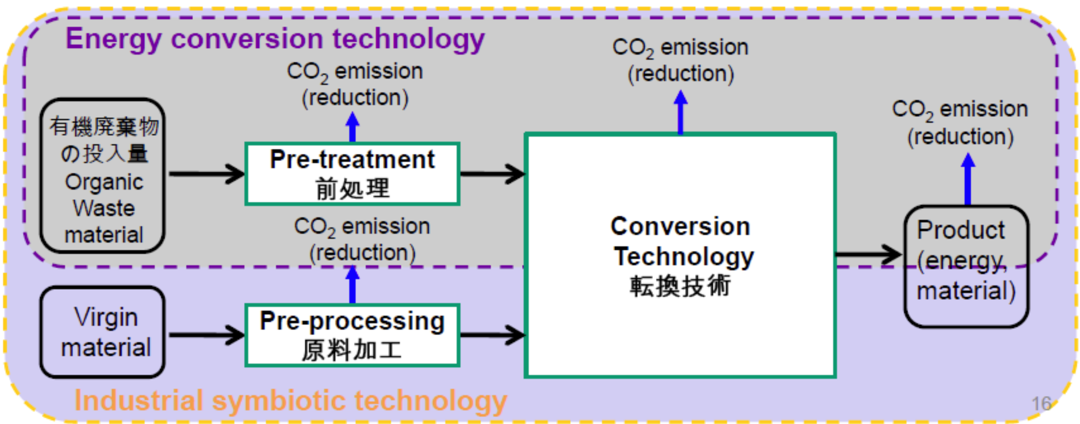


Definition of conversion technology production functions

In order to evaluate the effectiveness of conversion technologies, production functions were investigated and determined.

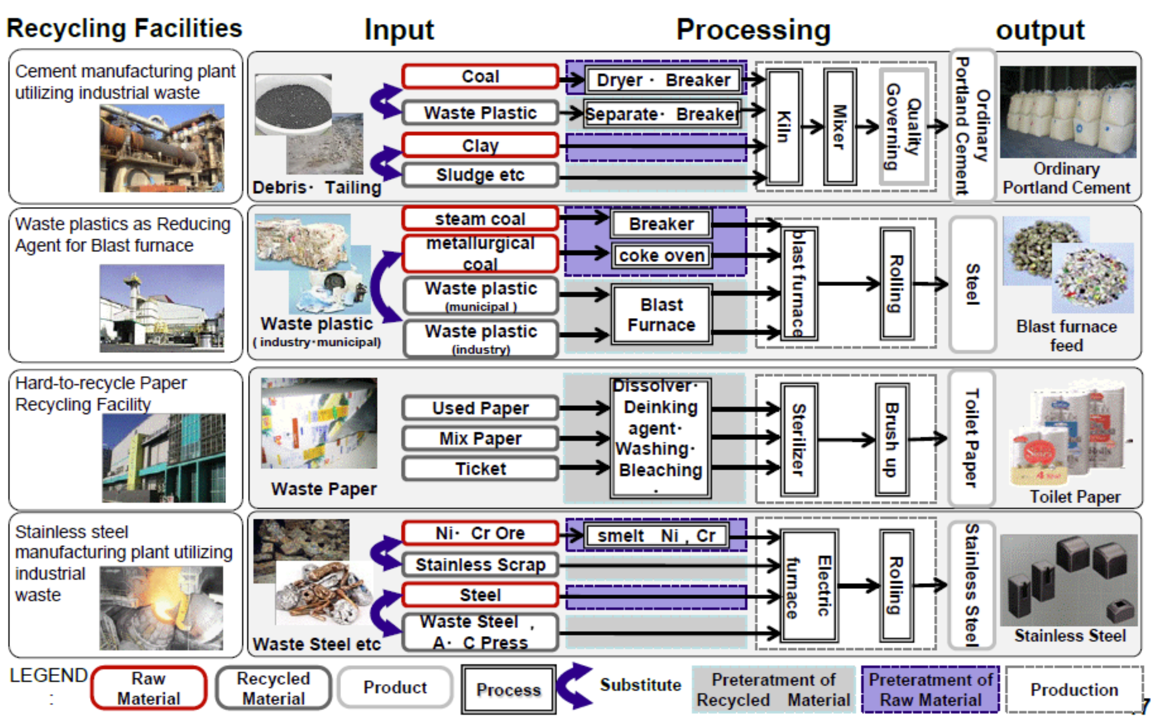
1. Energy conversion technology production functions
   Energy production per unit organic waste input was investigated.

2. Industrial symbiotic technology production functions
   Total CO_2 emission reduction (total energy consumption reduction) per unit organic waste material input was investigated.



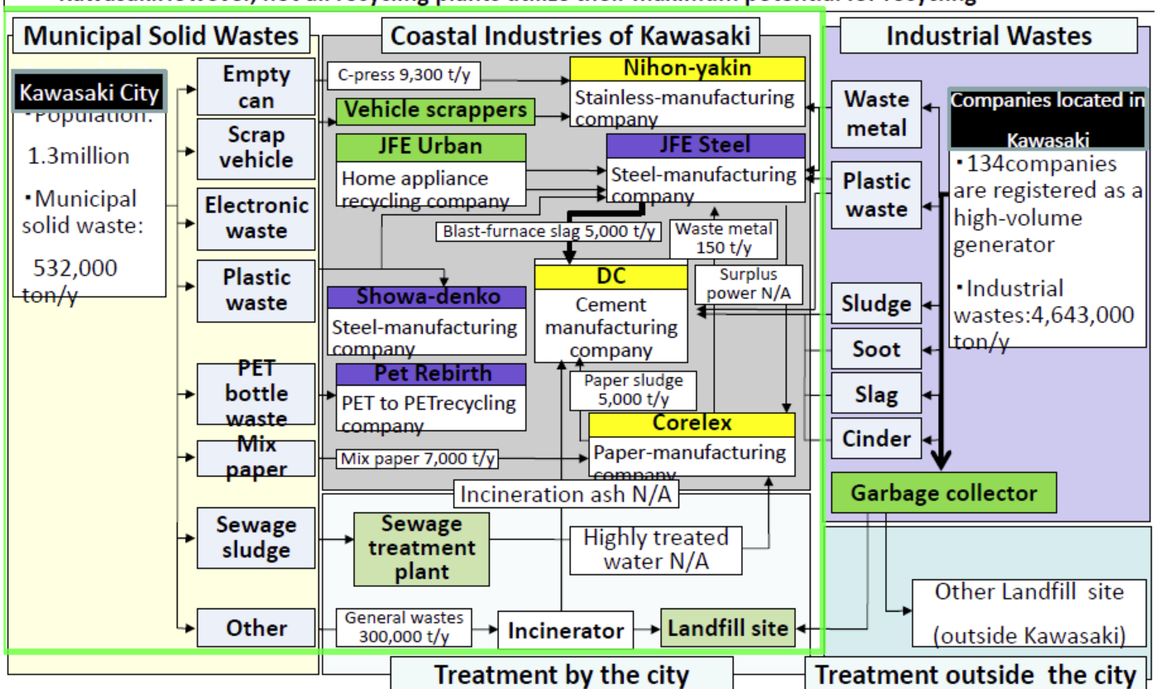
Quantified material accounting for Symbiosis in Kawasaki

R.V. Berkel and T. Fujita et. al.; Environmental Science & Technology , Vol.43, No.5, pp.1271-1281,0129.2009



Symbiotic synergy analysis of by-product exchanges in Kawasaki Eco-town

- **Both industrial and municipal solid wastes are utilized in manufacturing industries of KawasakiHowever, not all recycling plants utilize their maximum potential for recycling**



＊This figure was developed based on interviews to corporate and city officials

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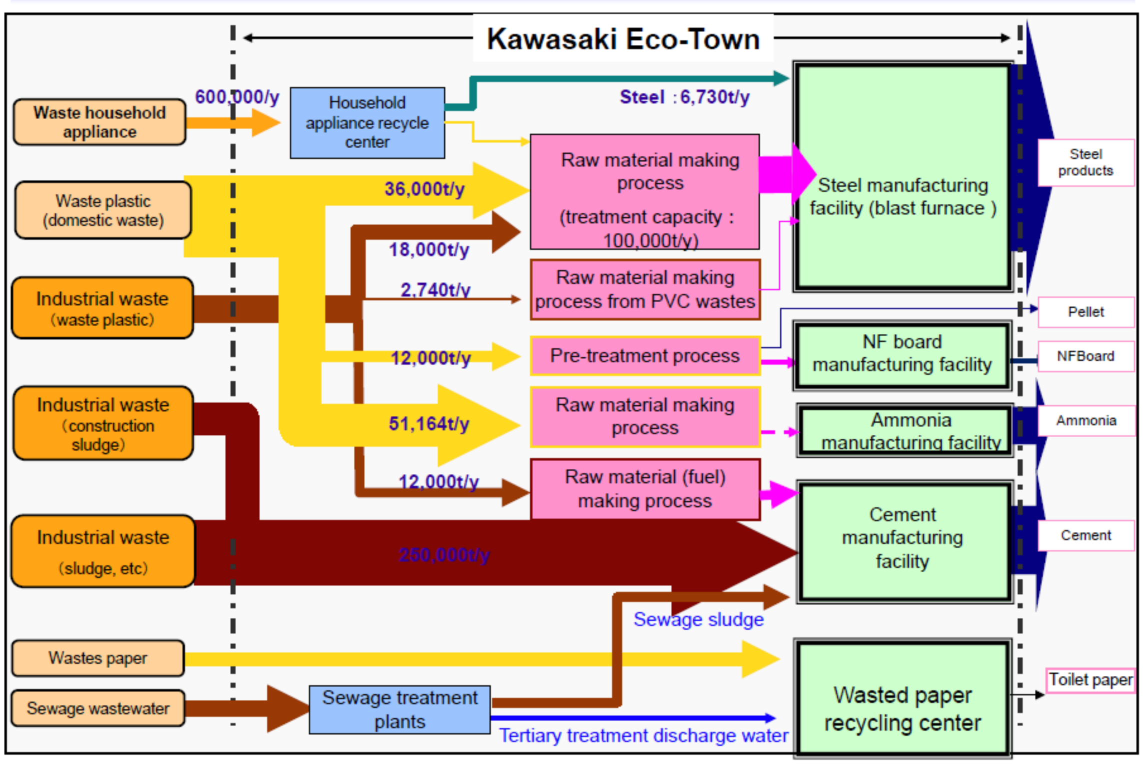
Material Flow in Kawasaki Eco-Town



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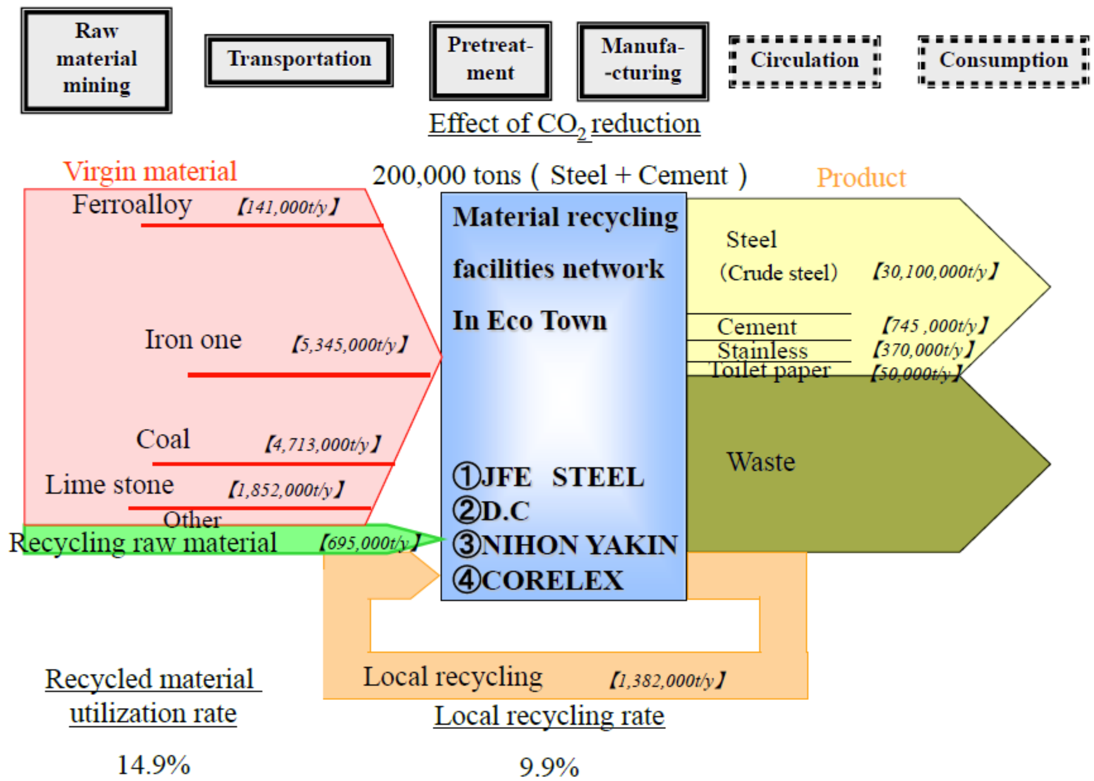
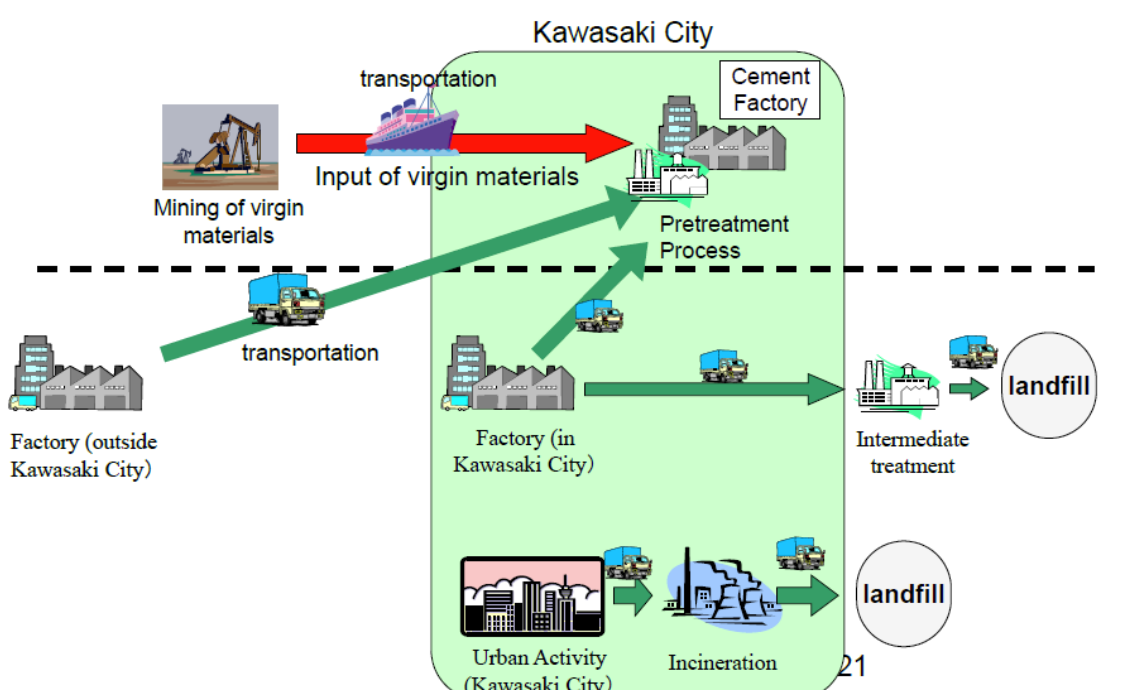
Material flow analysis of circular technologies in Kawasaki Eco-town



Material flow of industrial symbiosis in Kawasaki Eco-town (Present Condition)



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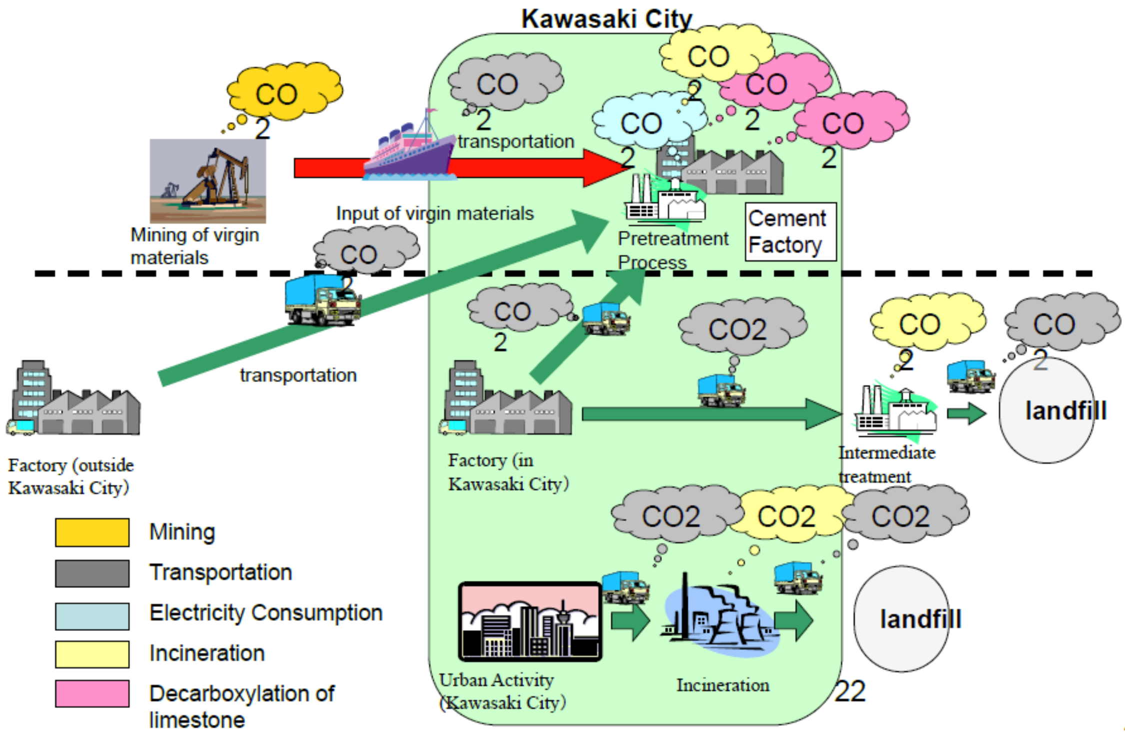
Evaluation of CO2



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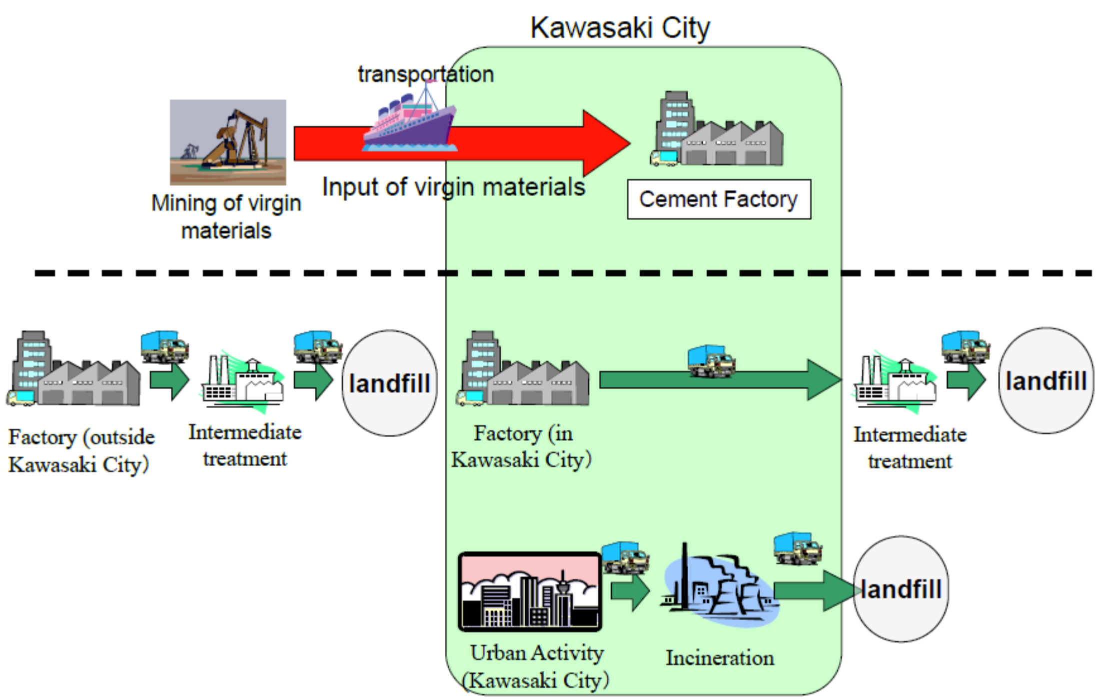
Material flow of industrial symbiosis in Kawasaki Eco-town (Base line Condition)



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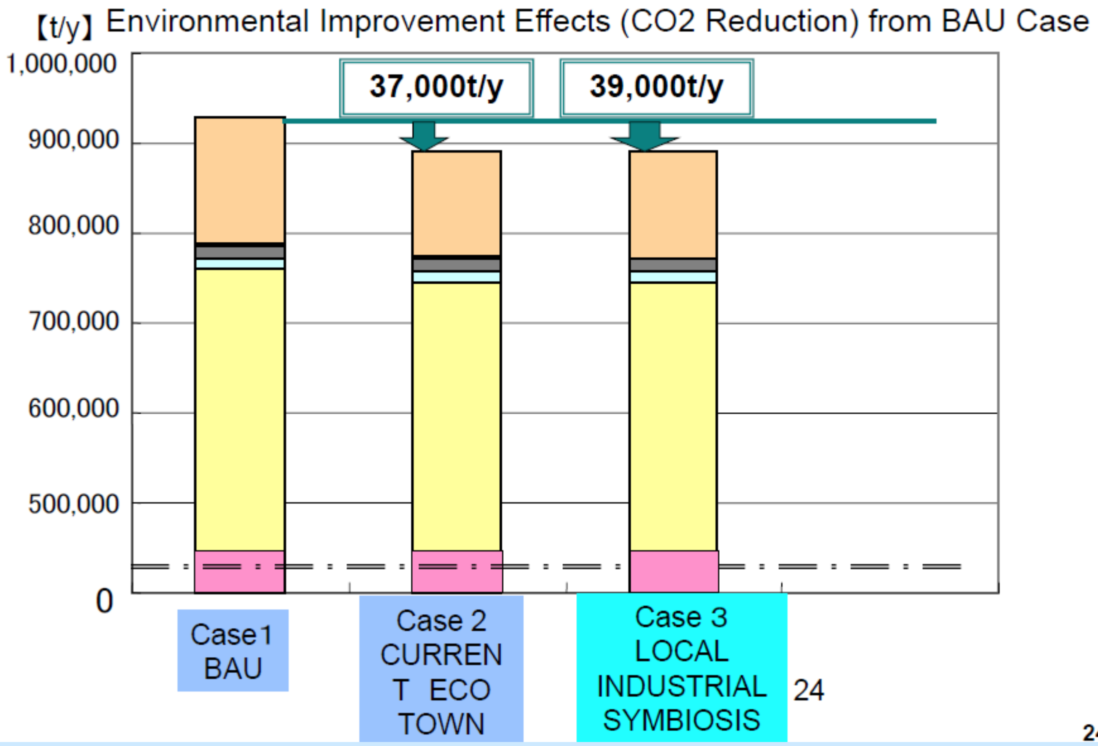
Evaluation of Local Industrial Symbiosis Effects



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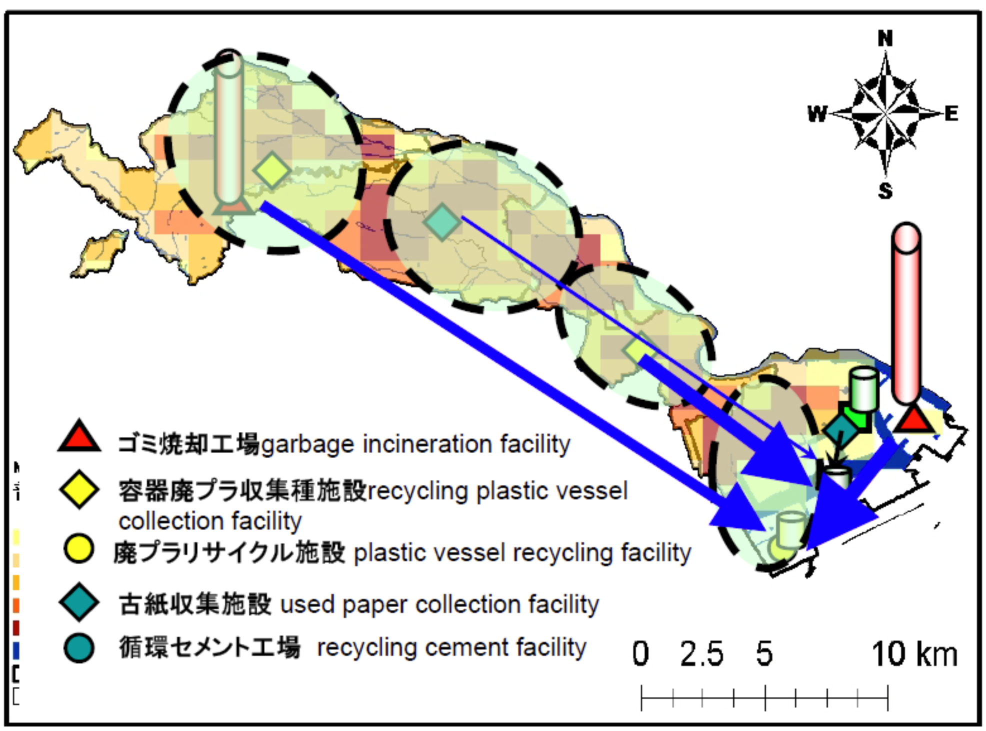
Urban resource recycling technology/policy simulation calculation



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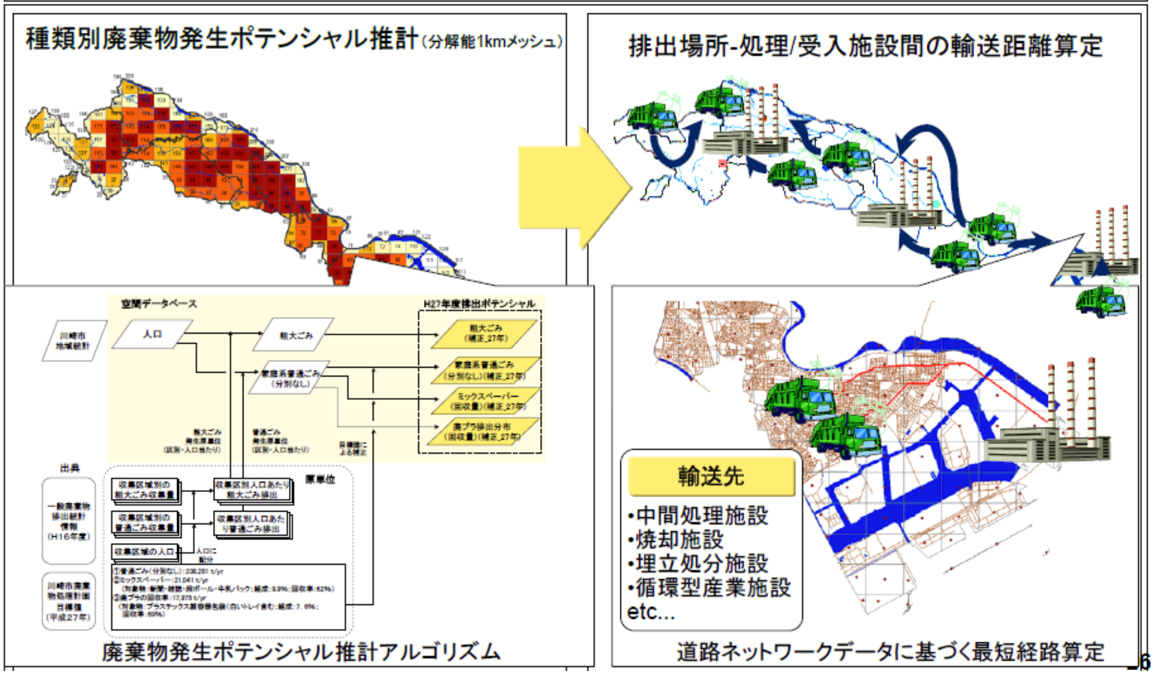
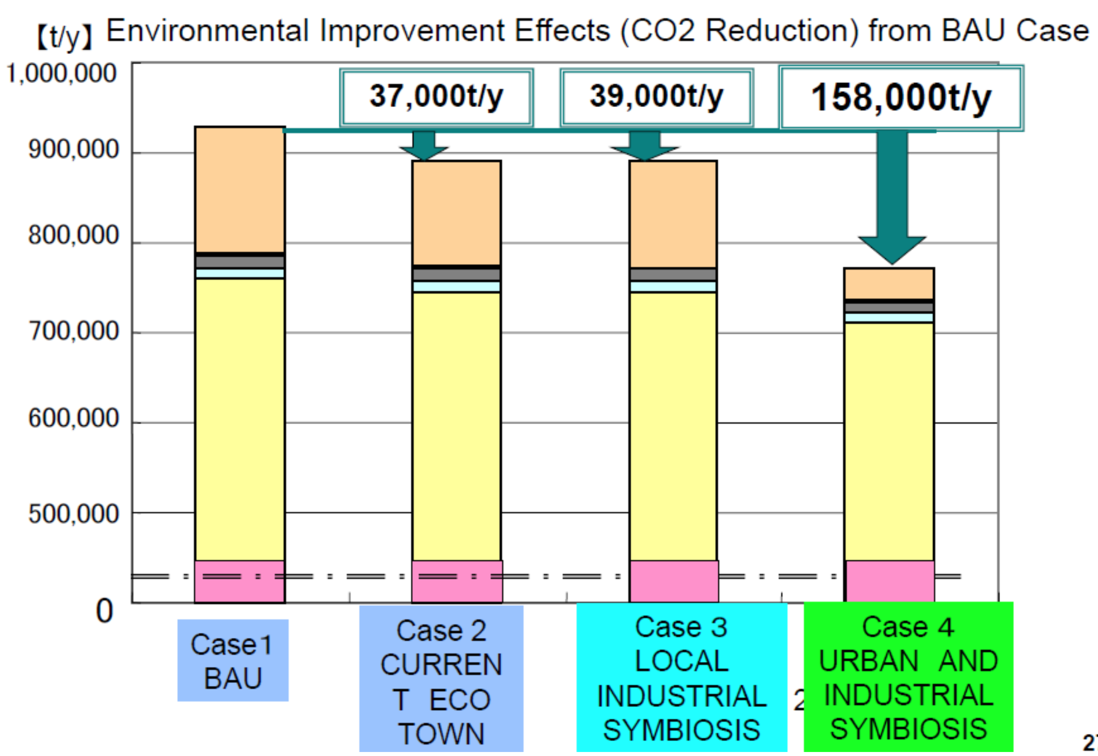
Transportation network analysis of urban symbiosis

○人口統計，廃棄物統計および建物用途データに基づき拠点都市における廃棄物資源の種類別発生ポテンシャルを1km分解能で算定
○各メッシュ（排出場所）から廃棄物の処理/受入施設間の輸送距離を，道路ネットワークデータに基づく最短経路問題として算出→廃棄物資源輸送負荷算定に活用



Evaluation of Local Industrial Symbiosis Effects



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Alternative Symbiotic Facilities in Kawasaki Eco-town

Incinerators	Separation types				Scenarios adopted
Continue with 4 plants					Case 1-0
	Mix paper				Case 1-1
		C&P plastic wastes			Case 1-2
			Food wastes		
	Mix paper	C&P plastic wastes			Case 1-3
	Mix paper	C&P plastic wastes	Food wastes		Case 1-4
	Mix paper	C&P plastic wastes	Food wastes	Incineration ash	
Reduced to 3 plants	Mix paper	C&P plastic wastes			Case 2-1
	Mix paper	C&P plastic wastes	Food wastes		Case 2-2
	Mix paper	C&P plastic wastes	Food wastes	Incineration ash	Case 2-3

Scenarios were tailored combining the number of incinerators and separation types of non-industrial wastes, and hearing opinions of city officials who are in charge of waste management

*C&P plastic represent plastics provided by the Containers and Packaging Recycling Law

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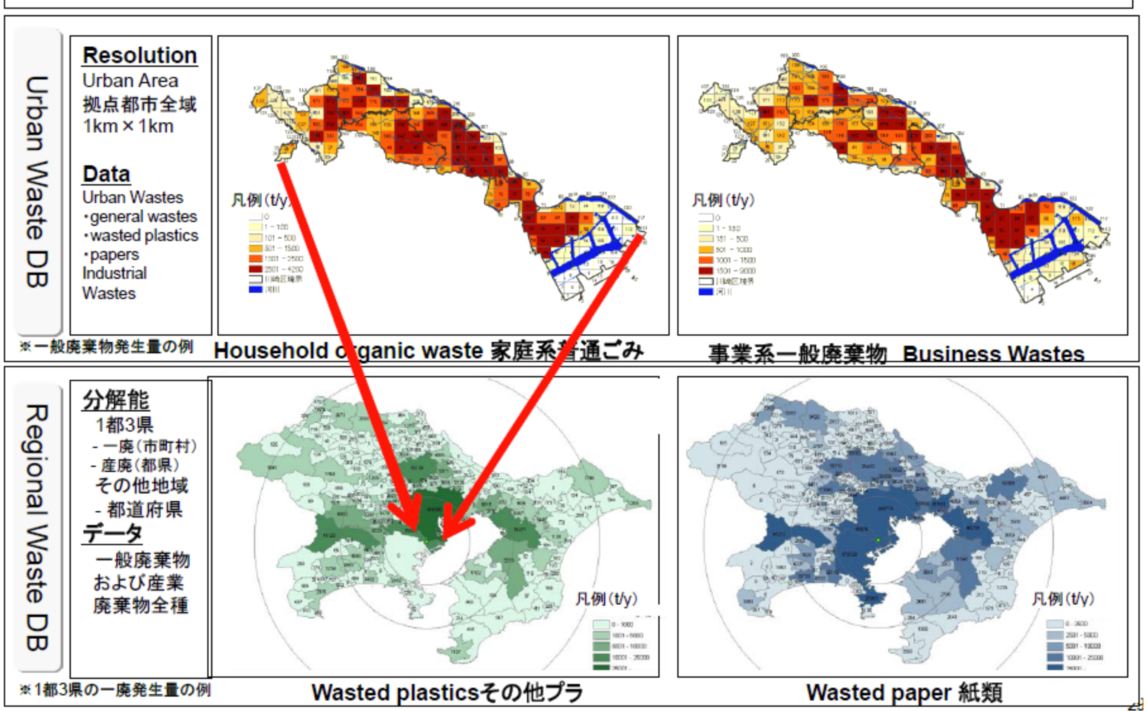
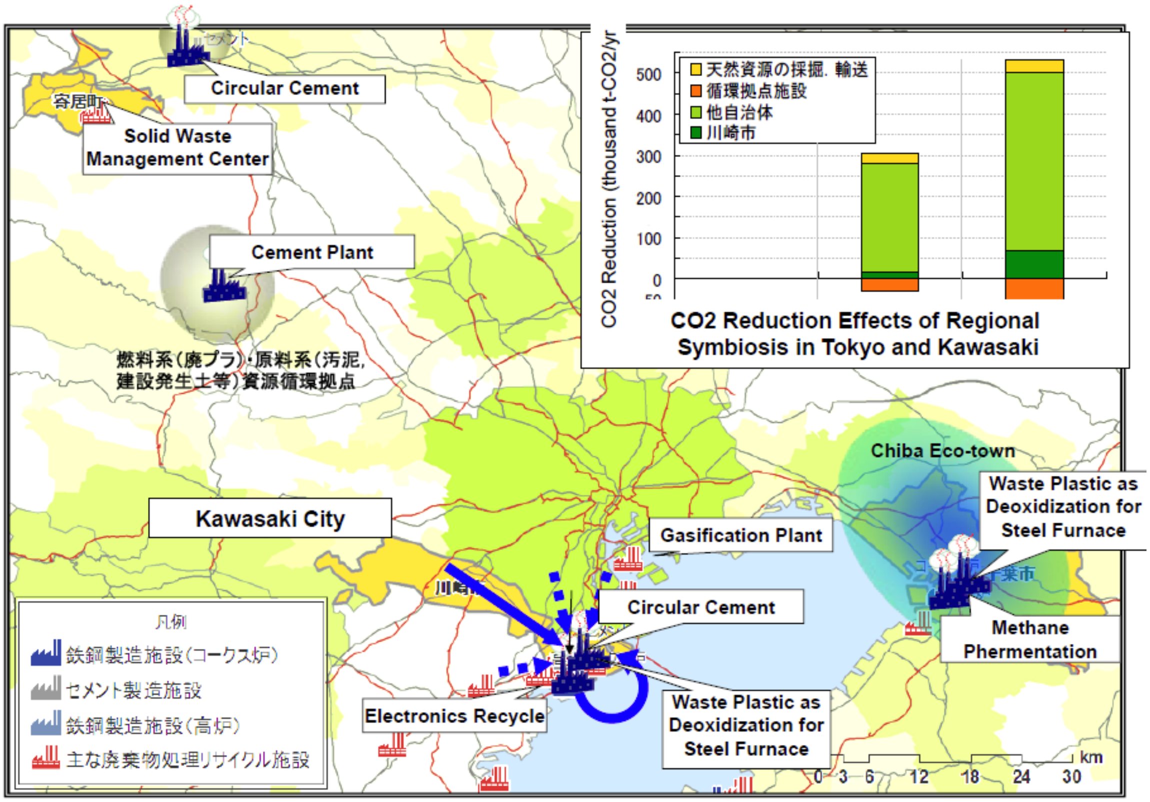
Multi-Scale Circular Material GIS Data base System

○Focal City (Kawasaki);1km grid solid waste generation estimated from urban activities
○Surrounding Region; Urban and industrial solid waste generation from municipalities





Coming Challenges for Quantification of Industrial Symbiosis

- Boundary condition for quantifying industrial symbiosis effects extensively rather than narrowly.
- Rational and agreeable principle or rule to allocate carbon credits from industrial symbiosis actions among by-product emitter, symbiotic conversion facilities, and users for recycled material and products.
- Scientific theories and implementational evaluation need to be accumulated and politically utilized as inputs into the discussion for national low carbon strategies as international platform as well as for international discussion such as COP and UNFCC.

Thank you for your Attention

Data Processing Process of DMSP-OLS Nighttime Lights

The population density is estimated based on light data

Target area: Liaoning province
Version 2 DMSP-OLS Nighttime Lights (2001) was used

Extract China from Global DMSP data

↓ China is cut off from german

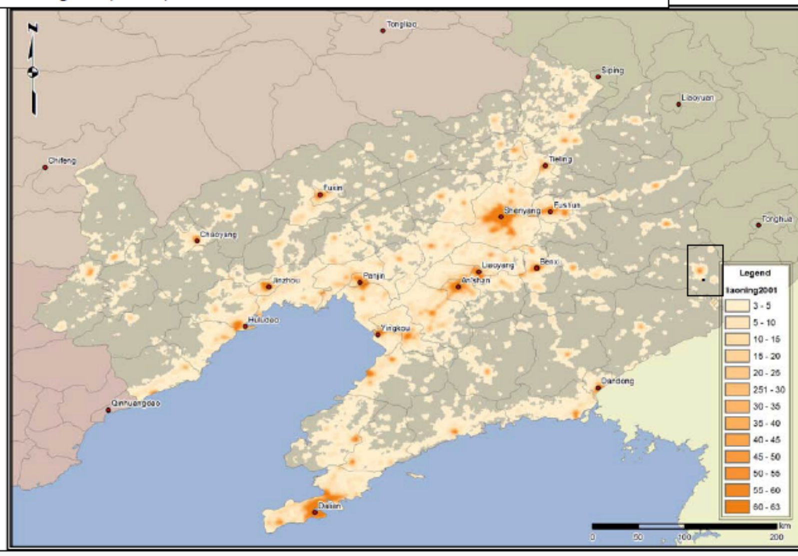
Area correction

↓ Eliminate north-south distortion

Extract Liaoning province from China

↓

Derive cummulative value of DMSP-OLS by administrative units

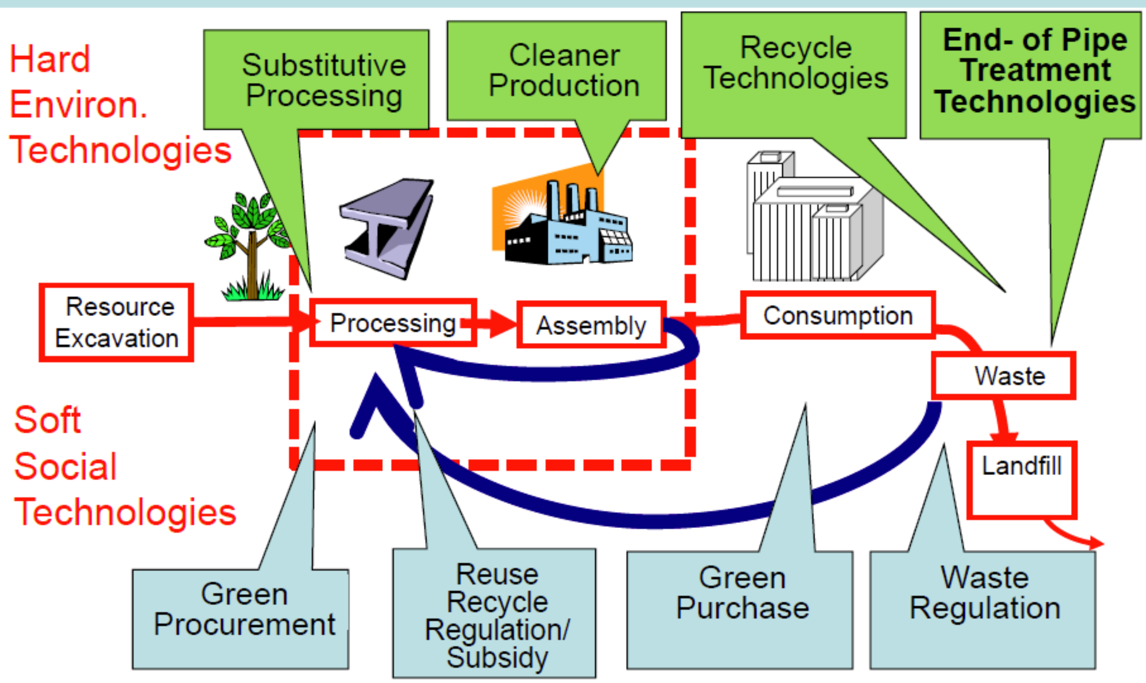


DMSP-OLS Nighttime Lights:

- Data is obtained with DMSP OLS (Operational Lines can System) sensor which can generate visible and infrared imagery of 30 seconds resolution
- Ephemeral events, such as fires have been discarded as errors
- Data value of each gird ranges from 1 to 63 depending on its intensity

→DMSP-OLS Nighttime Lights imagery is often utilized in population estimation for developing worlds where demographic statistics with high spatial resolution do not exist

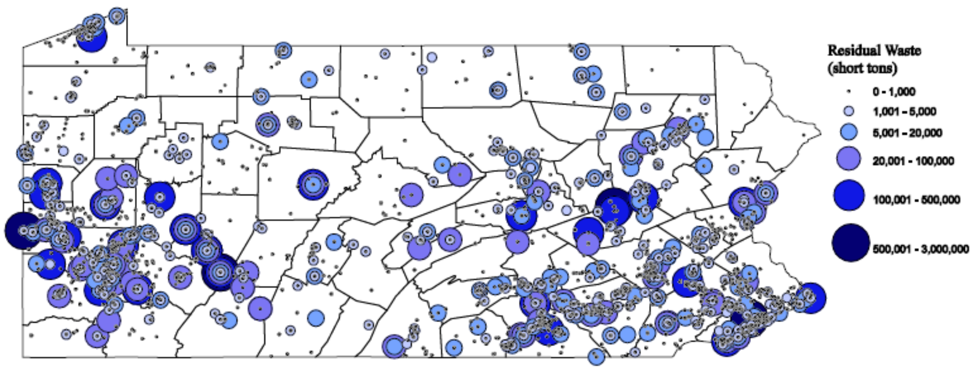
Alternative technologies for circular economies; resource circulation



3. Quantifying Energy and Environmental Benefits of Secondary Material Use in Pennsylvania (Matthew Eckelman, Yale University, New haven, USA)

Matthew Eckelman is a doctoral student in environmental engineering and works with the Center for Industrial Ecology at Yale University. His research examines the life cycle environmental impacts of complex industrial systems and the material requirements and constraints to sustainability in urban and island areas. He is also part of a green engineering firm that consults with a range of businesses and organizations on environmental issues. Prior to this, Matthew worked with the Massachusetts State Executive Office of Environmental Affairs and Design that Matters, a non-profit product design company, and was a Peace Corps science instructor in southern Nepal for several years. He received his B.A. in physics and mathematics from Amherst College.

Quantifying Energy and Environmental Benefits of Secondary Material Use in Pennsylvania, USA



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
CENTER FOR INDUSTRIAL ECOLOGY
Environmental Engineering

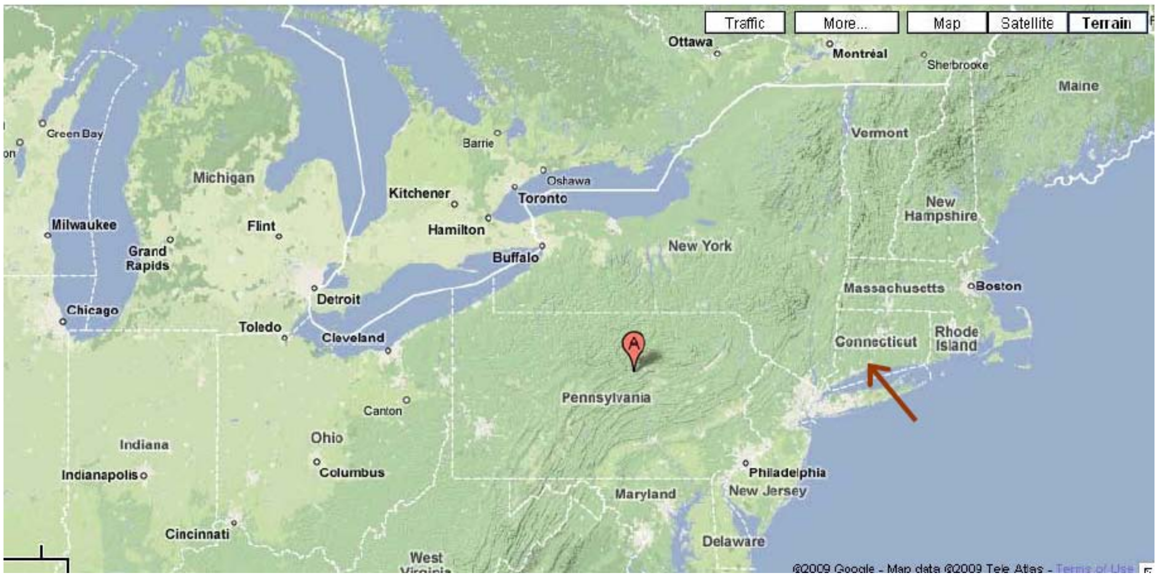
Matthew Eckelman
with Marian Chertow

Yale University

reported in *Environmental Science & Technology*, **2009**, 43 (7), pp 2550–2556

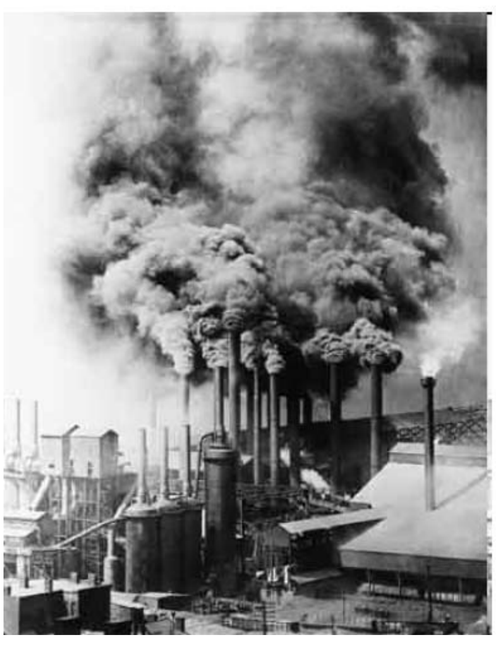
Where in the world is Pennsylvania?

'Virtue, Liberty, and Independence'



Industry in Pennsylvania

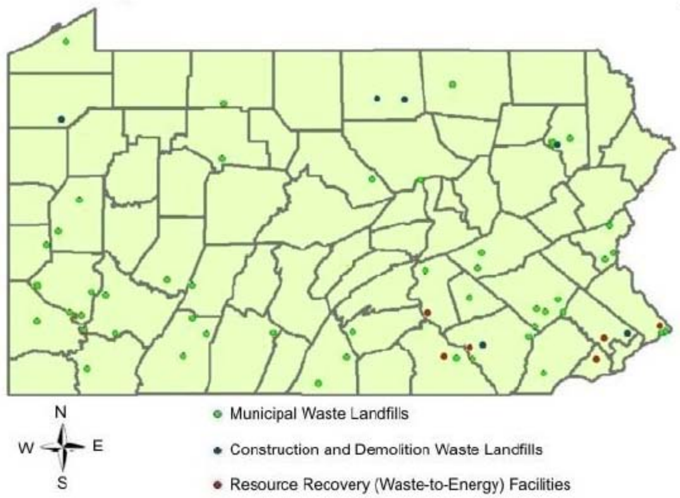
Coal, steel, and everything in between



Downtown Pittsburgh, as seen from the Liberty Tunnels (from the south)

Industry in Pennsylvania

Collapse, recovery, and diversification



Still generates plenty of waste, much of which is landfilled

Non-hazardous Industrial (*Residual*) Waste:

Overlooked but Dominant

- "The Other 96%" - J. Dernbach 1993
- No current estimate, since mid-1980s, of the amount of non-hazardous industrial waste generated, reused or disposed in the U.S.
- This is the very waste from utilities, pulp and paper, food processing, and other industries that could be identified for industrial symbiosis
- Now we see that what PA calls "residual waste" can have significant value.

Pennsylvania Residual Waste Regulations

- PA requires generators who produce more than 13 tons/year of "residual waste" to report every 2-years: *Generator Name, ID, Address, NAICS code, RW code, Disposal Facility, RW in tons, Physical State, Destination Type*
- 111 residual waste codes, 13 destination (unit) types

1994 Pennsylvania Residual Waste Biennial Report Data

SORTED BY GENERATOR NAME

COMMONWEALTH OF PENNSYLVANIA,
DEPT. OF ENVIRONMENTAL PROTECTION,
[illegible] DIV. OF REPORTING & FEE COLLECTION [illegible]

RESIDUAL WASTE GENERATOR NAME	GENERATOR ID NUMBER	ADDRESS	CITY	ZIP	COUNTY	RW CODE	NAICS CODE	DISPOSAL FACILITY ID	DISPOSAL FACILITY	DISPOSAL FACILITY CITY	DISP FAC STATE	RW QTY IN TONS	PHYSICAL STATE	UNIT TYPE
1015 REALTY CO INC	PARW00000036	1015 N MAIN AVE	SCRANTON	18508	LACKAWANNA	710	212	101247	KEYSTONE SANITARY LANDFILL		PA	39	S	05
3M BRISTOL PACKAGING SYSTEMS	PAD000766170	2201 GREEN LANE	BRISTOL	19007	BUCKS	207	267	MND006172969	3M COMPANY COTTAGE GROVE	COTTAGE GROVE	MN	5	L	12
3M BRISTOL PACKAGING SYSTEMS	PAD000766170	2201 GREEN LANE	BRISTOL	19007	BUCKS	210	267	PAD000429589	GROWS LANDFILL	MORRISVILLE	PA	38	S	05
3M BRISTOL PACKAGING SYSTEMS	PAD000766170	2201 GREEN LANE	BRISTOL	19007	BUCKS	211	267	MND006172969	3M COMPANY COTTAGE GROVE	COTTAGE GROVE	MN	1	SL	02

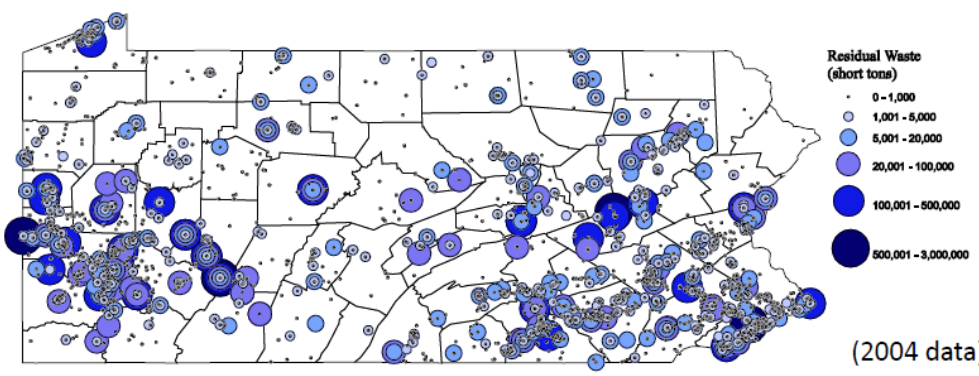
Destination Type

Code	Description
1	Composting Facility
2	Incinerator
3	Industrial Kiln
4	Underground Injection Well
5	Landfill
6	Land Application
7	Surface Impoundment
8	Other (Specify in comments)
9	Recycler/reuser
10	Wastewater Discharge to a Publicly Owned Treatment Works (POTW) or natural body
11	Wastewater Receiving Onsite Treatment Followed by Discharge Under NPDES Permit or to POTW
12	Treatment
13	Storage (onsite only)

For an Industrial Ecologist, the PA RW Database:

- Offers the most complete picture in the U.S. of management of non-hazardous industrial wastes.
- Provides data that could lead to market development for a stronger loop-closing economy.
- Suggests a long-term path to eco-restructuring of industrial activity.

Pennsylvania Residual Waste Generators



(2004 data)

Research Question:

How significant are the energy and environmental benefits of residual waste reuse and recycling activities?

Quantification of IS benefits

- IS researchers have a depth of knowledge approximately equal to that of LCA practicioners
- Supplements the quantitative work on cost savings that many IS projects have undertaken
- Several examples worldwide, and more to come
  - NISP
  - Puerto Rico
  - Kawasaki

Destination Type

Code	*Description*
1	**Composting Facility**
2	Incinerator
3	**Industrial Kiln**
4	Underground Injection Well
5	Landfill
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11	Wastewater Receiving Onsite Treatment Followed by Discharge Under NPDES Permit or to POTW
12	Treatment
13	Storage (onsite only)

Steps of the life cycle assessment

1 *Disaggregate residual wastes by type*

		1994		2004		Difference	
RW Code	RW Type	Tons	%	Tons	%	Tons	%
420	Process Wastewaters (Non-Haz)	587,575,003	84.5%	253,688,931	59.9%	-333,886,072	-56.8%
421	Contaminated Non-Contact Cooling Waters	70,156,379	10.1%	146,954,514	34.7%	76,798,135	109.5%
901	Auto Shredder Fluff	6,863,698	1.0%	58,281	0.0%	-6,805,417	-99.2%
201	Water Treatment Plant Sludge/Sediment	5,032,094	0.7%	3,614,500	0.9%	-1,417,594	-28.2%
002	Coal-Derived Fly Ash	4,021,384	0.6%	3,991,099	0.9%	-30,285	-0.8%
213	Lime-Stabilized Spent Pickle Liquor	3,343,138	0.5%	69,514	0.0%	-3,273,624	-97.9%
001	Coal-Derived Bottom Ash	2,705,037	0.4%	1,652,726	0.4%	-1,052,311	-38.9%
999	Other	2,521,628	0.4%	12,137	0.0%	-2,509,491	-99.5%
003	Flue Gas Desulfurization Residue (Fgd)	2,198,635	0.3%	3,573,399	0.8%	1,374,764	62.5%
430	Food Waste	1,540,008	0.2%	149,468	0.0%	-1,390,540	-90.3%
902	Non-Hazardous Residue From Treatment Of Hazardous Waste	1,258,620	0.2%	109,605	0.0%	-1,149,015	-91.3%
102	Slag	1,127,461	0.2%	1,183,770	0.3%	56,309	5.0%

Steps of the life cycle assessment

2 *Determine appropriate substitutions and allocation for each waste type*

Table 1. Current substitution of specific secondary non-hazardous industrial materials for virgin materials in Pennsylvania in 2004 (>1,000 metric tons current reuse)

Industrial Byproduct	Can substitute for	Current Use ('000 tons)	Total Generation ('000 tons)	% Current Reuse
Coal-derived bottom ash	Sand	1116	1499	74%
Coal-derived fly ash	Lime	1732	3621	48%
FGD residue	Gypsum	1435	3242	44%
Other ash	Sand	265	279	95%
Foundry sand	Sand	70	153	45%
Slag	Cement	362	1074	34%
Refractory material	Refractory material	7	45	16%
Ferrous scrap and dust	Virgin steel	49	117	42%
Non-ferrous scrap and dust	Virgin non-ferrous	6	20	31%
Water/ Wastewater treatment sludge	Compost	286	3787	8%
Food waste and sludge	Animal feed	256	340	75%
Oil/ Oily sludge	Fuel/ Engine oil	62	380	16%

many assumptions embedded here

Steps of the life cycle assessment

3 *Use LCIA databases to calculate the net unit environmental benefits of each substitution*

Material / *Byproduct*	Primary Energy GJ/ton	Emissions GHG kg CO_2eq/ton	SO$_2$ kg/ton	NO$_x$ kg/ton
Sand	0.03	2.4	0.02	0.02
Lime	0.3	19	0.11	0.13
Gypsum	0.03	2.1	0.04	0.08
Cement	2.7	762	1.22	1.43
Slag cement	*1.9*	*446*	*0.80*	*0.90*
Refractory material	22.8	2307	6.23	5.63
Steel	23.9	3934	0.73	2.38
Ferrous dust/ scrap	*13.1*	*822*	*1.60*	*0.81*
Copper/Aluminum/Lead/Zinc	56.1	5101	49.53	27.07
Non-ferrous dust/ scrap	*19.3*	*1524*	*13.01*	*6.48*
	36.8	**3577**	**36.52**	**20.59**

LCI data taken from:

- Ecoinvent (*most materials and substitutions*)
- GREET (*metals and transport, cross-checked*)
- U.S. Dept. of Energy (*fuels*)

Steps of the life cycle assessment

4 *Multiply unit benefits by the total masses in each waste category*

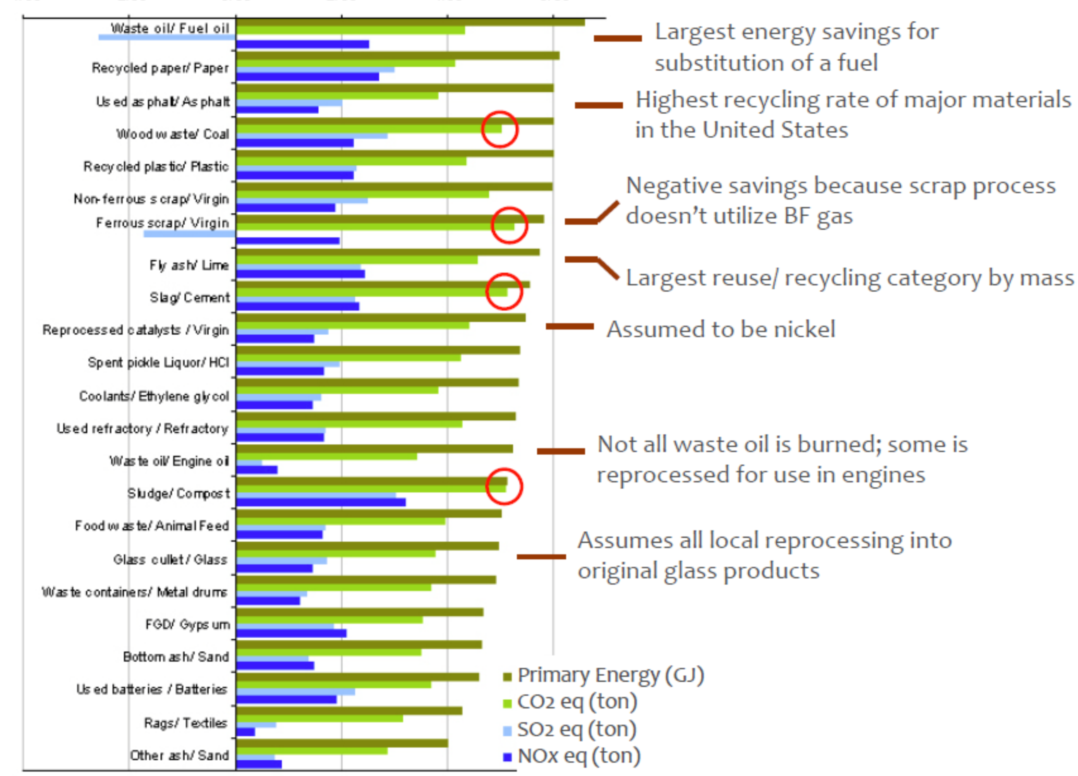
Non-ferrous metals (impacts per ton substitution)

6,000 tons currently recycled

X (20,000 tons potentially recyclable)

221 TJ	*21,462 t*	*219 t*	*124 t*	
primary energy	*CO_2 eq* 36.8	3577 *SO_2 eq*	36.52 *NOx eq*	20.59

Results for Current Reuse



Total results

Net energy and environmental savings

Current Savings

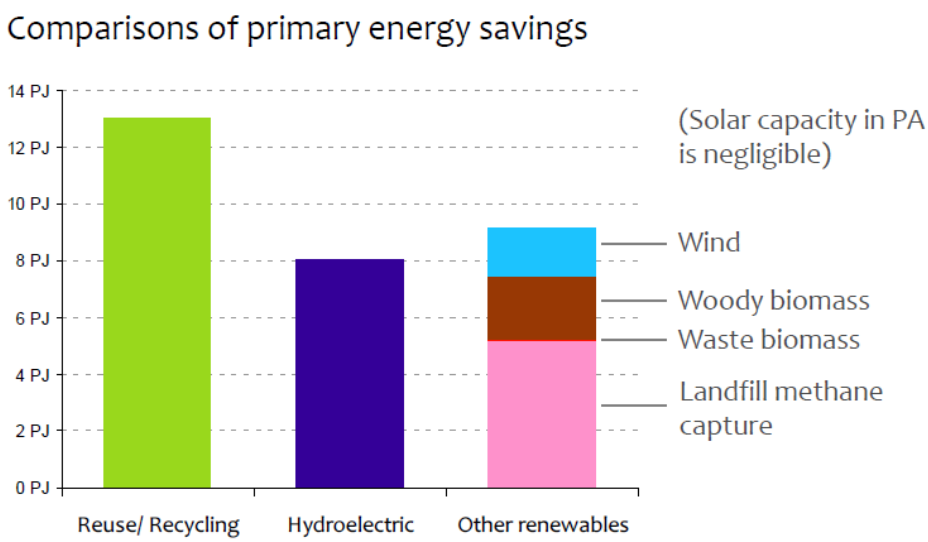
- **13 PJ** of primary energy (*compared to* ***1369 PJ*** *used by industry in all of PA*)
- **900,000 metric tons** of CO_2 eq (*or* ***0.6%*** *of the state industry total*)
- **4,300 metric tons** of SO_2 eq and **4,200 metric tons** of NO_x (*more than* ***2%*** *of the state total for the latter*)

Potential Savings

- **47 PJ** of primary energy and **3.6m metric tons** of CO_2 eq

Discussion Question:

What is an appoprIate context in which to consider energy and CO_2 results?



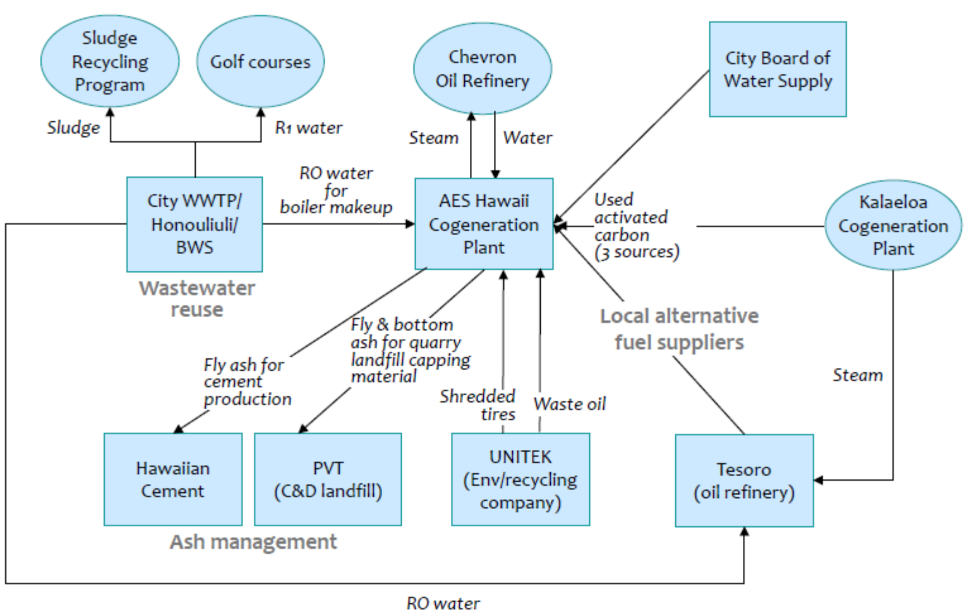
Issues with a regional analysis

(Weaknesses of the PA RW database)

- ***Substitution Definitions***
  Industrial waste substitute for different products and uses
- ***Allocation Questions***
  Necessary to allocate savings among several end-uses
- ***Overestimate or Underestimate?***
  Not all businesses that sell byproducts report to the database and not all industries are represented (-); Not all residual waste can actually be used, bringing down the potential results.
- ***Unknown Import / Export***
  Imports are not part of the residual waste database, and PA industries may be reusing/recycling more than we know
- ***Inappropriate Life Cycle Data***
  Most of the LCIA data were gathered from Ecoinvent and are not specific to Pennsylvania

Symbiosis at Campbell Industrial Park

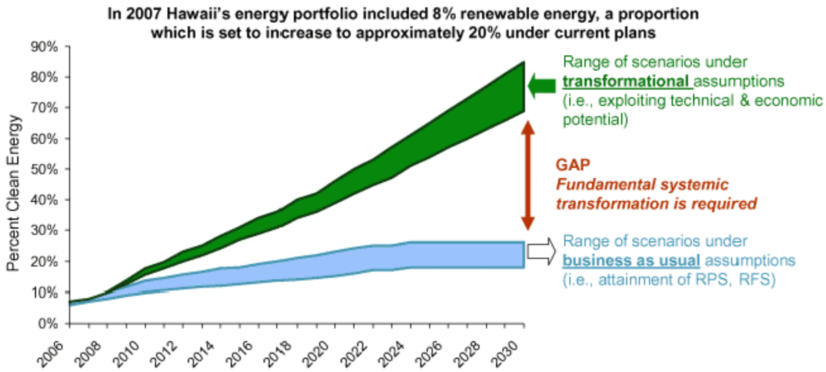
O'ahu, Hawai'i, United States



Discussion Question:

What is an appopriate context in which to consider energy and CO_2 results?

Hawaii needs to transition to an economy powered by clean energy, instead of imported oil…



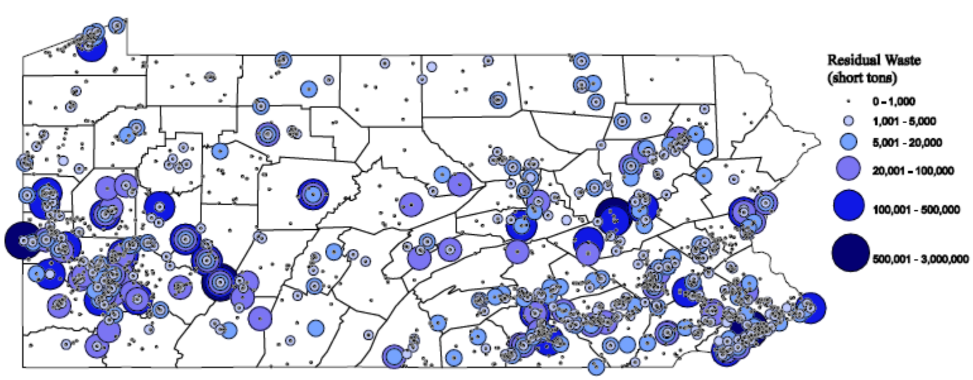
…but doing so will require a substantive transformation of regulatory, financial, and institutional systems

2

Discussion Question:

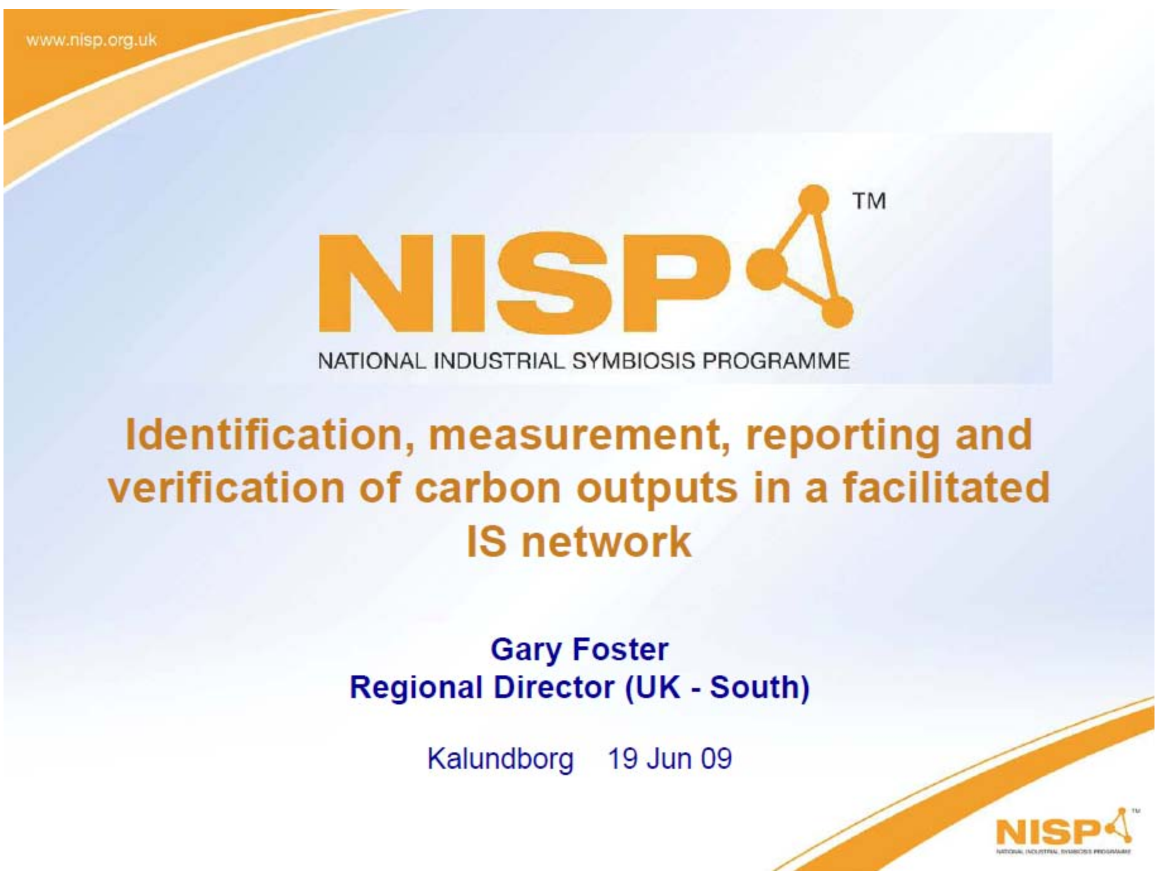
What is the goal of quantifying the environmental benefits of IS?

Many thanks for listening.



4. The Identification, Measurement, Reporting and Verification of Carbon Output in a Facilitated IS Network (Gary Foster, National Industrial Symbiosis Programme, Hampshire, UK)

Gary Foster is a Regional Director for the National Industrial Symbiosis Programme (NISP), having worked in the programme for the last 2 ½ years. He leads a team of practitioners covering the London, East of England and South East England regions. NISP specializes in identifying and facilitating attractive business opportunities that improve resource efficiency between organizations, and which also benefit the environment. The programme has thousands of members across the UK drawn from many different industries, and has a strong focus in the construction sector. It has a clear beneficial role to play in the current economic environment. Before joining NISP, Gary worked at the South East England Development Agency and the Carbon Trust for 4 years as a regional manager, promoting and managing low carbon resource efficiency projects to businesses across the South East region. He also has a background in international wind farm development, local authority energy management, and air engineering management from the Royal Navy.



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Contents of presentation

1. Introduction to NISP
2. Business drivers for carbon management
3. Identification of carbon reduction opportunities
4. Measurement and reporting of carbon emissions reductions
5. NISP Case studies
6. Verification of carbon emissions reductions
7. Conclusions

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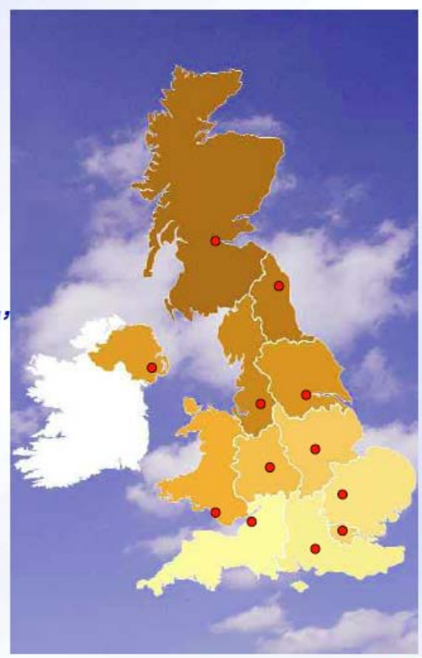
Regionally Delivered, Nationally Coordinated



'THE SECOND INDUSTRIAL REVOLUTION'

- Began as 3 regional pilots in 2002/3
- Now has 6 years practical experience
- World's first fully facilitated National Industrial Symbiosis Programme
- 12 regional offices across the UK
- 50+ NISP practitioners in place across all regions
- Funded by UK Government (Defra)

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NISP delivers …

NISP INCREASES

Jobs
Profits
Sales
Learning
Innovation
New business
Inward investment
Knowledge transfer
Utilisation of assets

NISP REDUCES

Use of virgin resources
Use of potable water
Hazardous waste
CO_2 emissions
Transport
Pollution
Landfill
Costs
Risk

NISP creates real business opportunities

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Programme Achievements so far…

Metric	Unit	Total to date
Landfill Diversion	Tonnes	5,222,384
Carbon Savings	**Tonnes**	**5,238,059**
Virgin Raw Materials	Tonnes	7,954,711
Hazardous Waste Savings	Tonnes	357,626
Water Conservation	Tonnes	9,469,738
Cost Savings to Busin		131,082,258
Increased Sales		1,097,919
Jobs Created		840
Jobs Saved		1,376
People Trained	Qty	3,602
Private Investment	£s	116,017,487

Over 1000 synergies completed across UK – over 67% have led to reduced carbon emissions

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The strength and impact of NISP

Substantial impact and value due to:

- Immense savings with **'embodied carbon' reductions.**
- **Experience and skill:**
  - We know where to look
  - We have learnt who best to work with
- We are very **'light touch'** – members do the work, we claim the benefit
  - Only facilitation, no time intensive consultancy
- **Independent verification** of outputs

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UK Drivers for 'Carbon Management' – NISP members

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Identification of carbon emissions opportunities

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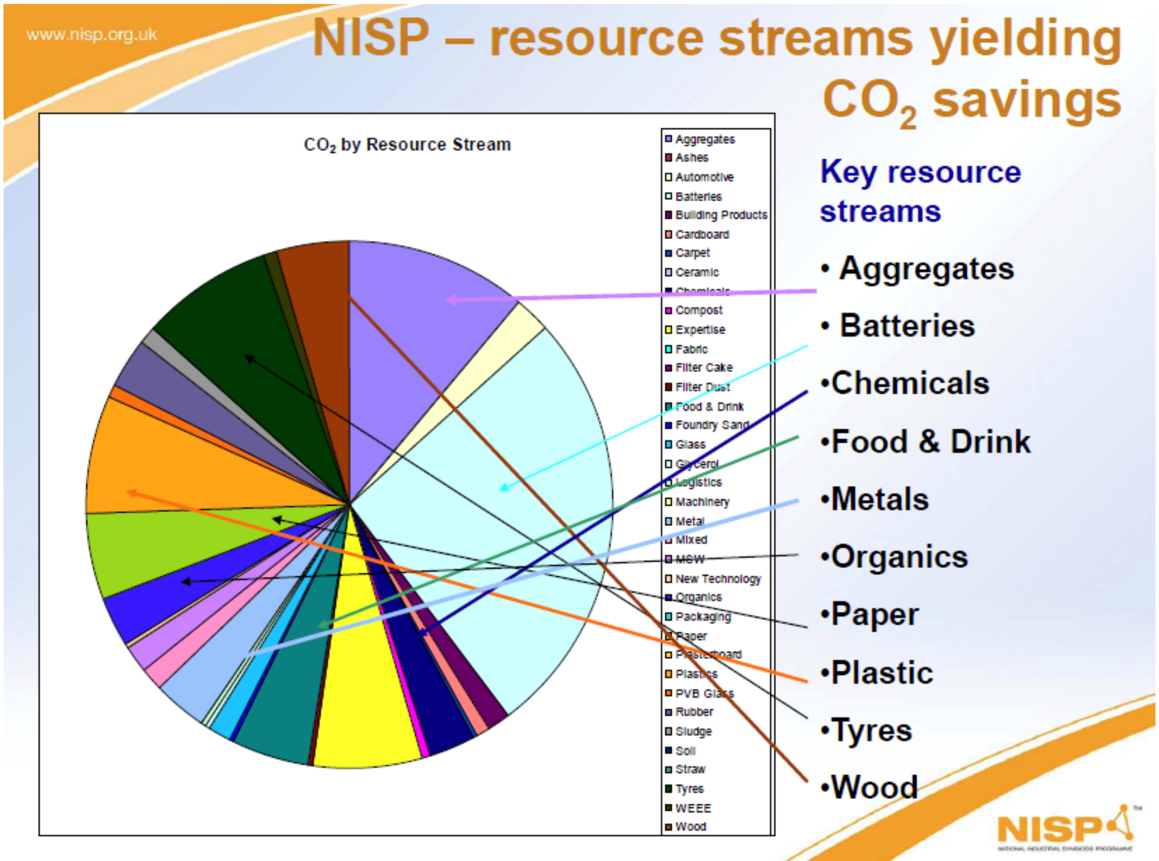
NISP East of England Construction and Utilities Workshop – 14 Jan 09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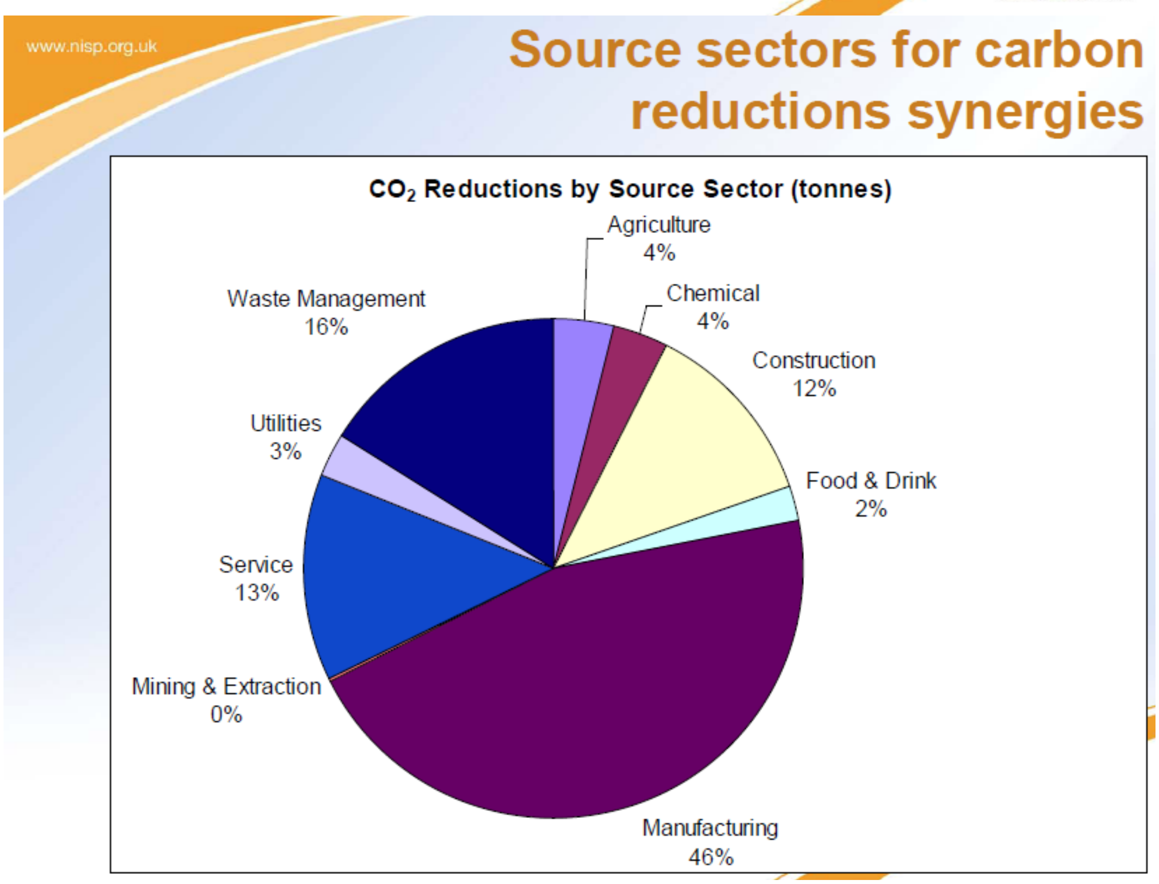
NISP – resource streams yielding CO2 savings
CO2 by Resource Stream
Aggregates
Ashes
Automotive
Batteries
Building Products
Cardboard
Carpet
Ceramic
Chemicals
Compost
Expertise
Fabric
Filter Cake
Filter Dust
Food & Drink
Foundry Sand
Glass
Glycerol
Logistics
Machinery
Metal
Mixed
MSW
New Technology
Organics
Packaging
Paper
Plasterboard
Plastics
PVB Glass
Rubber
Sludge
Soil
Straw
Tyres
WEEE
Wood
Key resource streams
• Aggregates
• Batteries
•Chemicals
•Food & Drink
•Metals
•Organics
•Paper
•Plastic
•Tyres
•Wood
NISP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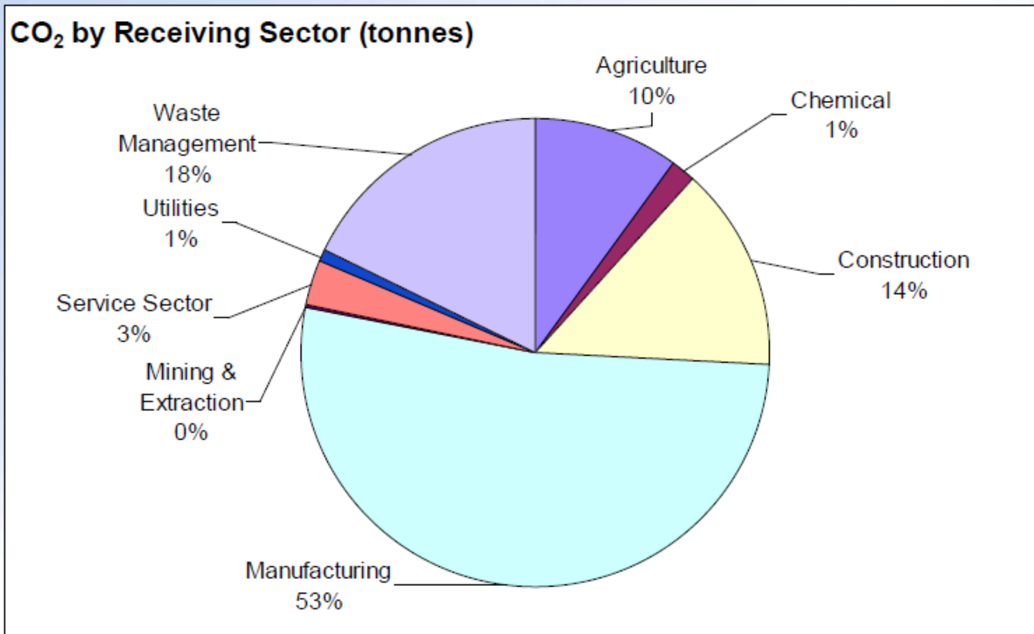
Source sectors for carbon reductions synergies
CO2 Reductions by Source Sector (tonnes)
Agriculture 4%
Chemical 4%
Construction 12%
Food & Drink 2%
Manufacturing 46%
Mining & Extraction 0%
Service 13%
Utilities 3%
Waste Management 16%

Receiving sectors for carbon reduction synergies



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Measurement and reporting of carbon emissions reductions

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Carbon accounting and reporting – practical issues

- Assessment boundaries 'Where to draw the line'
- Appropriate carbon emissions conversion factors
- Number of methodologies
- Expertise needed
- Availability of data
- Consistency of approach
- Accuracy
- Speed of calculation
- Attribution
- Verification

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NISP's accounting methodology

- Submitted and approved by DEFRA (UK)
- Use of average conversion factors - winners and losers – a balanced mix of over and under reporting
- Simple
- Comparable
- Less margin for practitioner error
- Fast
- Verified before being reported

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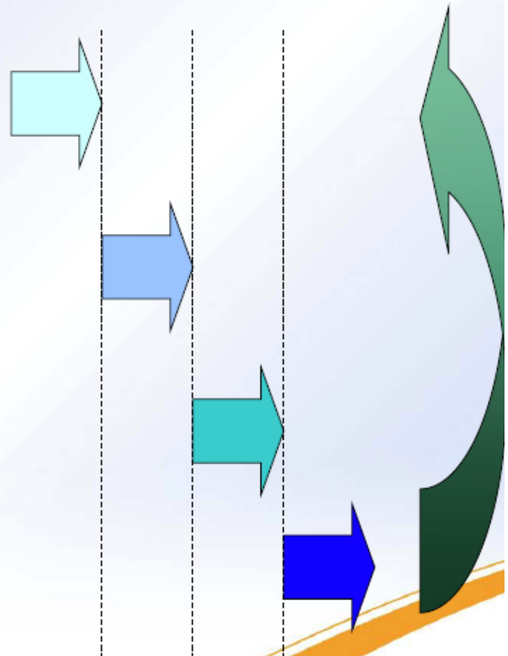
Types of carbon emissions savings

- **Input savings** – Lower embedded energy in recycled materials than virgin raw materials to be processed.
- **Process savings** – savings in gas, electricity or other fuel use by one of synergy partners
- **Transport savings** – reduction in transport directly associated with synergy
- **Disposal savings** – reduction in biodegradable material sent to landfill



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Input savings – conversion factors

Material	Embodied fossil energy (tonnes CO_2e saved per tonne of waste prevented)
Paper and card	2.556
Kitchen/food waste	2.428
Garden/plant waste	0.089
Wood	0.256
Textiles	19.294
Plastic (dense)	12.778
Plastic (film)	10.222
Ferrous metal	1.917
Non-ferrous metal (incl. Aluminium)	16.1
Silt/soil	0.004
Aggregate materials	0.102
Misc. combustibles	0.102
Glass	1.406
Estimated impact of materials not covered in ERM study (municipal and C&I)	2.86

[2] Defra (2007) Waste Strategy for England 2007 Annex A – Impact Assessment http://www.defra.gov.uk/environment/waste/strategy/strategy07/pdf/waste07-annex-a.pdf Last accessed 10/08/2007

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Process emissions savings – conversion factors

Fuel Type	Conversion factor (tonnes CO_2/kWh)
Grid Electricity	0.00043
Natural Gas	0.00019
Gas/ Diesel Oil	0.00025
Heavy Fuel Oil	0.00026
Coal	0.0003
LPG	0.00021
Coking Coal	0.0003
Jet Kerosene	0.00024
Ethane	0.0002
Naptha	0.00026
Petroleum Coke	0.00034
Refinery Gas	0.0002

[1] Carbon Trust Energy Conversion factors http://www.carbontrust.co.uk/resource/conversion_factors/default.htm Last accessed 10/08/2007

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Disposal savings – conversion factors

Material	CO_2e saved per tonne of waste not landfilled (tonnes)
Paper and card	0.687
Kitchen/food waste	0.258
Garden/plant waste	0.135
Wood	0.298
Textiles	0.233
Plastic (dense)	0.01
Plastic (film)	0.01
Ferrous metal	0.01
Non-ferrous metal	0.01
Silt/soil	0.01
Aggregate materials	0.01
Misc. combustibles	0.305
Glass	0.01
Estimated impact of materials not covered in ERM study (municipal and C&I)	0.081

- Note: the above are lifetime factors
- Need to convert to annual figure
- Apply decomposition half-life methodology and conversion factors
  - *contact NISP for more detail*

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Case studies

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NISP Carbon methodology- example

Thames Water – waste utility pipes (MDPE) plastics

150 tonnes of pipes diverted from landfill, sent for re-use/recycling.

CO_2 reduction calculations:

- Reduction in CO_2 = Reduction from use of virgin materials + reduction from Landfill Diversion.
- Reduction in CO_2 = (Tonnes x Embodied fossil Energy) + ((Tonnes x lifetime emissions) /2 / decomposing half life)
- Reduction in CO_2 = (150 x 12.778) + ((150 x 0.01)/ 2 / 7) = **1,916.7 + 0.107**
- Reduction in CO_2 (to nearest tonne) = **1,917 Tonnes**

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Case Study - Alternative recycled materials

Cambridgeshire Guided Bus-way with
BAM Nuttall & McGrath/Wastefile

- Alternative to virgin aggregate requested.
- NISP proposed tyre shred as an alternative
- McGrath introduced to BAM Nuttall/Wastefile via NISP
- 18,000 tonne of tyre shred used by BAM Nuttall
- Replication for Luton Guided Bus-way
- Winner of CIWM award - Construction and Demolition Product Use category

- **60,000m3 of drainage material**
- **Tyre shred used as alternative**
- **£100,000s cost saving**
- **c.6,000 tonne CO_2 saved**

Facilitated by NISP

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Case Study - Chemicals and food sector

NISP North East is working with members Terra Nitrogen (UK) Limited and John Baarda.

- Terra Industries Inc, - a leading international producer of nitrogen products and methanol.
  - Looking for alternative ways to use its by-products
  - Teamed up with Humberside fruit and vegetable grower John Baarda Ltd
  - To provide the infrastructure to supply and deliver utilities to the 38 acre site.
- The site will use more than 12,500 tonnes of CO_2, a by-product of Terra's nearby manufacturing site
- Steam from the plant will also be used to heat the greenhouses.
  - **65 new jobs created**
  - **Reduction of 12,500 tonnes of CO_2 emissions**
  - **Successful reuse of waste heat**
  - **£15 million private investment in region**

Introduced by NISP

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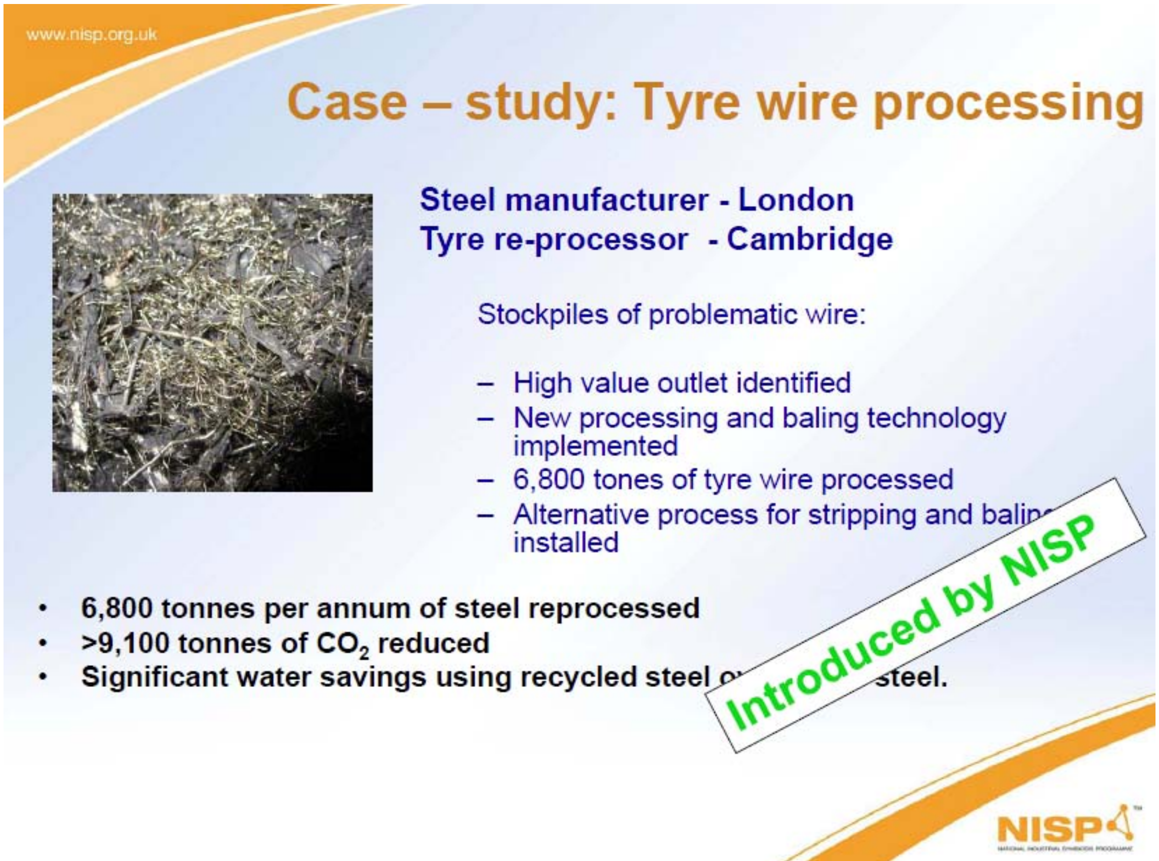
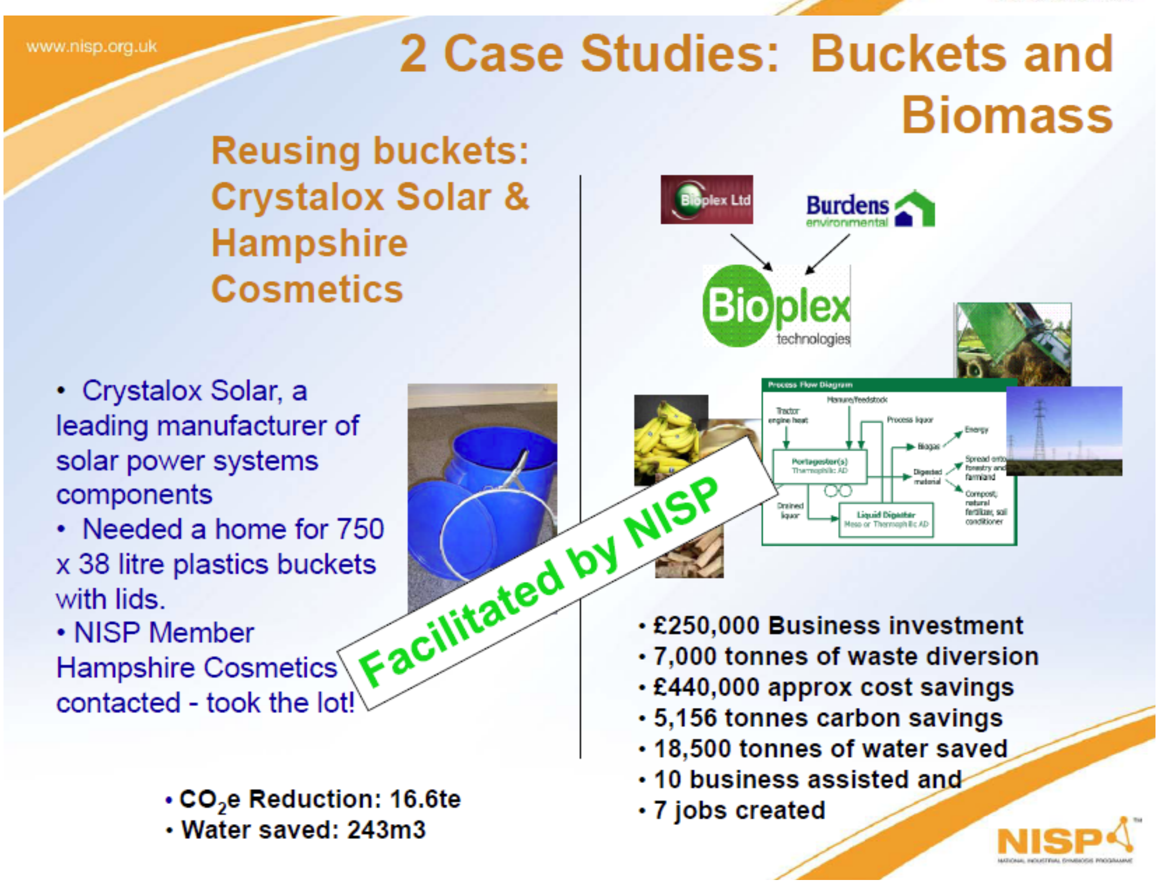
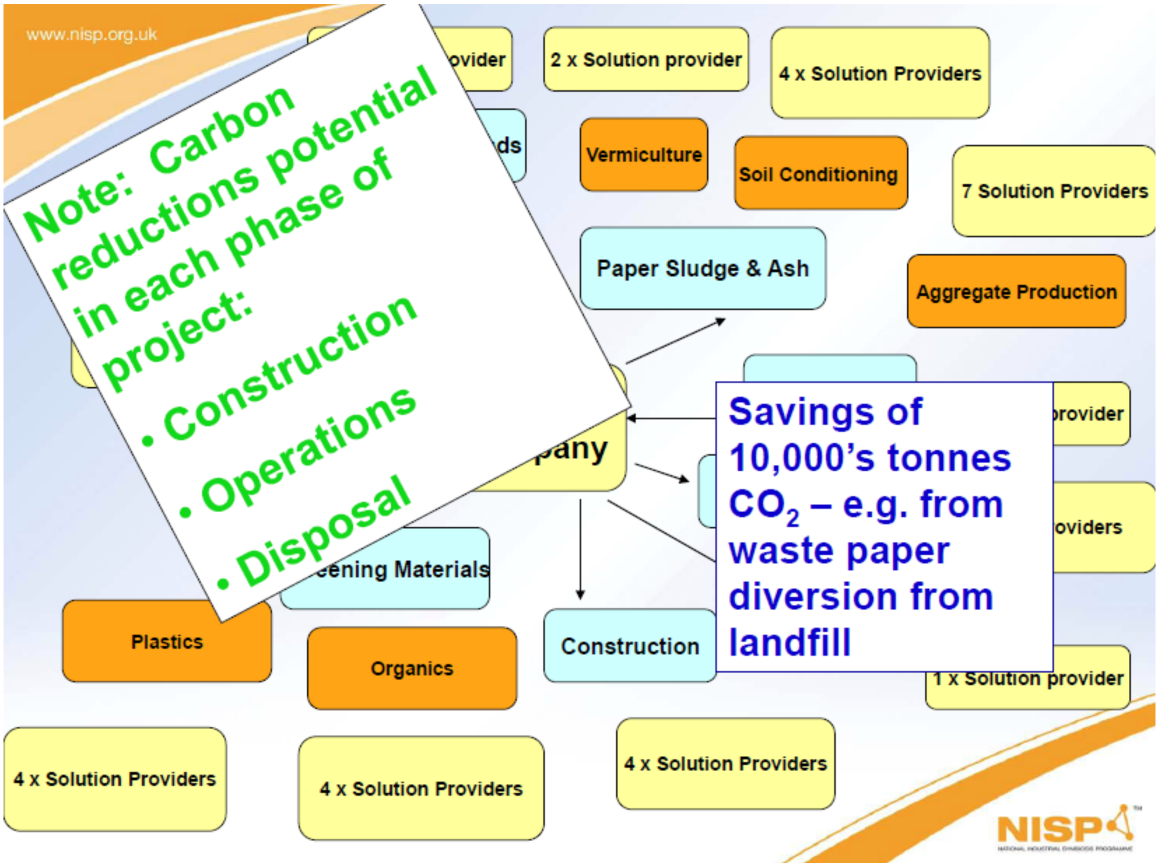

www.nisp.org.uk
Case – study: Tyre wire processing
Steel manufacturer - London
Tyre re-processor - Cambridge
Stockpiles of problematic wire:
– High value outlet identified
– New processing and baling technology implemented
– 6,800 tones of tyre wire processed
– Alternative process for stripping and balin
installed
• 6,800 tonnes per annum of steel reprocessed
• >9,100 tonnes of CO_2 reduced
• Significant water savings using recycled steel o
steel.
Introduced by NISP
NISP


www.nisp.org.uk
2 Case Studies: Buckets and Biomass
Reusing buckets: Crystalox Solar & Hampshire Cosmetics
• Crystalox Solar, a leading manufacturer of solar power systems components
• Needed a home for 750 x 38 litre plastics buckets with lids.
• NISP Member Hampshire Cosmetics contacted - took the lot!
• CO_2e Reduction: 16.6te
• Water saved: 243m3
Facilitated by NISP
Bioplex Ltd
Burdens environmental
Bioplex technologies
Process Flow Diagram
• £250,000 Business investment
• 7,000 tonnes of waste diversion
• £440,000 approx cost savings
• 5,156 tonnes carbon savings
• 18,500 tonnes of water saved
• 10 business assisted and
• 7 jobs created
NISP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Note: Carbon reductions potential in each phase of project:
• Construction
• Operations
• Disposal
2 x Solution provider
4 x Solution Providers
Vermiculture
Soil Conditioning
7 Solution Providers
Paper Sludge & Ash
Aggregate Production
Savings of 10,000's tonnes CO_2 – e.g. from waste paper diversion from landfill
Plastics
Organics
Construction
1 x Solution provider
4 x Solution Providers
4 x Solution Providers
4 x Solution Providers
NISP


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Verification of carbon emissions reductions
NISP

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Verification of NISP Outputs

- **Synergies independently verified**:
  - Covers vast majority of those completed
  - Gives confidence to funders
  - Other resource efficiency programmes following suit
- **Independent verification post-completion, often = greater outcomes**
- **Calculations recorded, e.g. for CO_2 emissions reductions**

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Conclusions

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Key conclusions about carbon emissions reduction from NISP work

- NISP acts directly in the ‘real world’
- CO_2 reduction = key metric of NISP – will remain so
- Often drives synergy identification
- Simple methodology
  - Approved by funders
  - Quick
  - Consistent approach

- Need to keep in perspective – maintain ‘holistic’ aspect of IS

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The Future

- Rising energy costs
  - Governing viability of synergy completion & IS
  - Increasing pressures on current supply chain models – opportunity for IS
- Increasing awareness of carbon foot printing in UK businesses
- Increasing levels of carbon accounting
- Waste/recycling solution viability co-determined by both waste & energy/carbon criteria.
- Increasing importance of ‘Embodied carbon’ vs ‘Operational carbon’
- Need to capture the value of embodied carbon.

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Contact details

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'High quality' synergy definition

Working with several companies or waste/resource streams associated with a key process or project <u>simultaneously</u>, in order to maximise the efficient use of resources associated with that project or process through the development of multiple synergies.

This would involve working on a key, often 'large' project or organisation which:

- *Contributes at least 10% of any given major metric target at the sub-regional level. (Landfill diverted, Virgin material saved, CO_2 redns.)*
- *Involve multiple resource streams and solution providers.*
- *Be an example of cross-sectoral collaboration.*
- *Where possible, embody 'closed loop' best practice and innovation.*
- *Has high PR value.*

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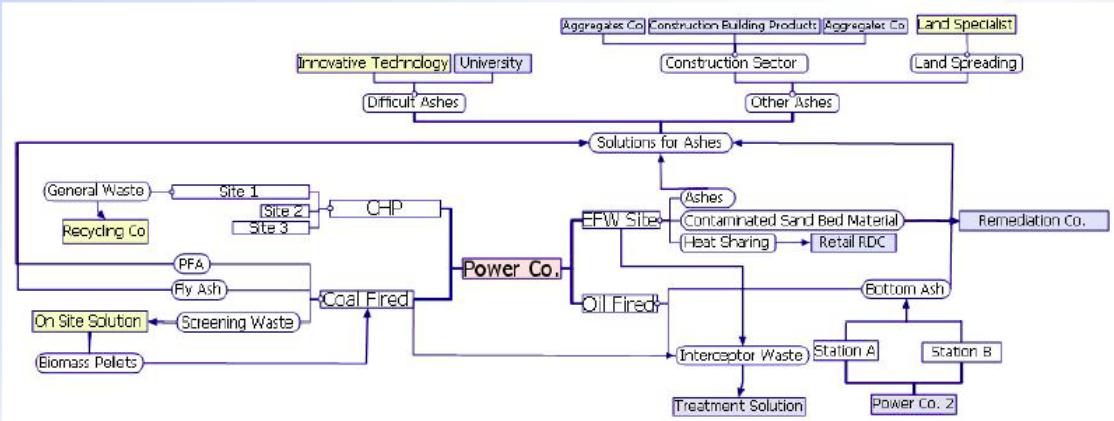
Applied Industrial Symbiosis – Power Generation



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Plenary Discussion for Presentation 2, 3, and 4

Marian Chertow, Yale University, USA – I'd like to ask questions about the scale we're dealing with here. We have seen projects presented at four different scales: individual company (NISP), eco-park (Kawasaki Eco-town), the whole state of Pennsylvania (Matthew Eckleman) and a national program through NISP. We're also looking at quantifying benefits more than we have in other such meetings. So, I guess my question is: are we looking at a very small piece of the pie? What makes us think industrial symbiosis is so important? We stay on the quest for industrial symbiosis, but we do not yet know analytically the effect of industrial symbiosis.

Gary Foster, NISP, UK – I think the great thing about industrial symbiosis and industrial ecology is that it is so flexible that it looks at different areas such as material savings, energy savings, or carbon savings. Also, it is important to examine embodied energy savings.

Matthew Eckelman, Yale University, USA – It is disappointing when the percent of savings is small, but I guess that is why the context is important. Speaking from the point of view of Pennsylvania, it only saves 1% of primary energy, but when you compare it to the renewable energy sector, something that has been pushed heavily by policy-makers, you find the point of comparison. It depends on what you compared to in the big picture. If you pick the right context, it would be more meaningful.

Fujita Tsuyoshi, NIES, Japan – Sharing responsibility among stakeholders is key to realizing sustainability. In the case of carbon emissions, industrial symbiosis shows the importance of embodied carbon emissions whereas many regions care about direct emissions. So, industrial symbiosis shows how stakeholders should share costs including embodied carbon emissions.

Cecilia Haskins, NTNU, Norway – (She mentioned the book, "the Medea hypothesis" by Peter Ward). Even if the savings are small and they seem inconsequential, eventually these steps will add up and hit some breakpoint. Industrial symbiosis is still positive and motivating. Maybe we're crazy, but it is a good crazy.

Shi Han, Yale University, USA – In all three presentations, I can see the need for baseline setting. Should we define a baseline based on common practice or by considering all virgin materials that are substituted for? The common practice approach is more convincing, but the virgin material approach is more ideal.

Valdemar Christensen, Denmark – Do you have any advice to national planners about how they should plan future industrial areas, considering transportation and carbon costs?

Fujita Tsuyoshi, NIES, Japan – It's my key question: how we can share industrial symbiosis idea with planners. If you make circular material flows within a short distance, you can reduce the carbon tax. However, it is not that easy of a question. Waste is different from crude/virgin materials and a company usually does not want to optimize distance for transporting waste. Suburban or rural areas can be optimal locations for EIP, but the location question is the one we should definitely discuss. Now we need different type of planning for symbiotic industrialization beyond modern planning during the industrialization era.

Gary Foster, NISP, UK – Transportation is critical to the viability of industrial symbiosis. For example, construction materials, as a rule of thumb, do not move farther than 30 miles. This is the local characteristic of heavy construction materials. High value materials can move farther. We don't quite have a handle around it fully, but we have committed research that is going to address the impact of transportation on symbiotic relationships.

Liddy Karter, Industrial Symbiosis Capital, USA – I'm pretty new to industrial symbiosis and I'd like to ask advice on prioritization from an investment point of view. You mentioned: the level of investment, CO_2 reduction, cost savings and increased sales. That captures pretty much everything, but what I want to know is the return on the investment. Which one of these things is the best return on investment?

Gary Foster, NISP, UK – Despite the metric I put up there, you should consider the concentration of the material. For example, textiles are very diffuse, so it's hard to recycle.

Angel Avadi, IfaS, Germany – How can industrial symbiosis compete with existing waste management solutions, for example, incineration facilities?

Fujita Tsuyoshi, NIES, Japan – From a pure scientific point of view, there is a principle tool called LCA. LCA-type evaluation needs to be done to compare these scenarios.

Gary Foster, NISP, UK – That is a really good question. England had that experience when the waste management sector was industrialized, commercialized, and centralized. When the trend of landfilling changed to the trend of incineration and composting, many existing waste management service providers were suddenly heavily impacted. It is a challenge to stay with cutting edge technologies and promote innovation. Which is cheaper, better for the environment? And at the same time, to do the right thing for people. It is hard, but it is something that we always have to focus on.

Matthew Eckelman, Yale University, USA – Companies will ultimately choose the most economically effective option and we might have limited capacity to interfere with that decision making and existing solutions that are working already. However, that is why it is an important activity to quantify, especially, environmental benefits and translate them into costs, so that people understand the tradeoff that is taking place and so that the company that is locked into old technology needs to understand the environmental implications of it.

Guillaume Massard, Université de Lausanne, Switzerland – I have a question about CO_2 accounting. How do you deal with rebound effects when you calculate CO_2

emissions? I also have a comment. You gave an example of reuse of used oil as engine oil. You can give advice to policy makers or to the company to assess life cycle impacts of those technologies. In the case of Switzerland we have a tradeoff between existing incineration facilities and waste recycling. We already built incinerators and huge heating networks in the 60s to recover 50% of heat.

Fujita Tsuyoshi, NIES, Japan – Incineration is also a high priority issue in Japan. Japan decided to incinerate everything in the past, but by 2010, there is a possibility to transform the structure of waste management into a more symbiotic way. In the short-term, existing facilities should be considered in your prioritization, but not really for a time frame beyond mid to long-range. We need more flexible allocation of waste management facilities and prioritization in order to reduce carbon by 2020. The structure of the waste management system depends on the society. While Japan is already in a mature stage, China can change dramatically due to a strong planning approach and enough room for funding.

Gary Foster, NISP, UK – Practitioners in NISP or NIES get environmental training and have expertise to project ideal scenarios. So, we can know what will be going to happen before we bring people together, before implementation.

Ankit Aggarwal, Technical University Munich, Germany – How do social and human dimensions come into play?

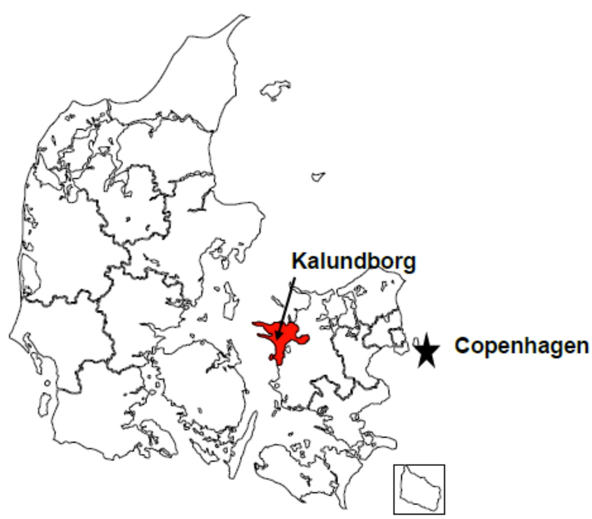
Matthew Eckelman, Yale University, USA – Some people consider industrial ecology as having nothing to do with people, which is false. Social dimensions need to be integrated into quantitative industrial ecology, like building metrics.

Gary Foster, NISP, UK – The NISP workshop usually generates 400 ideas and 60~70% of them may not happen due to economic or technical reasons and so on. However, it is people who realize these ideas and who bring all different pieces of ingredients. The people dimension of NISP is like heat.

Fujita Tsuyoshi, NIES, Japan – The social dimension is very important and will become a central issue of the integrative application of industrial ecology in the future.

Andreia Minulescu, Tomas Bata University, Czech Republic – We should emphasize the monetary value of industrial symbiosis in order to get companies involved. The social dimension is also related to economic benefits in this sense.

5. Kalundborg Industrial Symbiosis Today (John Kryger, Industrial Symbiosis Institute, Kalundborg, Denmark)


Kalundborg
Copenhagen

THE INDUSTRIAL SYMBIOSIS

The idea behind the Industrial Symbiosis is that one enterprise waste materials becomes an important resource for one or more other enterprises

Efficiency is the key!

Gasoline engine = 15-25%

Power plant = 40-50%

Combined Power Plant = 80-90%

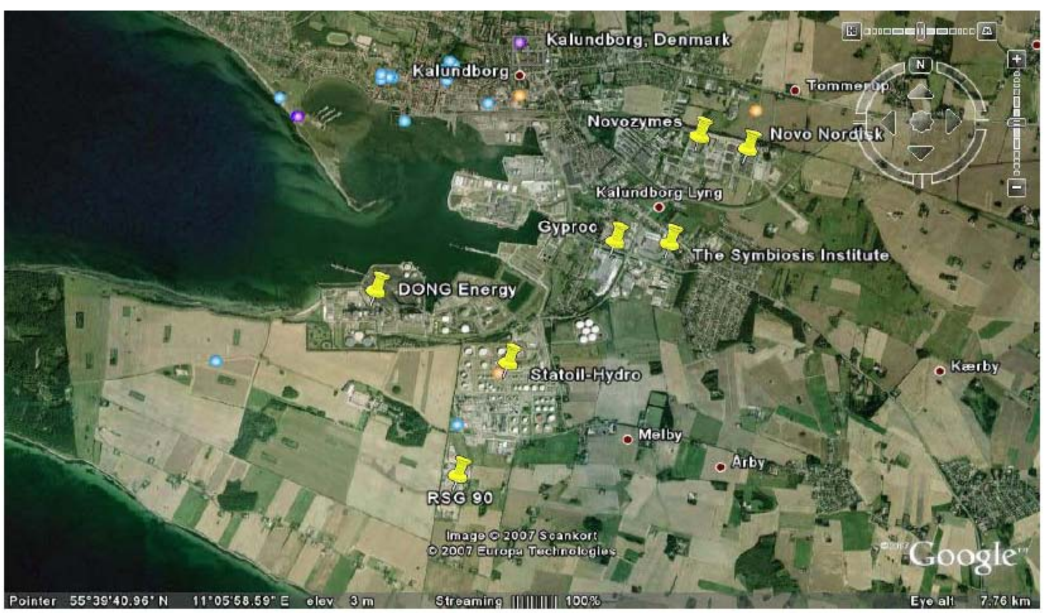
Electrical motor = app. 80%

THE INDUSTRIAL SYMBIOSIS

Modern enterprises of today do not produce waste – they produce bi-products!

Increase bi-product quality is the key!

Kalundborg Symbiosis



THE INDUSTRIAL SYMBIOSIS

The Industrial Symbiosis at Kalundborg is a resource and environmental network, consisting of twenty-six bilateral, commercial agreements between five industries, two waste handling companies and the utilities department of the municipality.

Asnæs Power Station

Production of electricity and heat

250 employees

Denmark's largest power Station 1053 GW

DONG energy

Statoil Refinery

Production of gasoline and other oil-based products

330 employees

Denmark's largest oil Refinery 550.000 t oil/year

STATOIL

NOVO NORDISK A/S

NOVO NORDISK A/S
Production of insulin etc.

novo nordisk®

Altogether >4000 employees

NOVOZYMES A/S
Production of industrial enzymes

novozymes®
Rethink Tomorrow

Gyproc

Production of plaster boards.

165 employees

>200.000m2/year

RGS 90

Remediation of 250.000 tons oil and metal polluted soil per year.

65 employees

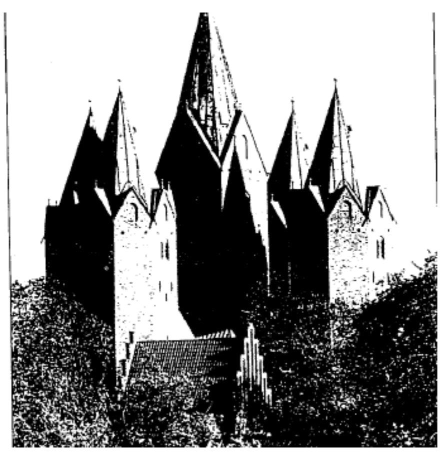
KARA/NOVEREN

Waste handling company, owned by 9 municipalities.

Handles 350,000 tons waste annually, recycles 82%

KARA / NOVEREN
- SIKKERHED FOR MILJØET

Kalundborg Community



Distribution of water and energy

Population: 49,000
(the town: 20,000)

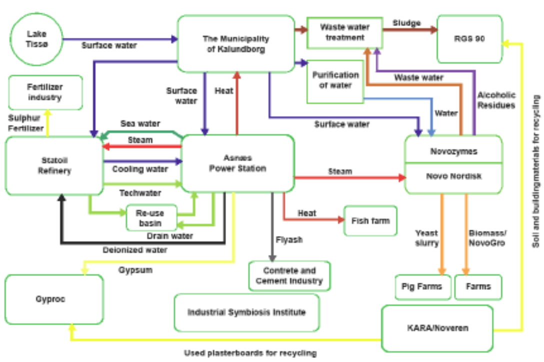
Symbiosis Projects

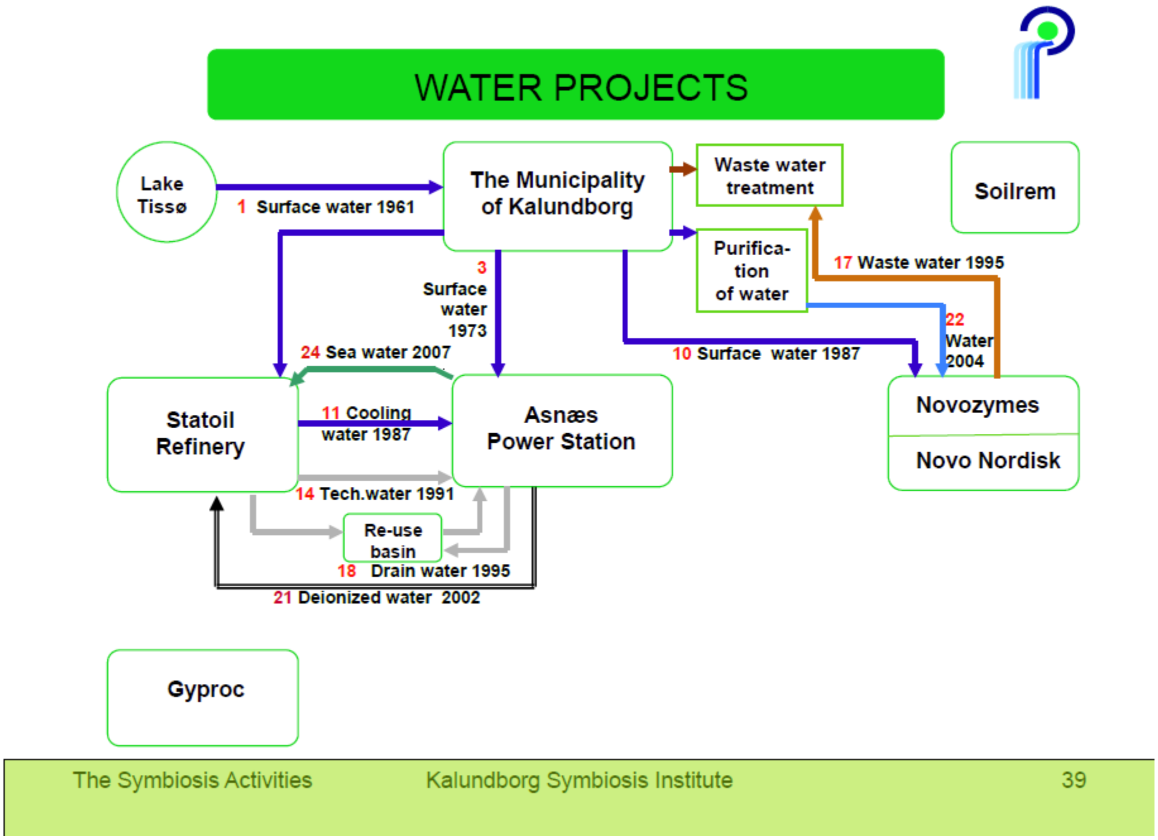
Three types of projects:

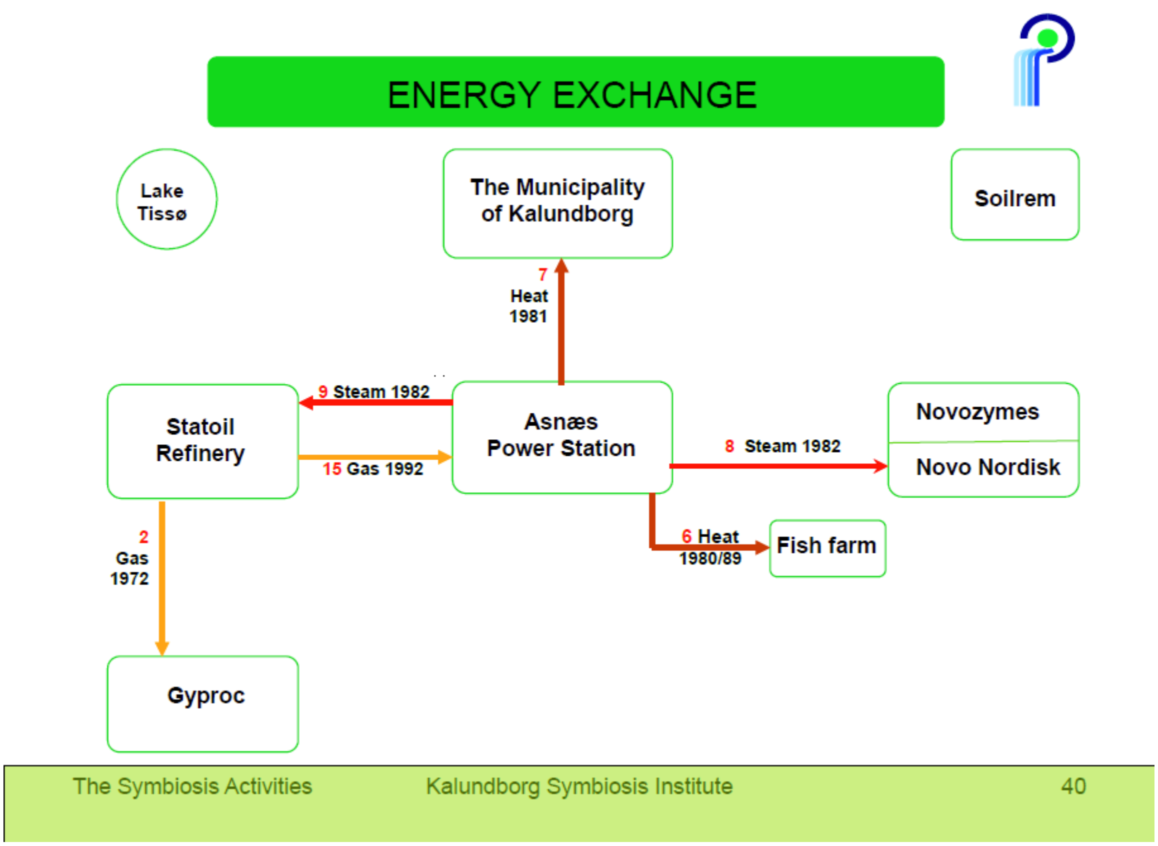
Recycling of water:	**12 Projects**
Exchange of energy:	**6 Projects**
Recycling of waste products:	**8 Projects**

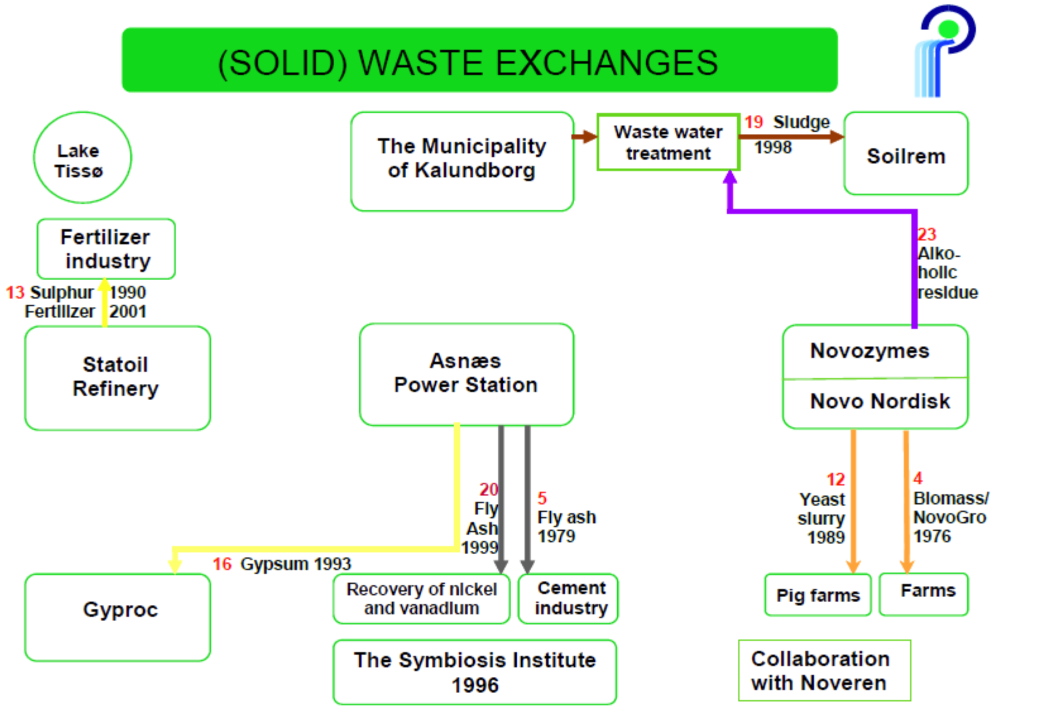
+ a special project: The Symbiosis Institute

Symbiosis Projects 2008

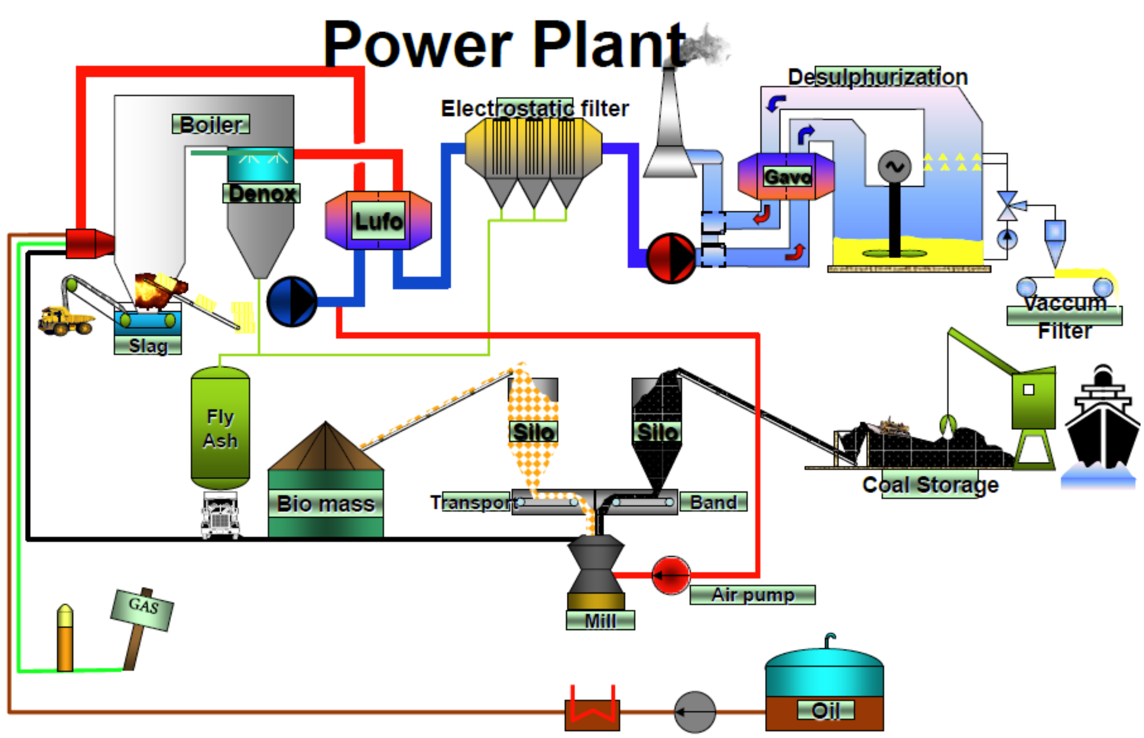



WATER PROJECTS
Lake Tissø
1 Surface water 1961
The Municipality of Kalundborg
Waste water treatment
Purification of water
Soilrem
17 Waste water 1995
3 Surface water 1973
22 Water 2004
24 Sea water 2007
10 Surface water 1987
Statoil Refinery
11 Cooling water 1987
Asnæs Power Station
Novozymes
Novo Nordisk
14 Tech.water 1991
Re-use basin
18 Drain water 1995
21 Deionized water 2002
Gyproc
The Symbiosis Activities
Kalundborg Symbiosis Institute
39


ENERGY EXCHANGE
Lake Tissø
The Municipality of Kalundborg
Soilrem
7 Heat 1981
9 Steam 1982
Statoil Refinery
Asnæs Power Station
Novozymes
Novo Nordisk
8 Steam 1982
15 Gas 1992
2 Gas 1972
6 Heat 1980/89
Fish farm
Gyproc
The Symbiosis Activities
Kalundborg Symbiosis Institute
40



The Symbiosis Activities Kalundborg Symbiosis Institute 41



The Symbiosis Activities Kalundborg Symbiosis Institute 42

Doc.info 42

Gypsum production in 2006

98.039 tons from Asnæs block 5

Doc. info

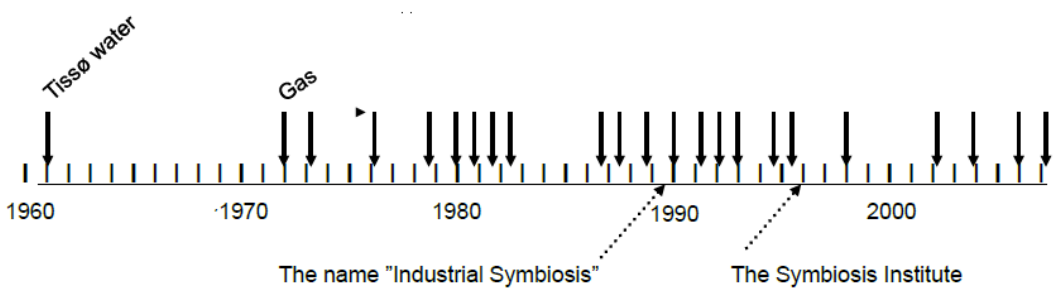
44

DONG energy

Recycling of used Plaster Boards

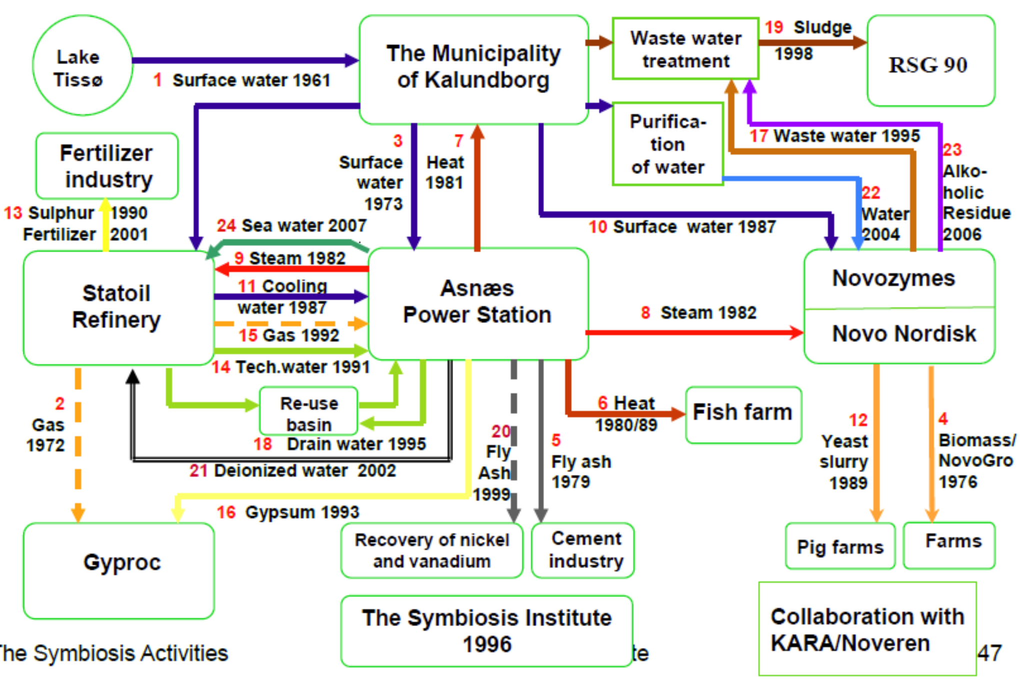
- **20% of input material are recycled materials**

CHRONOLOGICAL DEVELOPMENT



The Symbiosis Activities   Kalundborg Symbiosis Institute   46

TOTAL SYMBIOSIS SYSTEM 2007



The Symbiosis Activities   te   47

Industrial Symbiosis

What has been achieved?

- Environmental aspects
- Economic aspects
- Social aspects

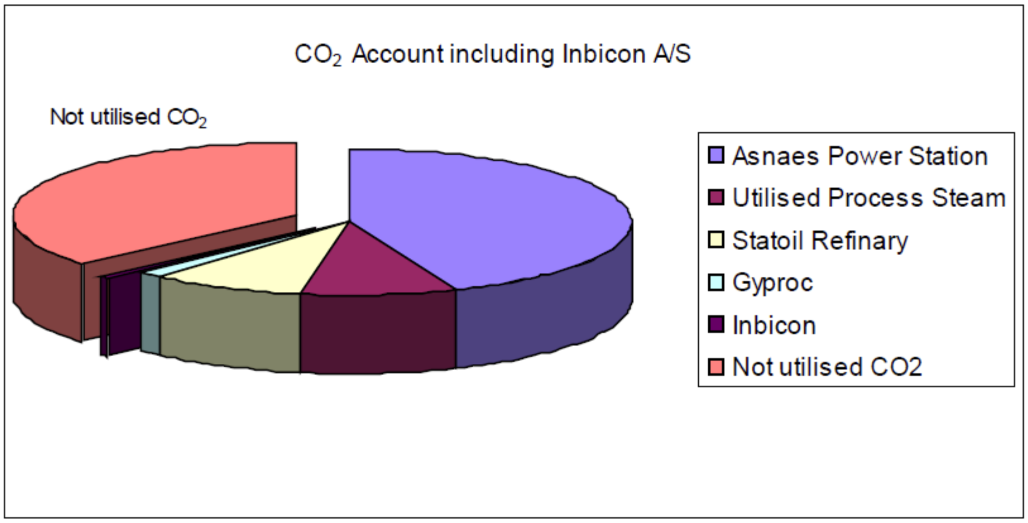
Environmental aspect

Resource savings.

Examples:

- Ground water ……………..... 1,9 mill. m3/year
- Surface water ……………… 1,0 mill. m3/year
- Natural gypsum ……………. 200,000 tonnes/year
- Oil ……………………………..20,000 tonnes/year

Reduction of emissions to water and air. E.g. 240.000 t CO_2 per year.



Industrial Symbiosis

Industrial Symbiosis was relatively new in the 1960-ties and is common know-ledge to-day.

The systematic use of the Industrial Symbiosis concept as i Kalundborg has been exported/copied in other countries and industrial parks, but is still not common practise in industrial parks.

What makes Industrial Symbiosis a success?

What is needed to implement, successfully, symbiosis among private industries?

- Awareness
- Feasibility
- Willingness

Thank you!

The Industrial Symbiosis 8 In cooperation with nature

6. Sustainability-Conscious Design (Jeanette Agertved Madsen, NNE Pharmaplan, Kalundborg, Denmark)

Program

nne pharmaplan®

- Introduction to NNE Pharmaplan A/S
- The concept Sustainable Conscious Design at NNE Pharmaplan A/S
- Case – Sustainable Conscious Design
- Case – CO_2 reduction at Novo Nordisk A/S
- Discussion

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NNE Pharmaplan at a glance

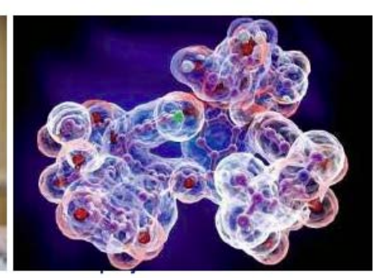
nne pharmaplan®

- Over 80 years of experience in the **pharma** and **biotech** industries
- Spanned over **3 continents** across Europe, North America and Asia
- Workforce 2009: More than 1500
- Turnover 2008: DKK 1.668M, €224M, $309M

We are the largest **focused** engineering and consulting company world-wide providing a **unique range of services** to the pharma and biotech industries with a **GMP-trained** workforce of more than 1500 people (2008).

- Capability to **execute all projects**; from the smallest to the largest
- A large **pool of specialists** with world-wide industrial experience





Our staff is our **greatest** asset

nne pharmaplan®

- **ISO 9001** certified since 1997; certified worldwide in 2008
- **ISO 14001** certified since 2003
- **OHSAS 18001** certified since 2003
- Global reach **covering all major markets**
- Capability of **executing** projects in **multiple locations** e.g. at client's headquarters and at the local site
- **Close to clients** through local offices providing service on site
- **State-of-the-art expertise** combined with the **knowledge** of local and international regulations

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HSE activities at NP

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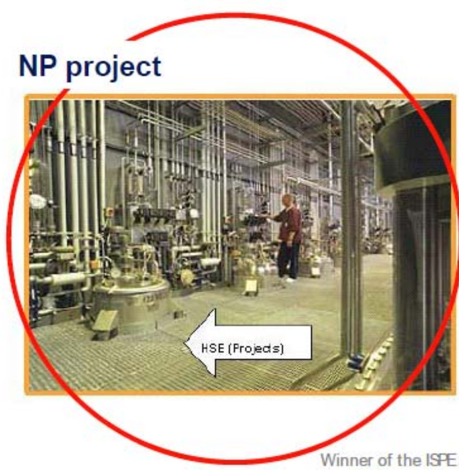
the abbreviation HSE

- stands for **Health, Safety and Environment**

NP operation

NP project



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HSE activities from sale to Handover

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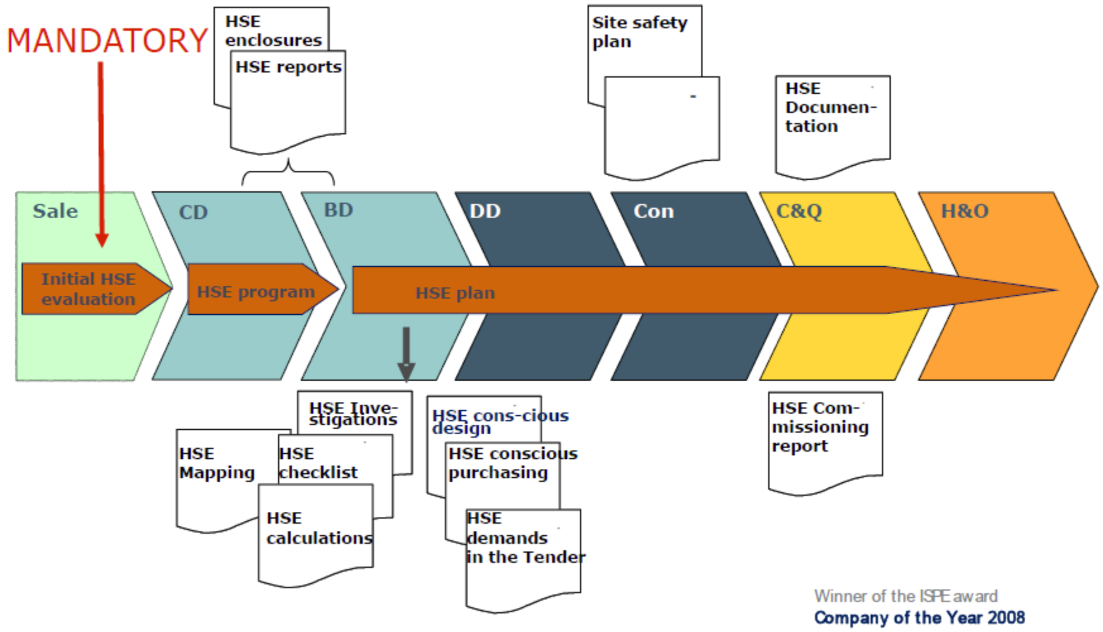

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HSE activities

nne pharmaplan

Always:

- As a minimum cover current legislation within Health, Safety and Environment.
- Plus HSE better practices if within the scope of economy, quality and time schedule.
- PM responsible.

Special HSE activities:

- Based on the evaluation it is agreed with the client which HSE consultancy services should be carried out.

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Initial HSE Evaluation - mandatory

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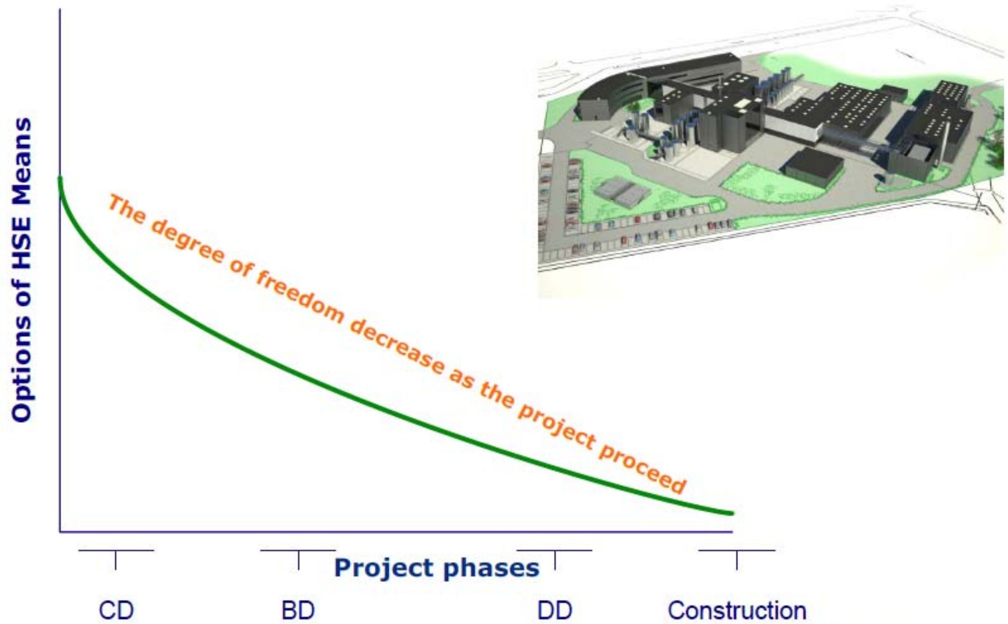

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Typical HSE Activities

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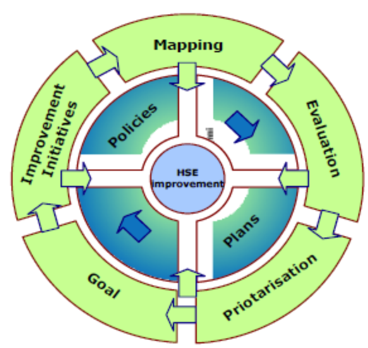
- **Planning** - Get the required approval by the authorities e.q.
    - Environmental Impact Assessment
    - Environmental approval
    - Waste water discharge permit
    - Building permit
    - Occupational Health and Safety
- **HSE project activities**
    - Compliance with the conditions stated in the approvals
    - Compliance with legislation requirements
    - Compliance with the client's demands
    - HSE conscious design
- **HSE Manager**



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CASE: Pharmaceutical Client

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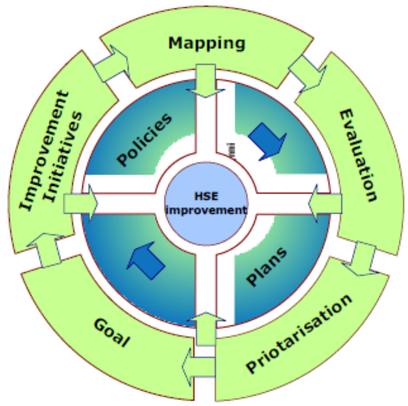
HSE Activities – comply with:



- Authorities:
  - Environmental approval
  - Occupational health and safety
  - Waste water permit
  - GMO production
- Client
  - Improvements with respect to working environment
  - Instruction Environmental and Energy sound design
    - Assessment of impacts
    - Improvement initiatives PBT < 4 years

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CASE: Pharmaceutical Client

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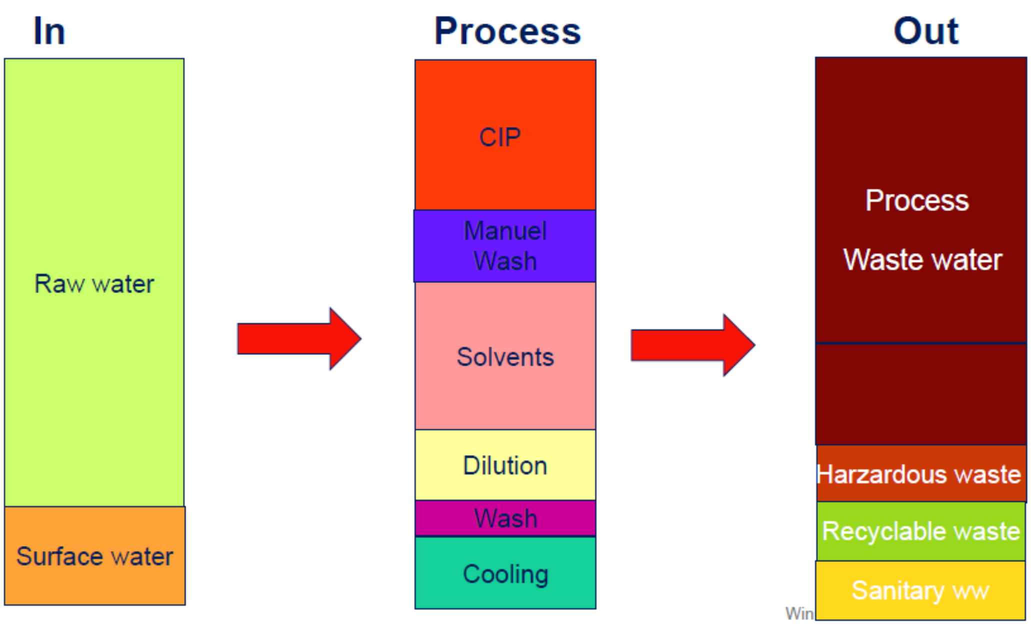
Water and liquid waste - Assessment



Win
Company of the Year 2008

CASE: Pharmaceutical Client

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Improvement initiatives

- Identify improvement initiatives < 4 years payback time.
- Multidisciplinary:
  - Technical description
  - Investment (equipment and engineering)
  - Saving potential
  - Payback time
  - Operational reliability
  - Uncertainty

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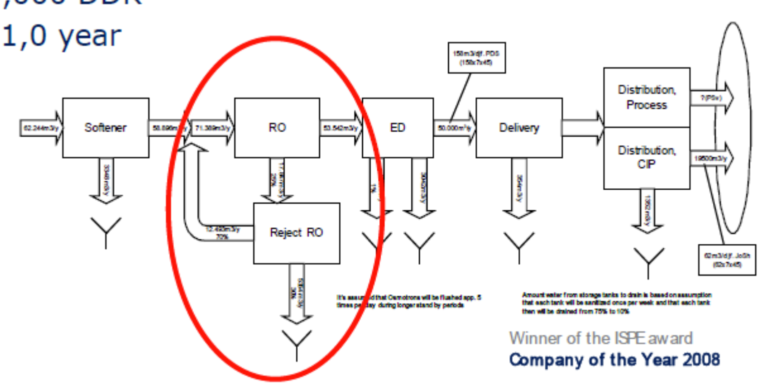
Case: Pharmaceutical Client

nne pharmaplan®

Improvement initiative – Recycling of RO-reject water

Facts :

- Saving of 15,300 m³ drinking water/year
- Reduction in process waste water: 15,300 m³/year
- Reduction in operation cost: 675,000 DDK
- Investment: 680,000 DDK
- Payback period: 1,0 year



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CASE: Pharmaceutical Client

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In summary - optimization of energy and water

Compound	Reduction (%)
Water	16
Surface water	55
Electricity	8
Steam	21
Process Waste water	19
CO2 emission	23
District heating	From consumption to surplus

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Summary HSE activities in projects

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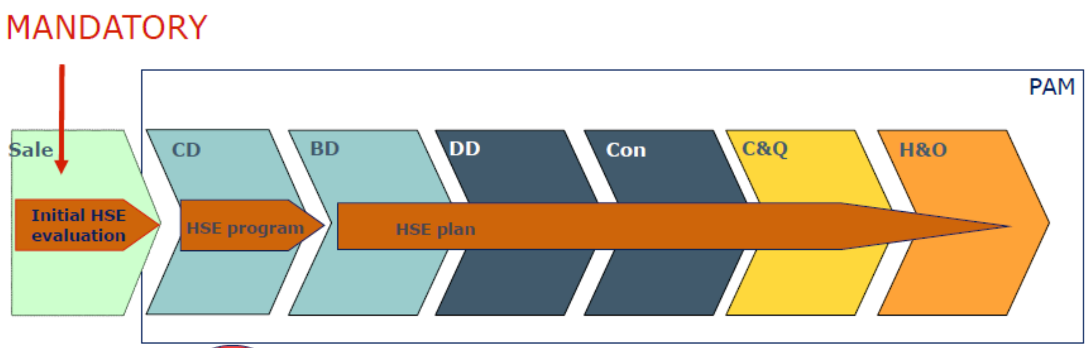
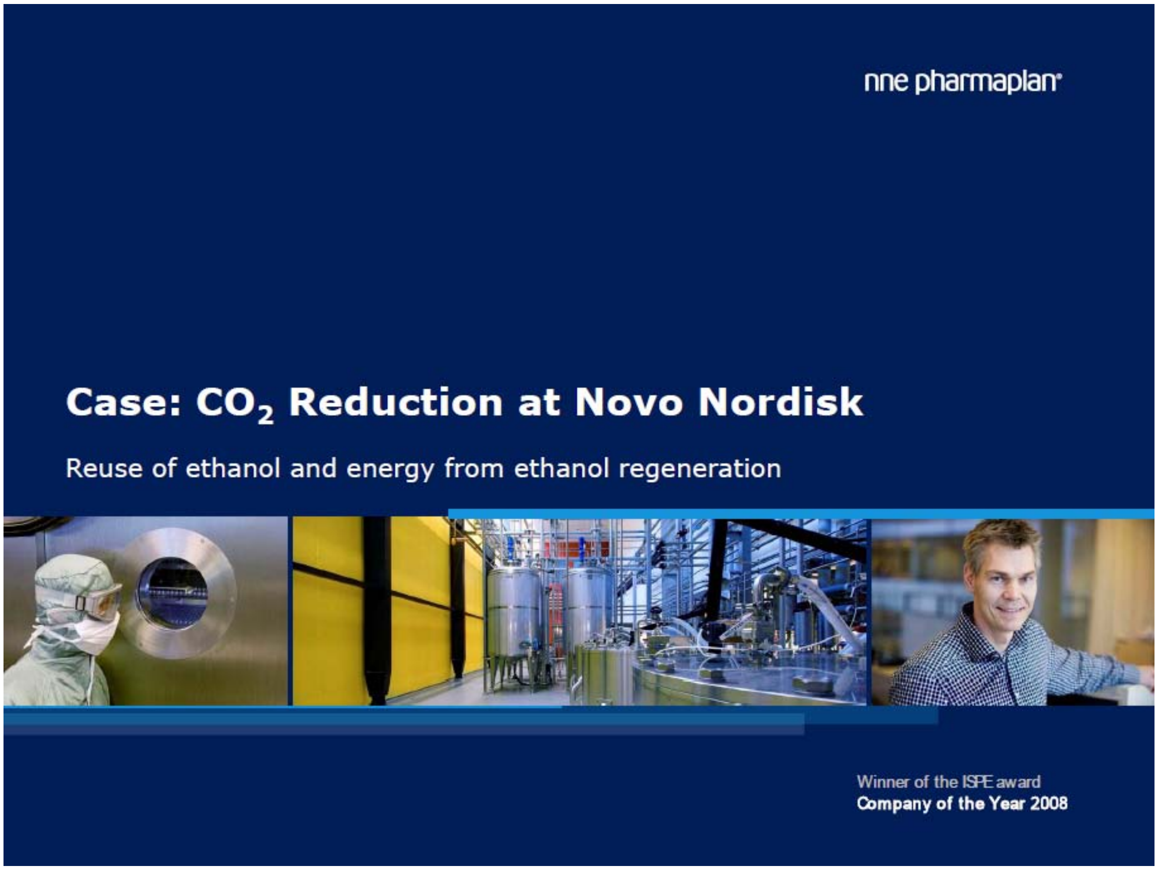


7. Reuse of Ethanol and Energy from Ethanol Regeneration at Novo Nordisk (Lars Raagert, NNE Pharmaplan, Kalundborg, Denmark)



Background

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- Novo Nordisk uses a significant amount of 80% ethanol in the production of Insulin in their bulk factories.
- The ethanol is bound by pharmaceutical regulations, and is therefore generated from 100% ethanol mixed with purified water.
- Some years ago, Novo Nordisk introduced distillation plants next to each factory in order to regenerate 80% ethanol from the ethanol waste flow and reduce the use of 100% ethanol.
- The reuse of the ethanol waste flow reduces the use of raw materials. Consequently, the use of 100% ethanol has been reduced to a minimum over the years.

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Today

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- Regeneration of 80% ethanol takes up a lot of energy and it generates 30-40% of the annual consumption of steam in an Insulin Bulk Plant.

- In 2002, when Novo Nordisk was building a line of new production facilities, NNE Pharmaplan was asked to reduce the energy consumption from regeneration of ethanol from ethanol waste.
- The problem in reusing the waste energy from the distillation plants was that the columns were running almost atmospheric. This left little possibility of reusing the energy, unless for low temperature purposes. Low temperature purposes were generally not applicable, so NNE Pharmaplan came up with the idea of increasing the temperature and pressure of the distillation plant.

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Atmospheric distillation

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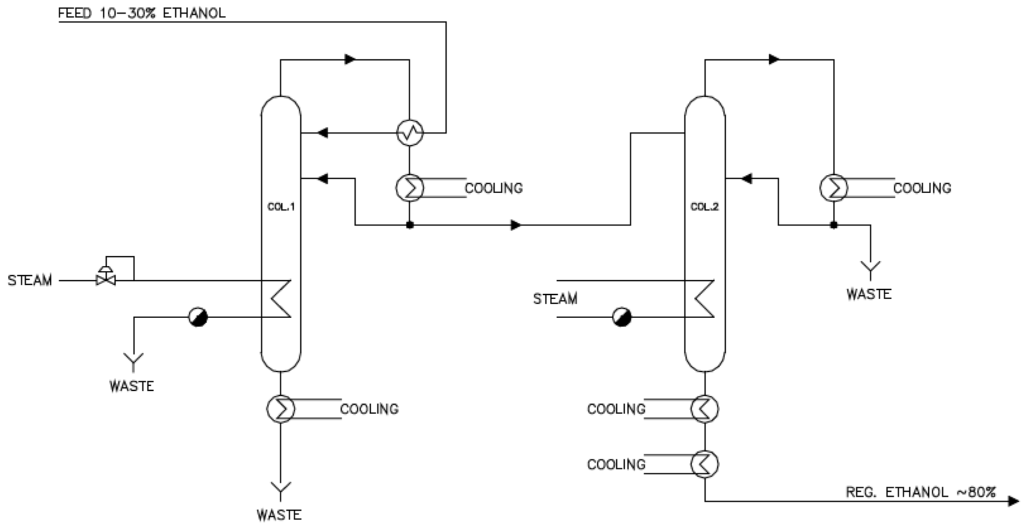

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Pressurised distillation

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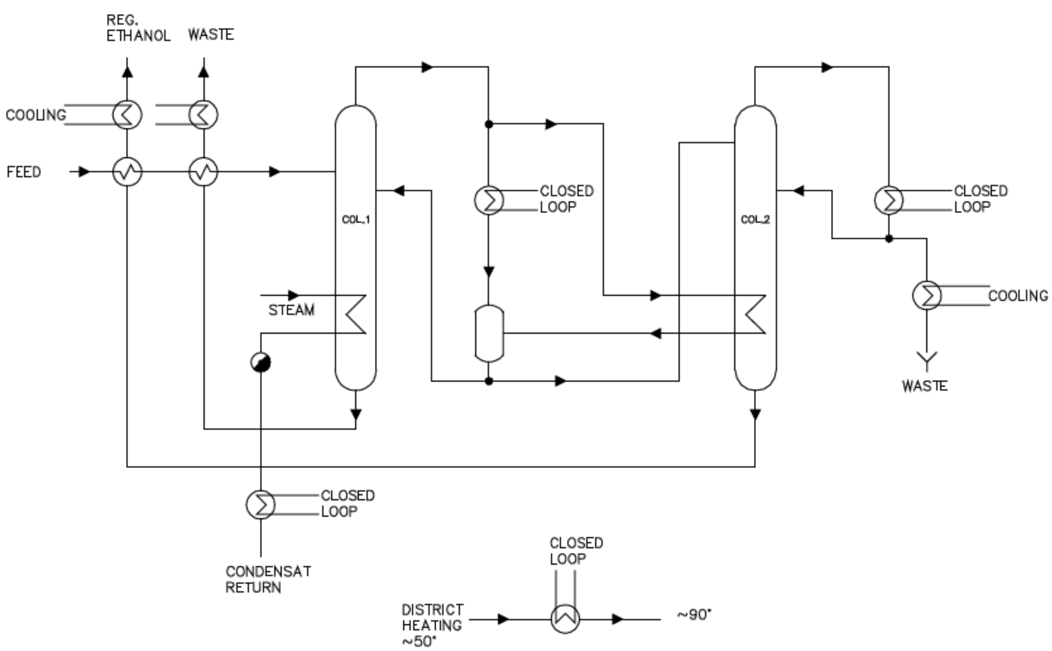

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What did we save

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- The old column and the new one use the same amount of input energy on regenerating one kg ethanol.
- However, the new column recovers more than 60% of the used energy.
- In 2008 the saved amount of CO_2 was measured to 3,000 tons.
- Equivalent to driving 17,000,000 km in a normal house car,
- or 430 times around the earth....

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Pros and cons

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- Increasing the temperature and pressure of a system is usually not recommendable because of the increase in thermal conduction and pumping energy.

- However, the energy used to evaporate and condense water does not change remarkably, when changing the pressure.

- Therefore, an increase in the pressure and temperature works effectively on an ethanol distillation plant, when the purpose is to increase the temperature in order to reuse the waste energy.

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Future

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- Next step for NNE Pharmaplan is to find ways to reuse the energy from the existing atmospheric distillation plants on site. The process has already started by means of:
  - Supplementing exchangers
  - Reuse of condensate heat and flash steam
  - Heat pumps
  - Absorption cooling / Adsorption cooling

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Pitfalls

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- Parallel to increasing the temperature the requirements for the materials increase as well.
  Consequently, the cost for the distillation plant increases considerably.
- The regained energy must be used somewhere else - preferably close to the plant.
- On a pharmaceutical plant like Novo Nordisk there are also a great deal of concern related to pharmaceutical regulations.
  Most of them related to contamination of the product.

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Industrial Symbiosis – Contributing to CO_2 Reduction and Sustainability

What are the drivers and why is it not so easy to implement CO_2 reduction ideas.

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What are we looking for ?

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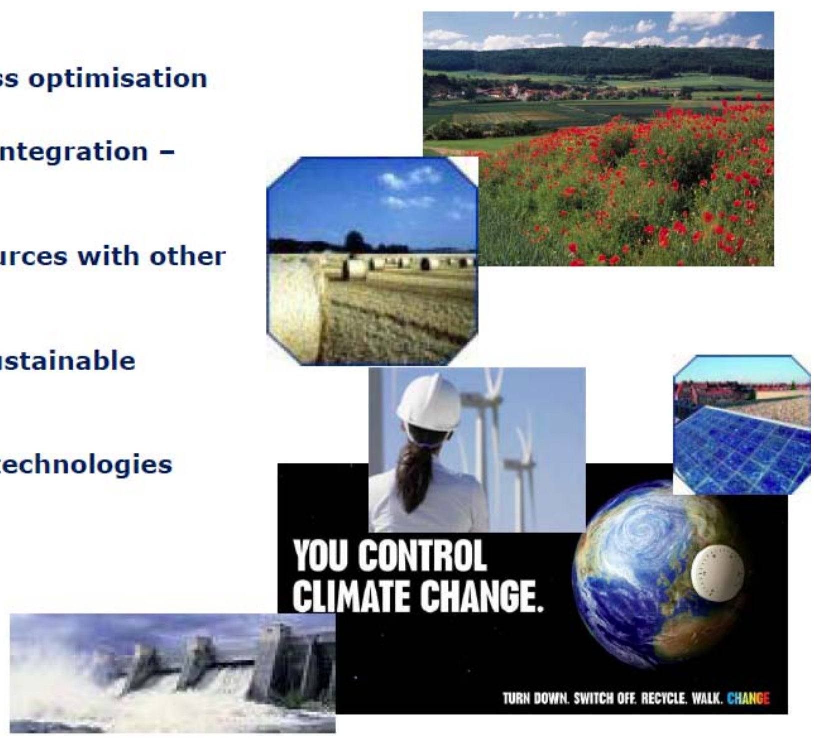
- **Production process optimisation**
- **Internal process integration – process & utility**
- **Exchange of resources with other industries**
- **Introduction of sustainable supplies**
- **New sustainable technologies**
    - reduce
    - recycling
    - reuse
    - reclaim



Obstacles in implementing Sustainablity and CO_2 reduction

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Benefits

- Green image
- Goal settings
- Operational cost savings
- Room for expansion in the current supply of water and energy
- Lean thinking
- Aligned with future demands and regulations and long term relations

Challenges

- Economy (pay-back)
- The investment is better off used in production capacity (less pay-back time)
- Time
- Risks
- Internal resistance against new technology
- The investment has been spent
- Lack of incitement
- Lack of knowledge

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Any Questions

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?

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Discussion for Presentation 5, 6, and 7

Ankit Aggarwal, Technical University Munich, Germany – Which approach did you use to optimize both material and energy flows at the same time?
Largs Raagert, NNE Pharma A/S, Denmark – The idea of reusing waste to regenerate ethanol was from the 90s. Novo came up with the need to increase energy efficiency in 2002.

Liddy Karter, Industrial Symbiosis Capital, USA – Could this be replicated across pharmaceutical plants in general?
Largs Raagert, NNE Pharma A/S, Denmark – Yes, I guess, so, as long as they use ethanol. However, it is unusual to find energy improvements in pharmaceutical plants as well as in other industries. The scale of 6% or more depends on industries and how much energy they use. It's fairly common that pharmaceutical industries use a lot of energy, but the pharmaceutical industry is an old-fashioned business that is reluctant to change.
Liddy Karter, Industrial Symbiosis Capital, USA – So, is this the first insulin production plant that reached this level of efficiency?
Largs Raagert, NNE Pharma A/S, Denmark – Yes, we're one among three.
Jørgen Christensen, JC consult, Denmark – And the idea is that if you raise the temperature, you're able to reuse the energy. It depends on whether you can send residual heat somewhere else. Here, we have district heating. Raising temperature could have negative effect in other cases.

Tian Jinping, Tsinghua University, China – How much ethanol is used per year? Also, in this a two-column process, what are the concentrations of the feed materials (i.e., 10% of ethanol is suitable for atmospheric distillation and 30% for pressurized distillation)? Is 80% is enough for insulin production?
Largs Raagert, NNE Pharma A/S, Denmark – I don't know the exact number for that. Approximately 31,000 tons of ethanol is used for one month, but that is regenerated now.
Mads Tarp, NNE Pharma A/S, Denmark – It is normal to use 2~3% of reused ethanol.
Largs Raagert, NNE Pharma A/S, Denmark – There are changes among factories and processes, but usually feed ethanol is 10~30% and solvent ethanol is 20%. They're regenerated to 80% ethanol. You cannot regenerate more than 80% of ethanol by distillation. Otherwise, you should have more options, like absorption. 80% is sufficient for most of the productions.

John Kryger, Kalundborg Symbiosis Center, Denmark – I have a question for Jeannete. You talked about optimizing processes within a company. However, we can optimize process between companies as well. This is where we have challenges with symbiosis, how to bring knowledge, make companies work together and look further.

Cecilia Haskins, NTNU, Norway – You were talking about how residential areas were incorporated into industrial analysis. What is the community distance – are they all within bicycle distance or are they farther away?
Jørgen Christensen, JC consult, Denmark – I would say the majority is in the area, but some percentage of people commute from a far distance.

Inês Costa, IN+/IST, Portugal – I have a question for John. I'm particularly interested in the implementation process of industrial symbiosis considering the role of regulation. What is the process – how much does it cost for companies to get a license to handle waste, how much time does it take to get a license, how close are regulators to companies and so on?
John Kryger, Kalundborg Symbiosis Center, Denmark – Of course, industries have to be licensed to do industrial symbiosis. There is a process of negotiating it with authorities. Sometimes this process acts as a barrier and symbiosis does not happen. Working closely with authorities would be helpful for symbiosis. If companies are used to negotiating, then they would not be afraid to go into this process.

Leonard Mitchell, University of Southern California, USA – Do you buy or manufacture your version of ethanol? What is the feedstock?
Largs Raagert, NNE Pharma A/S, Denmark – We buy it. It is not fermented ethanol, it is from refineries

PANEL DISCUSSIONS WITH KALUNDBORG VETERANS

Members of the Panel:

Name	Firm	Tenure
Valdemar Christensen	Asnæs Power	Retired Production Manager
Morgen Olesen	Asnæs Power	1967; Manager 1984-1994; retired
Leif Andersson	Kalundborg Municipality	1977-1991; Manager district heating and water supply
Benny Madsen	Statoil-Hydro	1974 (Esso)
Finn Grob	Gyproc	1974-2001; retired
Jørgen Christensen	Novo Nordisk	1981-1995; now an independent consultant

Panel – Opening Reflections

Jørgen (JC) began the introductions by informing us that this event was the first time all of these managers had appeared together in a panel in the past 20 years.

Finn (FG) started with the engineering firm that built the Gyproc factory in 1968. Noticing the flare from Statoil motivated him to begin discussions about the possibility of drying the plasterboard in a dryer using this gas – the project was started in 1972. Later he began to consider getting gypsum from the power station; this became a reality in 1983 at which time they used 20% raw material from Spain and 80% from the power station. Beginning in 1987, they began to recycle gypsum from used plaster board – accounting for 5% of production.

Benny (BM) observed the surplus and looked to his neighbors to arrange exchanges. It was all about avoiding potential problems that were related to flare gases, heated water, etc. He observed that “structured formalism is less successful.”

Leif (LA) is happy that Kalundborg is serving as a model for others. During his 15 years as manager of water supply and heating distribution he often experienced problems meeting water demands. He is sorry that these solutions have not been implemented elsewhere in Denmark. He hopes that the meetings in Copenhagen this December will motivate members of parliament to seriously consider the Kalundborg model – “free heat” from large and small industrial plants.

Morgen (MO) noted that the power station has a focal contribution in the symbiosis. He recalls that in 1989 some local students documented the then-existing cooperation between the firms. In 1990, Jørgen came across an article in the Financial Times. Morgen stated that 1991 was the first time the 5 managers were gathered together to describe the symbiosis. His assessment of why the linkages were established is that both the companies and the people fit well together; the managers experienced weekly encounters in their daily lives and had good trust and knowledge of each other. Over time there has been some lost of connection as the companies became larger and developed global footprints. But all the linkages that have been established have been continued because everyone has benefited. However, he noted that he has been unsuccessful in introducing these concepts to managers of other power stations.

Valdemar (VC) remembers the 1990 article on the front page of the Financial Times – a picture of pipes and clean air – "so clear you can see the mountains in Norway." After the Brundtland report with its definition of sustainability, industrialists were tagged as "bad" polluters. Valdemar had a meeting scheduled in 1989 with a group of students in the Environmental Club and he wanted to present the positive things that were already happening in Kalundborg to dispel this stereotype. It was his hope to challenge and pass the baton to the next generation. In conversation about this presentation with his wife, Inge, they coined the term "industrial symbiosis" (Inge offered the analogy to symbiosis, Valdemar tacked on industrial). It was these students who later made the first model of the cooperation.

Jørgen (JC) remembers arriving in 1981. He had inherited the job of engineering for the steam pipelines, and with it the problem of spent biomass – sludge spreading had already begun and was continued. The solutions were worked out between the engineers without fancy projects or communication. Worksheets with mass balances and process flow charts were just filed in binders. There were lots of excuses available for [not] cooperating, but transparency creates willingness.

Questions from the Floor and Answers:

Peter Lowitt – what role did the Rotary Club play?

> **MO** – The Rotary Club was a weekly meeting place and enhanced the relationships; such meetings lower the barrier of access.

Andreia Minulescu – has there been any third-party involved, and has the financial crisis influenced the symbiosis?

> **Answers** – no third-parties and no impact on current projects from the crisis.

Marian Chertow – what was Gyproc's motivation for locating in Kalundborg?

FG – Gyproc already had a factory in Jutland plus two in Sweden; increased market demand for plasterboard meant they needed another factory – Kalundborg was chosen as the location – the possibility to use the gas from Statoil came later, but was an idea that first arose in the planning phase. While there were precedents in Sweden where steam is used for the dryer, Kalundborg was the first location to use the gas. The primary location motivation was the year-round harbor.

BM – engineers are motivated to observe what their neighbors (other firms) are doing; people know each other, and engineers would occasionally discuss the problems they encountered at work. As these interconnections were made, they were encouraged by management – who met in their own clubs.

Liddy Karter – are there contracts?

MO – yes, prices were decided based on shared benefits; parties compared the cost to dispose of the byproduct and the cost of raw materials and shared the benefit.

VC – steam contracts took a long time because of outside factors.

JC – some projects only needed very simple contracts – it depended on the situation. But there is nothing special about these contracts – they were negotiated like any other agreement – with normal sound commercial practices, and in the end, everyone remained good friends.

Robin Branson – what has been the relationship of legislation in stimulating industrial symbiosis – for example, the waste handling?

VC – there exists today 4.6 kilometers of pipes carrying steam between Statoil-Hydro and Novo Nordisk.

BM – in some cases the projects were motivated by existing legislation, in other instances they anticipated legislation, for example, the fertilizer project.

JC – environmental taxes in 1985 were an incentive – the municipality asked Novo Nordisk to separate the sludge (80,000 tons). But sometimes taxation can create a barrier because there are many different measurement methods – for example, the taxation on district heating benefits to citizens' homes. The Kalundborg experience should contribute to influence new and less arbitrary legislation.

MO – most motivation was based on commercial benefits; the environmental improvements were an additional benefit and made it easier to receive both permission and forgiveness.

Shi Han – what type of people were the champions behind the projects – for example, general managers or engineers?

JC – it depends on the culture. Denmark has flat hierarchies and open management styles which mean that much decision-making is delegated. The ability to work and take initiative from the bottom-up facilitated these linkages.

BM – the environmental manager has the responsibility and is empowered to start inquiries about engineering changes, etc.

Leo Baas – what was the biggest surprise?

MO – the worldwide celebrity.

VC – the reaction of the young people to his challenge in 1989.

BM – the big interest in a “common sense” action from the whole world.

GENERAL DISCUSSION – WHEN IS INDUSTRIAL SYMBIOSIS, INDUSTRIAL SYMBIOSIS?

Marian Chertow, Yale University, USA – Is physical exchange the heart of industrial symbiosis? We thought it ought to be, but as eco-industrial development developed, it has not always been easy to find physical exchanges. The real distinguishing characteristic of industrial symbiosis, in my mind, is the fact that it is built around the physical relationships, and therefore based in industrial ecology. If industrial symbiosis works based on industrial ecology, then it revolves around material and energy flows.

I think that Pauline and her colleague David Gibbs made an excellent point that physical sharing of material and energy creates a more intimate relationship. When we think about "what is sustainability?" and "what is sustainable development?", it has to do with interdependence. When I am dependent on you for your raw materials, it is a much deeper model of sustainability that involves cooperation and interdependence.

Also, if we see the behavior of the agents in eco-industrial systems as emergent – now I am using the language of complex adaptive systems – industrial symbiosis can easily go beyond the dyadic relationships. The Kalundborg model is a spontaneous model of industrial symbiosis in contrast to a purely planned model. Peter Lowitt and I had a great debate last year at the 5th annual Industrial Symbiosis Research Symposium about whether or not you could plan industrial symbiosis. It is a very interesting question. Shi Han's work in China has shown that even in a planned system – the Chinese have been very effective about planning eco-industrial parks overall – there are still spontaneous aspects that show emergent behavior. There are probably more models that allow us to look at these questions together. The one that interests me is the question of planning and spontaneity and whether we really are observing the behavior of complex adaptive systems or more hierarchical systems.

It is never wise to draw a boundary around what is and is not industrial symbiosis. There are always surprises. There are systems that start in one mode, for example, economic efficiency, and over time they convert to another mode, such as we saw in Kalundborg. We have had many surprises in India in the past years of study, where we see such a high level of material reuse. In our Nanjangud study of an industrial area with 60 companies, we found that of total discards among the companies – close to 200,000 tons – 99.5 % of this amount was being reused or recycled at least once.

I think we can devise a new system that melds some planning around emergent behaviors, a sort of hybrid system. We need to continue careful scholarships in this area, but with an open mind.

Guillaume Massard, Université de Lausanne, Switzerland – Thank you for giving me an opportunity to make some comments on the definition of industrial symbiosis because it is something I have been thinking about for the last 4 years in the context of Switzerland. I want to go back to the most important citation of the IS definition, which is actually from you, Marian, from 2000. It says industrial symbiosis has "engaged traditionally separate industries in a collective approach to competitive advantage involving physical exchange of material, energy, water and/or by-products. The key to industrial symbiosis is collaboration and the synergistic possibility offered by geographic proximity." This is what I read the first day of my Ph.D. training. Then, the more recent paper in 2007 mentioned about 3-2 heuristics. I want to stick to this definition over other definitions such as "regional resource synergy" from Australia that includes all kinds of collaboration, or "eco-industrial parks." Based on this definition, I'd like to raise 3 questions.

Lots of projects around the world involve recycling businesses. Should we consider this as a part of an industrial symbiosis network? I notice that this is a tricky question. In the first definition, we consider traditionally separate industries as the basis for the industrial symbiosis. However, recycling business is not traditionally separate.

The second question would be, "is IS the human collaboration, social networking process or it is a concept that promotes the cyclic use of resources?" In other words, is IS a social approach or an engineering approach? In Switzerland, there is nearly no landfilling – maybe 2 or 3% of waste goes to landfill. A lot of waste is incinerated. Nearly 50% of all industrial waste is recycled. We have a very efficient recycling system and companies have already spent a lot of money to create the current system. So, what will be the added value of industrial symbiosis? How can industrial symbiosis optimize a system which already works very well?

For a third question, I'd like to make a link between industrial symbiosis and the waste hierarchy. I think industrial symbiosis is something about reuse, the cyclic use of resources. But other activities in material exchanges in industrial parks are actually energy recovery, which is just better than landfilling and incineration, but is much less efficient than material reuse, recycling or even downcycling. So my question is if we do not consider recycling as part of industrial symbiosis, then we only have reuse and energy recovery. What is the most efficient option for industrial symbiosis?

I want to thank Inês for developing these ideas together with me.

Shi Han, Yale University, USA – My research is looking at forms of inter-firm cooperation and transaction costs, which is important for the industrial symbiosis definition question. There are huge inconsistencies in the industrial symbiosis literature. First of all, they use different names: industrial symbiosis, an eco-industrial park, eco-industrial development, and eco-industrial network. But there are some key elements in which I see major conflicts. I will mention some of them. First, is industrial symbiosis inter-firm activity, inter-process or inter-facility activity? Leo Bass always talks about the boundary of organization. The first famous Chinese industrial symbiosis was in the Guigang sugar-making industrial complex. There, most of the industrial symbiosis was found within the same company – we can refer to it as inter-facility or inter-process.

The second question is whether we need to focus only on physical exchange of water, energy and materials. Or do we need to incorporate service, or information exchange such as shown in NISP cases? Some argue that information exchange is the basis of the physical exchange – could we build physical exchange without information, virtual exchange?

The third question is about differentiating industrial symbiosis versus traditional agglomeration economies. Cluster activities already have been explained for many years. Could we draw a line between industrial symbiosis and agglomeration economies?

The next question would be what the difference between industrial symbiosis and conventional recycling activities is. One of the most famous articles in the industrial symbiosis arena looked at the recycling network in Styria, Austria.

The last question is about whether we can call dyadic exchange industrial symbiosis. Or does industrial symbiosis need to have at least one 3-2 network?

We can define industrial symbiosis broadly, but I tend to follow a narrow definition using several criteria: these include cooperation, geographic proximity, wasteful nature of the object exchanged, traceable transformation of the subject, and positive environmental impacts.

It might be hard to have one precise definition of industrial symbiosis, but what is important is that we should have transparency. Define industrial symbiosis in your own way and use it consistently. I think this is the minimum requirement to make our community stand out.

Jørgen Christensen, JC consult, Denmark – Last year in Devens, we had discussion on this topic and we did not conclude anything. This means that we should continue to work on this and that is what I intend to do now. I found it a bit frustrating to celebrate the sixth symposium on industrial symbiosis and not be able to answer to the world what industrial symbiosis is. I suggest another way to make discussion easier. I would like to look at categories and eliminate ones that are not relevant to industrial symbiosis.

The definition we in Kalundborg have used for many years, is:

Collaboration between different industries for mutual economic and environmental benefit.

It resulted from an attempt to keep it as brief as possible, maintaining the most important words only:

> ***Collaboration***, to show that it was the communication between people which was more important than technology.
> ***Mutual benefit***, to indicate that it was normal commercial agreements.
> ***Economic and environmental***, to show that these two objectives both have to be fulfilled.
> ***Different industries***, because we wanted the definition to be restricted. A definition that included internal projects would include a larger number of projects, many of which would be unknown, because they were internal.

We also usually describe the main principles of the symbiosis as being:

> *"Someone's waste is another one's raw material"*
> *Projects should be economically and environmentally profitable*
> *Partners should be independent ("across the fence")*

The two latter ones in fact repeat some of the contents of the definition above, whereas the first one shows recycling, which is not represented in the definition.

All these considerations were used for the Kalundborg symbiosis only. If you widen the scope to cover many different networks which might or might not be called industrial symbiosis, many questions turn up, if you try to make a definition suitable and practical, but still using consistent criteria to categorize projects.
(Mr. Christensen then distributed a document on this topic which appears below.)

All projects can be described as a type of exchange. These exchanges may be described by a number of properties. A large number of categories may be listed:

1. The type of cooperation
    a. Transfer from a donor to a receiver
    b. Sharing of joint facilities
2. The type of matter exchanged
    a. Water
    b. Energy
    c. (Solid) waste
    d. Immaterial
3. The physical phase of the matter transferred
    a. Solid
    b. Liquid
    c. Gaseous
    d. Electronic/electric
    e. Abstract
4. Distance of transfer
    a. Within local industrial area
    b. Outside local industrial area
5. Means of transfer
    a. Pipeline
    b. Truck/train/ship
    c. Electric
    d. Electronic communication
    e. Printed communication
    f. Personal communication
6. Quantifiability
    a. Quantifiable
    b. Non-quantifiable
7. Relation between donor and receiver
    a. Donor and receiver have totally independent ownership
    b. Donor and receiver are legally different, but have some degree of common ownership
    c. Donor and receiver have the same ownership
8. Contractual relations
    a. With written contract
    b. Without written contract

Etc. – many other groupings can easily be imagined.

The combinations of all these categories may be described as a multidimensional matrix with a large number of cells, many of which are nonsense. However, if we want to find a suitable definition of industrial symbiosis, we should start with deciding which of these many combinations of categories should be excluded and which should be included in the definition. The phrasing of a definition will become much easier then.

Let us consider the categories. Which are reasonable and practical to include? I think there are good reasons not to include too many categories, since this might lead to too many projects, making industrial symbiosis "too thin a cup of tea."

Here are my opinions:

1. The type of cooperation
    a. Transfer from a donor to a receiver. This should be included.
    b. Sharing of joint facilities. This group may be doubtful. A few of the Kalundborg projects can be described as 1.b. Other projects of this type are not likely to be perceived as being industrial symbiosis. Will also depend on which of the others properties it is combined with.
2. The type of matter exchanged
    a. Water. To be included. Half of the Kalundborg projects are on water.
    b. Energy. To be included.
    c. (Solid) waste. To be included.
    d. Immaterial. This is questionable. In Kalundborg, we have considered such projects a spin-off effect, which did not count as industrial symbiosis, but admit that you could advocate for the point that many "software" projects may be just as beneficial as the project with mass or energy transfer.
3. The physical phase of the matter transferred
    a. Solid. To be included.
    b. Liquid. To be included.
    c. Gaseous. To be included.
    d. Electronic/electric. Transfer of electric energy should be included. Electronic: same considerations as under 2.d.
    e. Abstract. Should probably be excluded, since a delimitation may be very difficult (Sharing of know-how by patent licensing would then be industrial symbiosis).
4. Distance of transfer
    a. Within local industrial area. To be included.
    b. Outside local industrial area. To be included. Distance is not important.
5. Means of transfer
    a. Pipeline. To be included.
    b. Truck/train/ship. To be included.
    c. Electric. To be included for energy transfer.

   d. Electronic communication. Depending on 2.d.
   e. Printed communication. Depending on 2.d.
   f. Personal communication. Depending on 2.d.
6. Quantifiability
   a. Quantifiable. To be included.
   b. Non-quantifiable. To be discussed. May be relevant to include in some cases, but transfer of something that cannot be measured or counted will at least create problems by comparing and making statistics.
7. Relation between donor and receiver
   a. Donor and receiver have totally independent ownership. To be included.
   b. Donor and receiver are legally different, but have some degree of common ownership. A typical grey zone. A number of future potential projects in Kalundborg may belong to this group.
   c. Donor and receiver have the same ownership. Not to be included, for the reasons stated earlier (Too many projects, too many unknown).
8. Contractual relations
   a. With written contract. To be included. All Kalundborg projects are this category.
   b. Without written contract. Questionable, but probably with minor importance, since all agreements of a certain size by tradition will be documented on paper or electronically.

My conclusion is that we could simplify the debate to only discussing five points: 1.b, 2.d, 3.d, 6.b, and 7.b. When we have decided on these points, a phrasing of a definition could be much easier.

Liddy Karter, Industrial Symbiosis Capital, USA – I have another piece of definition that I always have in mind. I wonder whether the materials being transmitted have to have a zero or negative value.

Jørgen Christensen, JC consult, Denmark – It would be hard since it enters into a context. Even if it has a negative value, it can be used as a positive value resource.

Marian Chertow, Yale University, USA – I can see already that we are entering into a complicated discussion. Questions raised are at different levels and we all see industrial symbiosis from our perspective. From Kalundborg, the Center of the Universe, you will see it one way. In a completely different economic system like China, you will see a completely other way. So, I'm going to ask you all something very hard. Try not to think from your own position, not to think from where you are. Let's try to stick to the fundamental question.

Anne Hewes, Ecomaine, USA – As a starting point, let's discuss physical exchange of the material.

Gary Foster, NISP, UK – What about office space?

Marian Chertow, Yale University, USA – In our research groups, we talk about material exchange, utilities and service sharing. And we always fight about service sharing.

AliciaValero, CIRCE, Spain – Just a question because I'm rather ignorant about this field. When the mining industry provides materials to, let's say, a power station, is that industrial symbiosis?

Marian Chertow, Yale University, USA – I guess I have a leaning that it would be some kind of a by-product or waste. Do you try to talk about raw material?

Alicia Valero, CIRCE, Spain – What about coal waste, is that a physical exchange of material?

Marian Chertow, Yale University, USA – Is a single exchange ever "industrial symbiosis?" I think we could highlight that question. I think material exchange can be part of industrial symbiosis, but industrial symbiosis can have more parts. It does not mean that we should not do the exchange, or we should start it somewhere else. But the reason that we chose 3-2 is to show that industrial symbiosis is a little more complicated than a single exchange, it involves human behavior, cooperation, and elements that are not just transactional.

Inês Costa, IN+/IST, Portugal – If I look back, many industry examples of exchange already exist. Think of a cement company and power station. For years, they have been exchanging ash to incorporate it in cement and cement companies have been receiving sludge to incorporate it in clinker. This has been a common practice for many years. So, suddenly, we come along and say, this is industrial symbiosis and you will be happy to place a new label on it.

Marian Chertow, Yale University, USA – Does that mean that it is not industrial symbiosis since it has been going on for years and years?

Jorgen Christensen, JC consult, Denmark – Exchanges existed before industrial symbiosis was named.

Marian Chertow, Yale University, USA – So, it is not that we are saying that industrial symbiosis has to do with intent. It was not environmental intent when industries started to exchange many years ago.

Inês Costa, IN+/IST, Portugal – What do you mean? Does that mean that you have to have a purpose right from the beginning?

Marian Chertow, Yale University, USA – No, it can change over time. But industrial symbiosis embeds some kind of environmental intent.

Robin Branson, University of Sydney, Australia – Can I offer a definition of waste, which makes discussion easier? I think that waste is something that a generator does not want. If the only disposal route is to dump it, then any attempt to divert that material away from dumping can be classified as industrial symbiosis. Merely because the generator of the material does not want it does not mean that the material has no value and it does not mean that the material cannot be used by another organization. That is the way that I reconcile my experience with an academic definition. My reaction to your question about multilateral industrial symbiosis is that industrial symbiosis is a bilateral arrangement, and the industrial network is the accumulation of bilateral arrangements. That is how Kalundborg developed. In my opinion, it is an industrial ecosystem. Inge Christensen said that had she read the paper by Frosch and Gallopolous, which was only published three months before Inge and Valdemar had their conversation inventing the term industrial symbiosis, she would have used the expression "industrial ecosystem."

Guillaume Massard, Université de Lausanne, Switzerland – We're quite new to industrial ecology in Switzerland and actually other faculties say that "Sorry, we're working on this for years." Efficient recycling systems that exist in Switzerland come from somewhere else and a lot of solutions are already there. Does industrial symbiosis want to be an academic field of study or a description?

Anne Hewes, Ecomaine, USA – It is an interesting question. I came with a premise of what we're talking about – waste by-products. Those of you who have been working in this area for a while took that assumption. So, I feel humbled for your comments. Any material that is being used as a commodity is industrial symbiosis. I don't know whether we need a preface of a definition from the start.

Pauline Deutz, University of Hull, UK – Let's not define, then there will be no future discussions. The 3-2 heuristic is appropriate for describing networks. Also, there are different scales – I think industrial symbiosis and industrial ecology are beyond scales.

Xudong Chen, NIES, Japan – I'd like to raise two points. The first one is, why don't we take from something that already exists, for example, economic geography or mathematical modeling? Second, it's a pity for planners to talk about these things. So far, we don't have many successful cases of planned EIPs, why is that? Why should planners be a part of this discussion while no contributions to the real practice? I think that is the part we should talk about rather than a definition. The reason I guess, to my mind, why it was not successful to plan EIPs is that we do not know yet the mechanisms of exchange. We only observe what we have observed.

Gemma Cervantes, Nat. Tech. Inst., Spain/Mexico – If we look at the definition of symbiosis in nature, it is interactions among two living organisms for mutual benefits. However, experiences and beliefs lead to the 3-2 heuristic and this is industrial symbiosis for networks. It targets more than two organisms and come to regional definition by adding more aspects.

Tian Jinping, Tsinghua University, China – Most of us are from universities and only few from business. Industrial symbiosis must be both environmentally favorable and economically profitable. In China, industrial symbiosis also means, to some extent, "Circular Economy." "Circular" refers to method and "Economy" refers to the end result. There should be positive benefits to the economy in order to implement industrial symbiosis by involving businesses.

Megha Shenoy, Resource Optimization Initiative, India – I was wondering about whether it is still industrial symbiosis if there are mutual benefits for two parties involved in exchange, but not for the system itself, or people around the parties.

Gary Foster, NISP, UK – Let's incorporate social dimensions as well in addition to environment and economic benefits.

Andreia Minulescu, Tomas Bata University, Czech Republic – I'm curious whether it should be a good definition or a true definition.

Marian Chertow, Yale University, USA – So, that raises the question of environmental benefits, but what if there are also environmental costs. Are we concentrating too much on measuring environmental benefits, not enough on examining the costs?

Ankit Aggarwal, Technical University Munich, Germany – I don't know how geological proximity and an intent of doing something for environment can be combined together. Even though we want to replicate the successful Kalundborg model in India, the same approach or intent of doing good won't work there since the two countries are different.

Philipp Rosenthal, IfaS, Germany – We have a similar term in Germany called material flow management. It refers to a responsible and efficient way of dealing with flows of material and energy in a system to reach social, environmental, and economic benefits. It is very simple, but you can have a multitude of different aspects in that term.

Emilia Rutkowski, UNICAMP, Brazil – If there is no environmental aim/goal, whether it is at local, regional, or at global level, then it is just business as usual.

Gemma Cervantes, Nat. Tech. Inst., Spain/Mexico – I explain the difference between industrial symbiosis and industrial ecology in terms of objectives. While there is not much social consideration in industrial symbiosis, industrial ecology considers all three objectives, economics, environmental and social. This is not exactly true when observing Kalundborg, but this is because the Kalundborg model is moving into industrial ecology.

Gabriel Grant, Yale University, USA – I'd like to argue exactly opposite. The social objective is the prerequisite to establish trust required in the organizations that actually implement synergies.

______________ - That is between the two firms. It has no broader social context. Industrial symbiosis has to start with environmental objectives.

Hung-Suck Park, University of Ulsan, South Korea – When we consider industrial symbiosis, we consider biological symbiosis. It is an optimization process to enhance eco-efficiency and industrial symbiosis is the same concept. To enhance the efficiency, two sides of innovation are required: one is technological innovation and the other is mindset innovation. We should share and exchange visible and invisible resources. A definition is already made, but we need common understandings. Industrial symbiosis can be viewed differently according to different views and backgrounds, so we need to reconcile varying perspectives, such as engineering or sociological perspectives.

Marian Chertow, Yale University, USA – You include eco-efficiency within the optimization and that brings an environmental aspect.

Inês Costa, IN+/IST, Portugal – The environmental objective doesn't have to necessarily come from companies themselves. That is why we have policy and government. Government can set the environmental goal and companies just have to respond to that in an economic way. Part of my research is looking at government – government is missing in industrial symbiosis. We need to consider two agents, business and government.

Michelle Adams, Dalhousie University, Canada – We should not define industrial symbiosis with intent. Kalundborg did not start from the environmental intent and definition based on intent would preclude situations that we built on.

Guillaume Massard, Université de Lausanne, Switzerland – In Europe, many projects start from public funding. The goal of public funded projects is to coordinate and to communicate to achieve environmental purpose.

Xudong Chen, NIES, Japan – I'd like to divert discussion into students' point of view. I study industrial ecology and industrial symbiosis as a discipline. I know this is an infant stage of the study, but I even could not define whether it is social science or natural science. It is hard to define what it is and what can we do with this interdisciplinary study.

____: Is it emergent process or can it be planned?

Marian Chertow, Yale University, USA – That is the question. Formally, I have a piece of work called "Toward a theory of industrial symbiosis" written with John Ehrenfeld. We say that when exchanges happened a long time ago, it was probably for economic reasons. Only later do we recognize it as industrial symbiosis. I'm okay with that as far as we can stimulate more, whether with environmental intent or government funding. There are definitely emergent varieties. How much do we have to reconcile?

Robin Branson, University of Sydney, Australia – Environmental imperative is implied in sustainability benefits.

Marian Chertow, Yale University, USA – Sure, and sometimes we have to remind ourselves there it isn't "how many exchanges do you have" that makes your industrial symbiosis better than somebody else's. Sometimes we fall into that trap, but it is the amount of sustainability and environmental benefit that counts.

Emilia Rutkowski, UNICAMP, Brazil – Is industrial symbiosis descriptive or prescriptive?

Gabriel Grant, Yale University, USA – What is the intention of our definition? Because we brought up a lot of different points and nuances, and if you cannot create any definition out of this, it can turn people off. Is it the intention to be able to look at something and say what is industrial symbiosis and what is not, or is it the intention to inspire?

Marian Chertow, Yale University, USA – I have no intention, personally. I think we want to increase our common understandings. We want to start to look at the mechanisms behind this.

Megha Shenoy, Resource Optimization Initiative, India – How shall we weight different benefits of industrial symbiosis, for example, environmental, economic and social benefits? For example, in India, a large percentage of people are employed in recycling markets, but if environmental benefits are higher when directly exchanging waste within companies than having people employed in recycling markets, then should recycling markets be closed?

Peter Lowitt, Devens Enterprise Commission, USA – I think we should have a broader definition, one which is based on ecology, one which is recognized as recyclers as well as other types of exchanges. It is all part of the system. I would argue that we need to understand it holistically. We should be open to remembering that a whole idea is supposed to be modeled on ecology and natural systems.

Hung-Suck Park, University of Ulsan, South Korea – If we use industrial symbiosis as a tool, the overall value will increase, based on my experience as a director and coordinator in Ulsan Eco-center in South Korea.

Fujita Tsuyoshi, NIES, Japan – Let's make a focal point. We need a goal for industrial symbiosis, but the problem of goal setting is that it is totally different from engineering goal. Industrial symbiosis has social dimensions. Also, we should definitely provide added values. Integration would be a key for adding values.

Jooyoung Park, Yale University, USA – There are different ways to reuse material, so if you try to label all different ways, it becomes complex. I want to start with a simple belief that we share: we believe that all materials have value. Commonly valued materials are already traded within the traditional market. However, the reason why phenomena observed in Kalundborg surprises us is that they started reusing certain materials whose value had not been widely recognized since economics do not provide precise signals for those materials. Thus, I would rather define industrial symbiosis as the marketing activity for enhancing the recognition of the value of wasted materials.

WRAP-UP – CLOSING REMARKS

Brainstorm of Potential Future Topics

Liddy Karter, Industrial Symbiosis Capital, USA – What is the most available waste stream within a certain geographic boundary for the highest potential of success in terms of profitability and environmental efficiency? What will it take to get that implemented: is it carbon credits, capital, legislation, or high cost of landfill?

Valdemar Christensen, Denmark – The world needs food and biomass. It also needs water for irrigation. Water comes from water treatment and purification systems. However if this water is sent to the sea it kills fish. This flow is an interesting question to start.

Xudong Chen, NIES, Japan – The first interesting question would be identifying a baseline for different cases, for example between developing and developed countries. Second is about defining the scale and methodology of the study.

Gemma Cervantes, Nat. Tech. Inst., Spain/Mexico – Sustainability metrics for industrial symbiosis to evaluate the triple bottom line benefits and costs.

Philipp Rosenthal, IfaS, Germany – We can think about designing UNFCC methodology for industrial symbiosis credits to be approved by CDM.

Michelle Adams, Dalhousie University, Canada – Our group is studying the influence of the governance structure of organization on the willingness to participate in industrial symbiosis.

__________ - Despite the success of Kalundborg case, policy-makers don't know about this. We can do some research on how to make policy-makers aware of industrial symbiosis in order to build laws and regulations that provide incentives for industry to adopt industrial symbiosis.

Jørgen Christensen, JC consult, Denmark – How can we implement industrial symbiosis? We need awareness, willingness, and communication. Limitations lie in the human relationships, not so much in technical aspects.

Shi Han, Yale University, USA – The fundamental approach to the environmental problem is how we can speed up the internalization process of environmental externalities. Conventional economic frameworks address this. Are there alternatives to this?

Shishir Behera, University of Ulsan, South Korea – How can we create indicators for industrial symbiosis that are not too simple, but also not too complex?

Location for 2010 Industrial Symbiosis Research Symposium

Fujita Tsuyoshi, NIES, Japan – The 7th ISRS in 2010 will be organized by three countries, Japan (NIES), China (Chinese Academic of Science), and Korea (University of

Ulsan). It will be held in conjunction with the MFA ConAccount meeting and the Asia-Pacific ISIE meeting in order to reduce carbon footprint and increase benefits for participation. Location would be an EIP or Eco-town city in one of these countries including Kawasaki and Ulsan. The date is temporarily decided to be November 8th or 9th. I will guarantee a happy hour!

Closing Remarks

Marian Chertow, Yale University, USA – Even though industrial symbiosis has a short history, we want to honor our history. As we have seen over these past few days, Kalundborg is both historic and constantly adaptive. Thank you to the organizing committee, Jørgen, Jane, John, Ray, Peter, Gabriel, and Melanie.

APPENDIX I. PROGRAM BROCHURE AND AGENDA

Researchers from all over the world will discuss and exchange experiences on the contribution of industrial symbiosis to the reduction of greenhouse gases and other sustainability issues. Industrial Symbiosis refers to clusters of companies exchanging resources across firm boundaries, especially water, energy, and materials. The term Industrial Symbiosis was created in Kalundborg, home of the most famous example of industrial symbiosis in the world. The Symposium will begin in the afternoon of June 18, and will end before lunch on June 20. The Symposium is organized in cooperation with the Center for Industrial Ecology at Yale University's School of Forestry and Environmental Studies and the International Society for Industrial Ecology - Section on IS/EIDC. The International Society for Industrial Ecology holds its 2009 Conference "Transitions toward Sustainability" immediately after the Symposium, June 21-24 in Lisbon, Portugal.

When		**What**
Thursday 18 June 2009	12.00 – 15.00	Arrival and registration Check in at Roesnæs Conference Centre
	15.00 – 15.15	Opening Remarks
	15.15 – 17.15	Around the World - exchange and update on global symbiosis initiatives
	17.15 – 17.30	Break
	17.30 – 18.00	The Clean Development Mechanism and Industrial Symbiosis (Kristian Brüning , Climate Wedge Ltd. Helsinki, Finland)
	19.00	Dinner and Welcome by Mayor
Friday 19 June 2009	8.30 – 9.00	Measurement of CO2 Emission Reduction from Industrial Symbiosis in Japanese Eco Towns (Tsuyoshi Fujita, National Institute for Environmental Studies, Tsukuba, Japan)
	9.00 – 9.30	Quantifying Energy and Environmental Benefits of Secondary Material Use in Pennsylvania (Matthew Eckelman, Yale University, New Haven, USA)
	9.30 – 10.00	Coffee break
	10.00 – 10.30	The Identification, Measurement, Reporting and Verification of Carbon Output in a Facilitated IS Network (Gary Foster, National Industrial Symbiosis Programme, Hampshire, UK)

When		What
	10.30 – 11.15	Plenary discussion
	11.15 – 11.30	Break
	11.30 – 12.00	Kalundborg Industrial Symbiosis Today (John Kryger, Symbiosis Institute, Kalundborg, Denmark)
	12.00 – 12.15	Sustainability-conscious Design (Jeanette Agertved Madsen)
	12.15 – 12.30	Reuse of Ethanol and Energy from Ethanol Regeneration at Novo Nordisk (Lars Raagert)
	12.30 – 14.00	Lunch
	14.00 – 14.45	Panel conversation with Kalundborg IS veterans (managers from the 1980's who are still around)
	14.45 – 18.00	IS Excursions around Kalundborg
	19.00	Symposium Dinner
Saturday 20 June 2009	8.30	Check Out from Conference Center. Bus transfer to the Industrial Symbiosis Institute
	9.00 – 9.45	When is IS, IS?
	9.45 – 10.30	Cultivating IS – Opportunities, Challenges and Necessary Steps
	10.30 – 11.00	Closing remarks – on the way to the 7th symposium
	11.15	Departure (Direct bus to the airport for participants to the ISIE Conference in Lisbon)

Industrial Symbiosis

The Industrial Symbiosis in Kalundborg is a resource and environmental network between a number of industries and the utilities supply department of the municipality. This symbiosis has developed over more than thirty years and consists of some 25 bilateral, commercial agreements in which water, energy and waste is exchanged.

The Industrial Symbiosis Institute

The Industrial Symbiosis Institute in Kalundborg is a cooperation among 8 partners, financed by the partners. The fields of responsibilities of the Industrial Symbiosis Institute are:

- Collection of information about the Industrial Symbiosis and other examples of industrial ecology
- Communication of experience from the Symbiosis project
- Organization of visits and study tours about the Symbiosis
- Co-ordination of studies about the Industrial Symbiosis
- Consultation about new symbiosis projects
- Contributions to forming new symbiosis projects

Kalundborg

Kalundborg is a modern, thriving and bustling provincial town, situated right in the middle of Denmark. There are 49,000 inhabitants in the municipality and 20,000 in the town itself. The biggest employers in Kalundborg are Novo Nordisk A/S, Novozymes A/S, Gyproc, StatoilHydro A/S, and The Asnaes Power Station (Dong Energy). Kalundborg Harbour is one of the biggest and deepest ports in Denmark, and is very international. Kalundborg is also famous for its old mediaeval town with the five-towered church from around 1200. Roesnaes is a beautiful peninsula with its hills and view to North Funen, Samsoe, and Mols.

Venue

The symposium takes place at the Roesnaes Conference Centre, 5 km from the centre of Kalundborg. This hotel and conference centre is situated on the South side of the peninsula of Roesnaes and has a panoramic view over the water. The beautiful main building is only 50 meters from the water and is surrounded by green fields and a nice garden in old English style.

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<u>Industrial Symbiosis Research Symposium</u>

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