Industriële symbiose: een casestudy in Kalundborg (Denemarken).
Symbiose industrielle: le cas de Kalundborg (Danemark).

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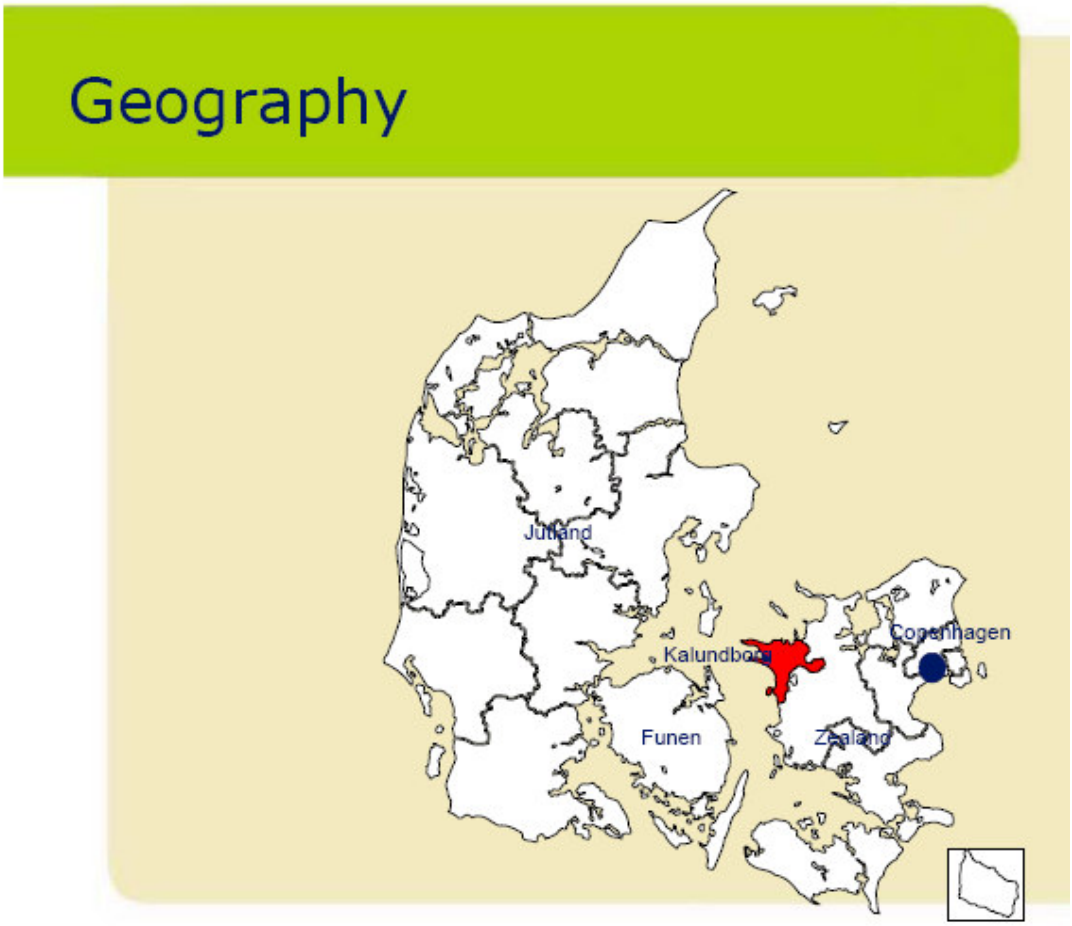
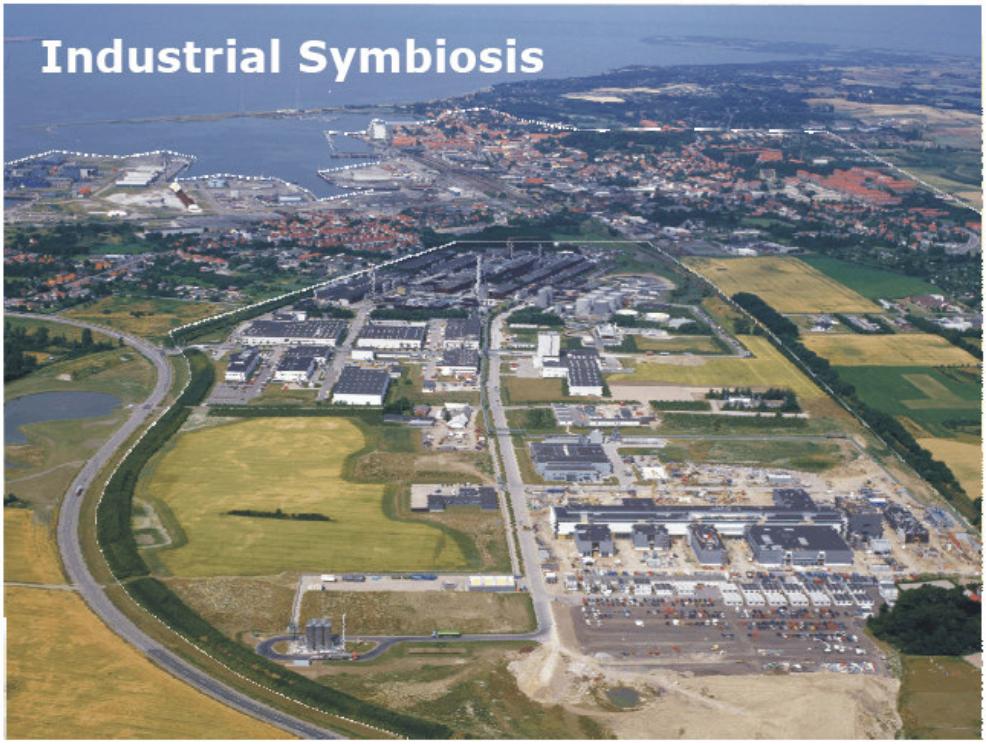
1 INTRODUCTION. LOCATION OF THE PROJECT.

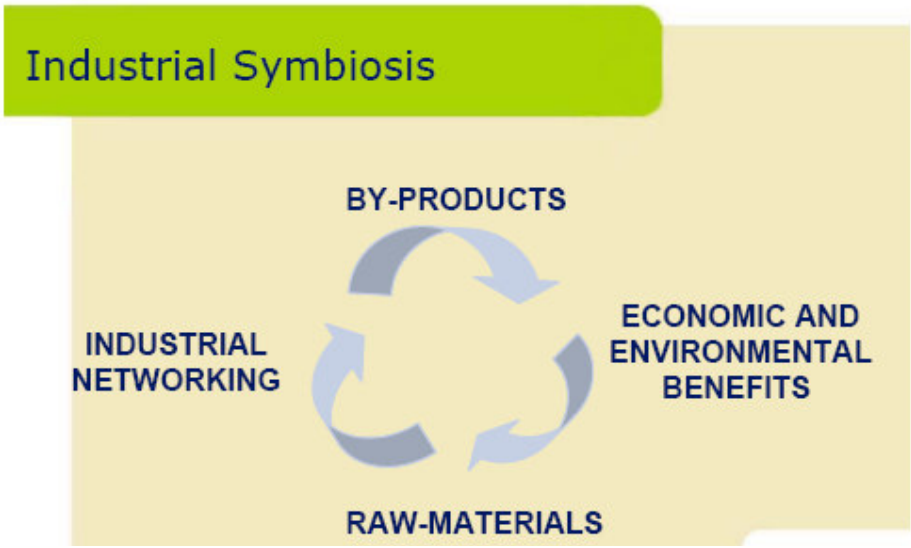




Industrial Symbiosis

Symbiosis is collaboration between different organisms for mutual benefit.

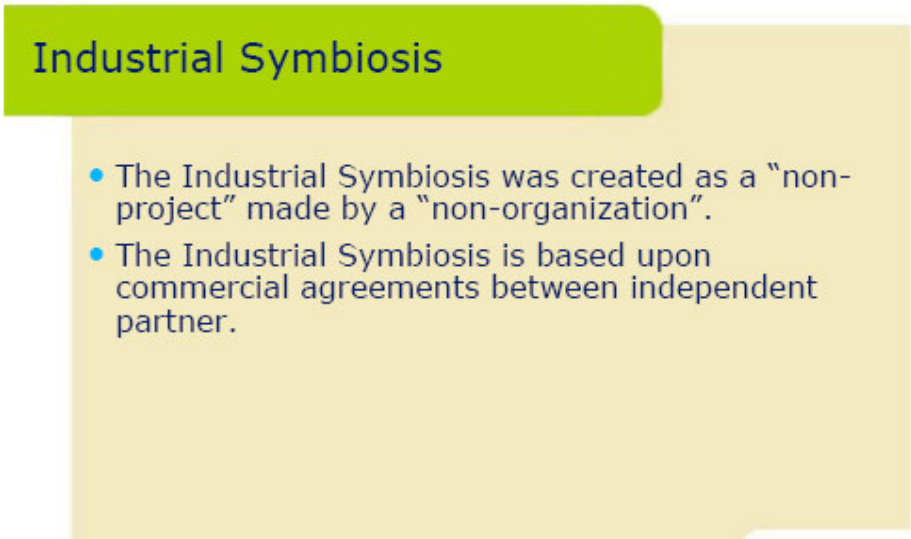
The clown fish and sea anemones



2.BACKGROUND AND PARTICIPANTS.

(from UNEP, 2001. Environmental Management for Industrial Estates, - Information and Training Resources Case Study/Kalundborg.

The history of Kalundborg really began in 1961 with a project to use surface water from Lake Tissø for a new oil refinery in order to save the limited supplies of ground water (Christensen, 1999). The city of Kalundborg took the responsibility for building the pipeline while the refinery financed it. Starting from this initial collaboration, a number of other collaborative projects were subsequently introduced and the number of partners gradually increased. By the end of the 1980's, the partners realised that they had effectively "self-organised" into what is probably the best-known example of a working industrial ecosystem, or to use their term – *an industrial symbiosis*.



Gyproc

Production of plaster boards.

165 employees.

Asnæs Power Station

Production of electricity and heat.

250 employees.

Denmark's largest power station.

Statoil Refinery

Production of gasoline and other oil-based products.

330 employees.

Denmark's largest oil refinery.

STATOIL

Novozymes
Production of industrial enzymes

Alltogether 3000 employees

novozymes

Novo Nordisk
Production of insulin etc.

novo nordisk

Municipality of Kalundborg

Distribution of
water and energy.

Population: 20,000.

Soilrem A/S

Remediation of
oil and metal
polluted soil.

65 employees.

A/S Bioteknisk Jordrens

3. MATERIAL AND ENERGY FLOWS IN HISTORICAL PERSPECTIVE.

(from UNEP, 2001. Environmental Management for Industrial Estates, - Information and Training Resources Case Study/Kalundborg.

It is important to understand initially that ***water*** is a scarce resource in this part of Denmark and is therefore systematically valorised. As we mentioned above, in order to reduce consumption of ground water, Lake Tissø has become the main source of water for the industrial partners in Kalundborg. The reduction in the use of ground water has been estimated at close to 2 million cubic metres per year (Christensen, 1999). However, in order to reduce overall water consumption by the partners, the Statoil refinery supplies its purified wastewater as well as its used cooling water to Asnæs power station, thereby allowing this water to be "used twice" and saving additionally 1 million cubic metres of water per year. Asnæs power station supplies ***steam*** both to Statoil and Novo Nordisk for heating of their processes. By functioning in a co-generation mode, the power station is able to increase its efficiency.

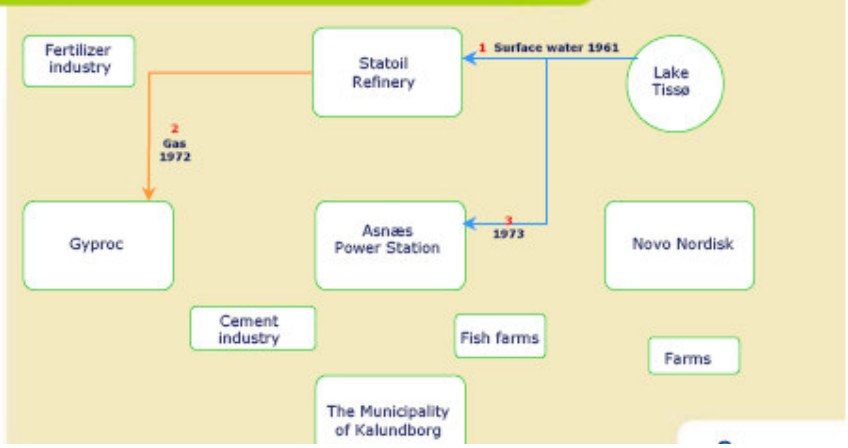
Excess gas from the operations at the Statoil refinery is treated to remove ***sulphur***, which is sold as a raw material for the manufacture of sulphuric acid, and the clean ***gas*** is then supplied to Asnæs power station and to Gyproc as an energy source.

In 1993 Asnæs power station installed a desulphurisation unit to remove sulphur from its flue gases, which allows it to produce ***calcium sulphate*** (gypsum). This is the main raw material in the manufacture of plasterboard at Gyproc. By purchasing synthetic "waste" gypsum from Asnæs power station, Gyproc has been able to replace the natural gypsum that it used to buy from Spain. In 1998 approximately 190,000 tons per year of synthetic gypsum were available from the power station.

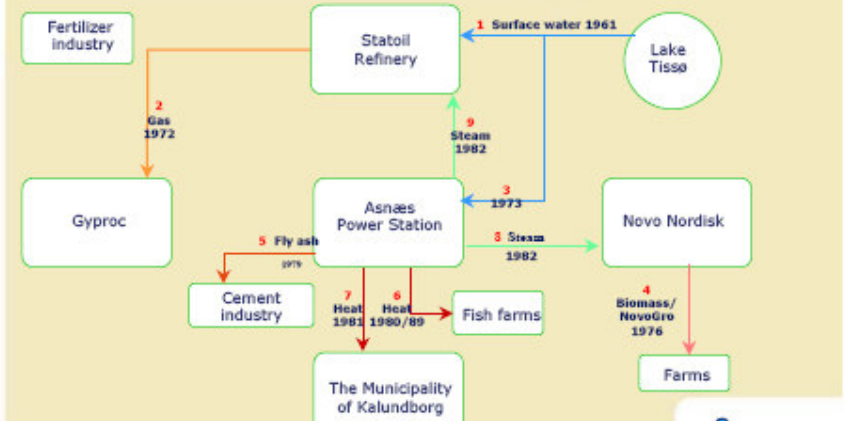
Novo Nordisk creates a large quantity of used bio-mass coming from its synthetic processes and the company has realised that this can be used as a fertiliser since it contains nitrogen, phosphorus and potassium. The local farming communities use more than 800,000 cubic metres of this liquid ***fertiliser*** each year as well as over 60,000 tons of a solid form of the fertiliser.

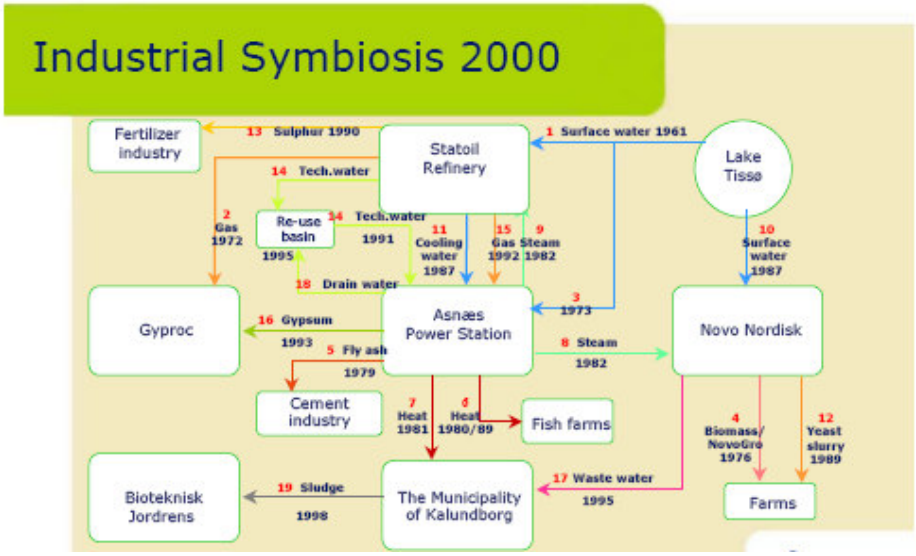
Finally, residual ***heat*** is also provided by Asnæs power station to the district heating system of the town. The system functions via heat exchangers so that the industrial water and the district heating water are kept separate.

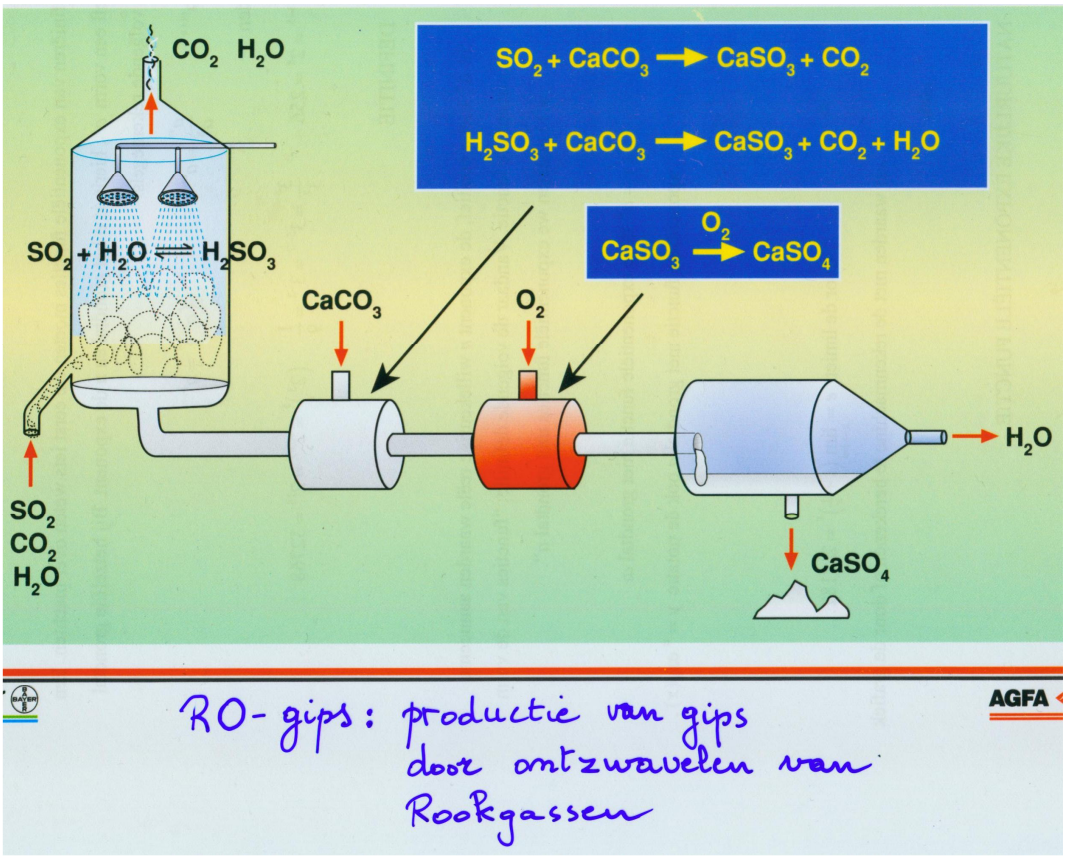
Industrial Symbiosis 1975



Industrial Symbiosis 1985







Met SO_2 vervuilde rookgassen kunnen worden gewassen met water. Door het ontstane zwaveligzuur (H_2SO_3) te laten reageren met kalksteen ($CaCO_3$) ontstaat er gips ($CaSO_4$). Dat zogenaamd sulfogips of ook RO-gips genaamd, kan als vervangproduct worden gebruikt in plaats van fosfogips(dat erg radioactief kan zijn) of van natuurgips (dat bij de winning veel landschappelijke schade kan opleveren) onder meer voor het maken van gipsplaten. Door de rook te wassen verwijdert men de SO_2 en kan verzuurde neerslag worden voorkomen (ROMBAUT,2007).

Table 1: Environmental Aspects of the Symbiosis [Erkman, 1998].

Reduction in consumption of resources	
oil	45,000 tons/year
coal	15,000 tons/year
water	600,000 m^3/year
Reduction in waste emissions	
carbon dioxide	175,000 tons/year
sulfur dioxide	10,200 tons/year
Valorisation of "waste"	
sulfur	4,500 tons/year
calcium sulfate (gypsum)	90,000 tons/year
fly ash (for cement etc)	130,000 tons/year

Industrial Symbiosis

Annual savings

- Economy: Approx.15 mio US$
- Ground water: 1,9 mill. m3/year
- Surface water: 1,0 mill. m3/year
- Oil: 20,000 ton/year
- Gypsum: 200,000 ton/year

Henrik Ehlers Wulff (2005)

4. CLOSING REMARKS.

Industrial Symbiosis

- Participants must fit together but be different.
- Each project must be economically viable.
- There has to be a short physical distance between the participants.
- There has to be a short mental distance between the participants.

Industrial Symbiosis in the Australian Minerals Industry

The Cases of Kwinana and Gladstone

Dick van Beers, Glen Corder, Albena Bossilkov, and Rene van Berkel

Keywords

by-product synergy
eco-industrial development
industrial ecology
industrial ecosystem
resource industry
utility synergy

Summary

The realization of regional synergies in industrial areas with intensive minerals processing provides a significant avenue toward sustainable resource processing. This article provides an overview of past and current synergy developments in two of Australia's major heavy industrial regions, Kwinana (Western Australia) and Gladstone (Queensland), and includes a comparative review and assessment of the drivers, barriers, and trigger events for regional synergies initiatives in both areas. Kwinana and Gladstone compare favorably with well-known international examples in terms of the current level and maturity of industry involvement and collaboration and the commitment to further explore regional resource synergies. Kwinana stands out with regard to the number, diversity, complexity, and maturity of existing synergies. Gladstone is remarkable with regard to unusually large geographic boundaries and high dominance of one industry sector. Many diverse regional synergy opportunities still appear to exist in both industrial regions (particularly in Kwinana), mostly in three broad areas: water, energy, and inorganic by-product reuse. To enhance the further development of new regional synergies, the Centre for Sustainable Resource Processing (CSRP), a joint initiative of Australian minerals processing companies, research providers, and government agencies, has undertaken several collaborative projects. These include research to facilitate the process of identifying and evaluating potential synergy opportunities and assistance for the industries with feasibility studies and implementation of selected synergy projects in both regions. The article also reports on the progress to date from this CSRP research.

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Het Fonds Duurzaam Afval- en Energiebeheer is een samenwerking tussen Indaver nv, Bond Beter Leefmilieu Vlaanderen vzw en het Actiecomité ter beveiliging van het Leefmilieu op de Linkeroever en in het Waasland (Abllo vzw). Het Fonds wordt beheerd door de Koning Boudewijnstichting. Jaarlijks wordt 125.000 Euro ter beschikking gesteld voor projecten over heel Vlaanderen.
In 2007 werd onder meer volgend project goedgekeurd:

"Inventarisatie en voorstellen tot valorisatie van reststromen in de Gentse kanaalzone" **Gent Milieu Front vzw**	**24.000 Euro**

De MilieuAdviesWinkel (het infoloket van het Gent Milieu Front) wil samen met een aantal projectpartners de reststromen van de Gentse haven in kaart brengen en de mogelijkheden van valorisatie van deze reststromen in de Gentse kanaalzone bekendmaken en promoten. Bedrijven hebben de laatste decennia belangrijke investeringen geleverd op vlak van milieuzorg. Toch zijn er nog heel wat stromen (vast, vloeibaar of gasvormig) die het bedrijf verlaten zonder dat deze een economisch nut hebben. Door middel van een inventarisatie wordt gefocust op de reststromen die het meest kans maken op valorisatie in de Gentse kanaalzone. Er wordt aandacht besteed aan het transport van reststroom van één bedrijf naar een andere, en het laagdrempelig aanbieden van reststromen aan bedrijven en potentiële investeerders. Het project wordt gerealiseerd in samenwerking met de provincie Oost-Vlaanderen, het Havenbedrijf Gent en de Vereniging van Gentse havengebonden ondernemingen (http://www.kbs-frb.be)

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