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The Industrial Symbiosis at Kalundborg, Denmark, - a case study.

by

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Summary.

The Industrial Symbiosis at Kalundborg, Denmark, is often referred to as the classic example of Industrial Ecology in practice.

The Industrial Symbiosis is an environmental network that has been developed over more than three decades. Six industries and the local municipality are co-operating through commercial agreements in order to obtain economic and environmental benefits.

The co-operation now comprises more than 20 part projects on the recycling of water, energy and waste. Many resources are being saved. When evaluated in 1998, the total investments of all these projects amounted to USD 75 million, and the annual income/saving exceeded USD 15 million.

The Kalundborg Symbiosis is constantly developed. New projects are being considered. An industrial symbiosis is never static; on the contrary, it is developed and changed under the influence of technology and market prices. In principle, the inter-dependence of the companies inside the network implies a certain risk, but in practice the disadvantages have been insignificant.

The factors that stimulate or impede the formation of an industrial symbiosis are discussed. The barriers for the introduction of an industrial symbiosis are neither technical, systematic nor environmental, but have to do with human communication and the ability to co-operate across company boundaries.

Technology never was the most important in creating a symbiosis network. The limiting factor is the communication between the potential partners.

Industrial Symbiosis does not depend on EMAS or any other certification, but may be a tool for environmental management.

Introduction.

It could be said that this presentation has not very much to do with EMAS. The Industrial Symbiosis is many years older than EMAS. On the other hand this presentation tells about a practice in environmental management that may be a profitable tool for many industries, both in existing industrial areas and for the planning of new industrial areas.

The Industrial Symbiosis at Kalundborg, Denmark is an early example of industrial, ecological practice. It is an environmental, co-operative network that has developed throughout more than three decades. It was never invented, it just happened because it made sense. It was a “non-project” created by a “non-organisation”.

Not as a carefully planned network, but as a series of individual projects which were initially quite independent of each other.

Not according to a joint managerial decision, but in the form of bilateral agreements between two of the seven independent symbiosis partners.

It was not a consequence of academic know-how, or environmental network theories, but as a result of simple attempts to create a good and commercially sound managerial practice.

This means that the original incentive to these projects was profitability and a desire to make sensible investments in order to cut down expenses. All part project agreements were negotiated on a commercial basis between two parties (a single case, however, involved four parties!). All part projects required investments and resulted in profits or savings for both parties. The total advantages were shared between the partners after normal, commercial negotiations.

The Industrial Symbiosis is the name used for the environmental co-operation between six industries and one municipality (the town of Kalundborg, Denmark). It is a network which involves the recycling of water, energy and waste, but it is more than that. It has had an impact in many fields and has, locally, created a lot of spin-off.

The Partners of the Industrial Symbiosis of Kalundborg, Denmark.

The partners of the Industrial Symbiosis are:

- Gyproc, a plaster board factory of 200 employees.
- Asnæs Power Station, the biggest power station in Denmark, with about 250 employees.
- Statoil Refinery, also Denmark’s largest, of about 350 employees and an annual production of 5 million tonnes of oil products.
- The Kalundborg Municipal Department for Supply of Water and Energy. Kalundborg is a small city of about 20,000 inhabitants (from 2007 49,000, due to merging with the suburban municipalities), located 100 kilometres west of Copenhagen.

- Novo Nordisk and Novozymes (until 2000 one company: Novo Nordisk) whose plants in Kalundborg produce insulin and industrial enzymes and employ more than 3,000 people.

Since 1982, these partners have been involved in the Industrial Symbiosis. They just did not know, because the acknowledgement of the whole concept came much later, as did the term "Industrial Symbiosis", which came into use in the late 1989.

- In 1998 a soil remediating company, SOILREM, has entered the Symbiosis Network.
- Finally, in 2001, Noveren, an intermunicipal waste handling company, has become a partner in the network.

Water, Energy and Waste.

The Symbiosis involves the recycling of water, transfer of energy and recycling of waste products. At the moment, the Symbiosis consists of 23 part projects, 12 projects of which involve water, 6 involving energy and 7 involving solid waste products. (Two steam projects are counted as both water and energy projects).

The Chronological Development of the Industrial Symbiosis.

The development of the Symbiosis has lasted for more than 30 years.

Let us consider the development:

In the year 1975, only three of the part projects existed. The first project was in fact the pipeline from Lake Tissø, which was established by the Refinery back in 1961. The new Refinery needed large quantities of water, and the municipal water supply was not sufficient. However, untreated water from Lake Tissø could serve the purpose and was much less expensive. The city of Kalundborg then built the pipeline and the Refinery financed it.

The next part project was the supply of excess gas from the refinery to Gyproc. Gas which would otherwise have been partly burned in the "eternal flame" of the refinery. The gas was now utilised as fuel for the drying of the plaster boards. (Later, the excess gas has been substituted by butane gas, and still later by natural gas).

The third project was the supply of water from Lake Tissø to the Power Station, as well.

During the next ten years projects were developed.

Novo Nordisk had a certain waste product, the used bio-mass, which was a sludge-like product consisting of dead micro-organisms that had been used in the fermentation processes for the production of enzymes. This bio-mass was initially mixed into the waste water, but from 1976, it was used as a fertiliser on local fields where it would replace inorganic fertilisers as a source of nitrogen, phosphorous and potassium.

After the first oil crisis, the Danish power stations all converted from oil to coal. This resulted in the formation of a lot of fly ash, which was initially a problem. However, they

succeeded in finding an application for the fly ash in the cement production, and now the fly ash is sold to a cement factory elsewhere in Denmark

Fish have a higher growth rate at elevated temperatures. Part of the sea water used as a coolant for the Power Station is reused in a fish farm. On a yearly basis, more than one hundred tonnes of trout are produced here.

The district heating already introduced by Kalundborg on a smaller scale in the late '70s, was expanded, and instead of the de-centralised oil heating, a double pipeline to the Power Station was built in 1981, in order that the hot circulation water could be heated directly from the Power Station.

In 1982 another two part projects were completed, which may be the most important of them all: the supply of steam from the Power Station to Novo Nordisk and to the Refinery. They were important, because they taught four parties how to co-operate: Asnæs Power Station, Novo Nordisk, Statoil and finally Kalundborg Municipality, who built the foundations that were jointly used by the district heating pipelines and the steam pipeline. In 2002, this pipeline will be duplicated.

In the years from 1986 onwards, the Symbiosis System has been expanded by twelve new part projects:

In 1987, Novo Nordisk was also connected to the crude water supply from Lake Tissø. In the same year, another project was initiated, in which used cooling water from Statoil – uncontaminated, only a few degrees warmer – was utilised at the Power Station.

Part of the bio-mass produced by Novo Nordisk consists of yeast. This yeast by-product was in fact too valuable to be used as fertiliser only. It made more sense to sell it as a pig fodder.

As the environmental rules were made stricter, it became necessary to desulphurise the gas from the Refinery. The method chosen was a catalytic process, which yields a pure, hot, yellow, liquid sulphur. This sulphur is sold for the production of sulphuric acid. (Later, this process has been changed to a process in which ammonium thiosulphate is formed. This product is then used as a fertilizer).

New environmental regulations forced the Refinery to establish a waste water treatment plant. The fine quality of the treated water enabled the Power Station to use it for certain purposes (cleaning of boilers, flushing of ashes, etc.).

The desulphurisation of the Refinery gas meant that it was now clean enough to be used as a supplementary fuel at the Power Station.

The Power Plant also had to take measures against the emission of sulphur. The smoke had to be cleaned. A method was chosen by which the smoke is treated with chalk lime (calcium hydroxide). In this process, gypsum is formed which may be used as a raw material for the production of plaster boards at Gyproc. This gypsum has replaced natural gypsum imported from Spain where it is extracted in open mines. The “industrial” gypsum has a uniform quality and performs very well in production.

In 1995, Novo Nordisk tried to develop a subsequent treatment of the already treated wastewater. This procedure was carried out in the municipal wastewater treatment plant and it turned out to be cheaper than an enlargement of Novo Nordisk's own wastewater treatment plant.

At the Power Station an artificial lake was built in 1995. It serves as a 200,000 cubic meter buffer basin for second quality water (such as the treated wastewater from the Refinery, drain water from the Power Station's own land, etc.).

In Kalundborg, is also located a soil remediation company called Soilrem, which cleans oil contaminated soil via microbiological processes. It has now been demonstrated that sludge from the municipal wastewater treatment plant will accelerate the microbiological processes.

In a period, a particular fuel, the so-called Orimulsion, was used at the power station. The fly ash from this fuel contained amount of vanadium and nickel and was used for recovery of vanadium and nickel. This recovery took place in Britain.

A few years ago, the power station also established a supply of ultra-pure, de-ionized water to the refinery.

In Denmark, ground water is the normal source of water supply. Use of surface water for production of drinking water requires special permission. Kalundborg and Novozymes got permission to build a water works to supply surface water in drinking water quality from the Lake Tissø, to be used in the production of technical enzymes. In this way the consumption of 1 million cubic metres per year was substituted by surface water

And very recently, the refinery agreed with the power station that the refinery could use sea water from the cooling water intake on the power station to be used as cooling water in a new part of the refinery.

A project of quite a different nature is the Symbiosis Institute. This small institute is organised under the auspices of the Kalundborg Regional Development Board. It is financed by the Symbiosis partners and revenues from services rendered to clients.

The purpose of the Institute is to collect information on the Industrial Symbiosis and other examples of industrial ecological practice and act as an information centre for the Symbiosis. Furthermore, the Institute is also intended to make contributions to the development of new Symbiosis projects – in Kalundborg or elsewhere - and to act as a consultant, both internally and externally.

Not only Successes.

Some projects have been suggested, but did not succeed, mostly because they were not profitable enough. One example of this is a district cooling project: The idea was to supply cooling for many different purposes to all the Symbiosis partners by way of a pipeline system from a central cooling compressor station. However, the investment turned out to be too large. Too much money had already been invested in the existing, decentralised cooling system. If the system should have been established from scratch, the project would have been profitable.

A production plant for potato starch was also planned. It would have created very good synergy with the other Symbiosis projects. Profitability, however, was too low, and the agricultural investors had to give up their plans.

The Environmental Aspect.

During the development of the Symbiosis, the environmental consciousness grew. Although profitability was the initial incentive to the Symbiosis projects, the companies involved gradually tried to achieve other objectives as well: the lowering of resource consumption, the reduction of emissions into the air, water and soil. At the same time, the companies wished to come forward as environmentally conscious. Such objectives are now prevailing.

The Symbiosis Network is presently handling considerable amounts of water, energy and waste. The resource savings are quite substantial, as well. On a yearly basis, 1.9 million cubic metres of ground water; 1.0 million cubic metres of lake water; 20,000 tonnes of oil and 200,000 tonnes of natural gypsum are saved.

The Economic Aspect.

How successful is the Symbiosis? Is it profitable? Has all the money been well spent? Economically, the Symbiosis has been a success. Each project has been carefully evaluated by the individual partners and - under the circumstances which then existed - found profitable and sensible. These considerations were not known by the other partner(s). Each party knew his own calculations only, and now, many years later, it proves very difficult to reconstruct everything in order to get a total picture of the economic aspects of a symbiosis project.

It is not possible to present a well documented overall picture. There are many obstacles: a lot of data have long been filed (or no longer exist). The central individuals in the companies may not be around, - some of them are retired, some are dead.

The investments are mostly well known and thoroughly described, but the delimitation may be difficult. What belongs to the Symbiosis and what would have been built anyway? The savings are still more difficult. Savings, by comparison to what situation?

Nevertheless, in 1998 we made an estimate. We believe that the total investments of all the projects amount to a total of USD 75 million. The annual savings for all Symbiosis partners put together exceed USD 15 million. The total savings accumulated over the years (until 1998) are likely to total USD 160 million. Today, the figures will be much higher.

The average pay back period is less than 5 – 6 years. The average made up by much different figures. For some projects (e.g. district heating, desulphurisation of gas), a very long period was accepted, because it was the best alternative. For other projects (e.g. steam, bio-mass, water), however, the pay back time was short (1-3 years). For each project, however, the best alternative has been found.

The Social aspects.

The industrial Symbiosis has had a number of spin-off effects in the local society, and has given inspiration to a lot of co-operations among private or public entities. Establishing of an Industrial Development Board, co-operation between five municipalities, establishing of joint training programmes for safety between the industries etc.

Developing the Industrial Symbiosis.

We are working hard to develop the Industrial Symbiosis even further. If we look back 10 or 15 years, the projects practically emerged "by themselves". In later years, we have been working hard to find new possibilities. Most likely, there is a potential that we have not yet exploited. The Symbiosis has already contributed to getting new industries to the area (although these industries not yet have been involved in joint projects).

There has been an increasing interest in applying the principles of the symbiosis elsewhere in the world. From about 1994 we have seen many attempts to copy the system, either in existing industrial areas or in new industrial areas (often called "Eco-industrial parks"). Many of these attempts failed initially, but after a long period it now seems that in many countries there are successful projects going on. The Rotterdam port is such an example. In Puerto Rico, an interesting project that aimed at a similar construction as in Kalundborg has been in operation for a couple of years. In China and South Korea a big number of Eco-Industrial Parks have been approved, and in Britain a big National Industrial Symbiosis Programme was launched in 2003 and is making a good progress in establishing symbiotic relationships in existing industrial areas.

What Stimulates and what Impedes an Industrial Symbiosis?

The industries must fit together. And they must be different (as two identical industries would have nothing to trade!). The geographical distance should not be too large. The length of pipelines in itself will constitute an economic limit.

Still more important, however, is the "mental distance" between the partners. Communication, confidence and a mutual understanding of what goes on in the different industries are important for the realisation of the economic and environmental potential that lie in inter-company network co-operation.

In some cases, legislation is an incentive to form a symbiosis. The environmental taxes, for instance, could encourage companies to co-operate to reduce emission and avoid taxes.

In other cases, legislation may prevent sensible solutions from being developed. For instance, if rules and regulations prevent a waste product from being moved to another place where it might be used as a raw material for another production. It is important that legislators are aware of the potential advantages of industrial symbiosis, in order that such contradictory obstacles may be avoided.

The realisation of an Industrial Symbiosis is not a technological problem. Nor an environmental problem. It is a human problem. A question of communication, of personal relations and of co-operation.

The process of change.

An industrial symbiosis is never static; it will be subject to developments, dynamics and dependence. We have experienced that the different projects change as a consequence of technological development or market prices. Some of the Kalundborg projects have lost volume during the years, two of them stopped, whereas others are getting more important and may have undergone technological changes, and new projects have emerged.

We are often asked about the dependence between the companies involved. It is true that each agreement implies a risk that it may stop one day due to changes or decisions on the part of one of the parties. In practice, however, it has less significance. In fact, the situation is not different from normal commercial purchase practice. If a company relies on one supplier only, it may become too vulnerable. It is common to have an alternative solution. In many cases the “old” solution from before the Symbiosis project may be used, but of course the advantages of the Symbiosis project will disappear.

Conclusion.

The principle of the Industrial Symbiosis is to co-operate “across borders”. It offers considerable advantages, both for the economy and for the environment. There is a substantial potential that ought to be used, both in existing industrial areas and in new “Eco-Industrial parks”. The barriers for the introduction of Industrial Symbiosis are neither technical, nor systematic or environmental, but have to do with human communication.

The Industrial Symbiosis is not a technological or an environmental phenomenon, but it is a management discipline.