New technologies and innovation through Industrial Symbiosis

The key element of industrial symbiosis is: **working together to find new solutions.** New solution to problems in relation to making by-products commercially interesting as new resources to production processes – or finding new solutions to new and innovative ways to utilise by-products in new processes.

The systematic use of the Industrial Symbiosis concept was coined in Kalundborg several decades ago, but is still not common practise in other industrial parks.

The challenges of the future are:

- Including new and alternative energy sources in the symbiosis energy cooperation. Biomass as fuel or biogas, solar energy or geothermal energy.
- Minimising the use of natural water resources by utilising cleaned waste water as process water
- New and innovative ways to utilise by-products and waste materials as raw materials.

The member companies of the symbiosis do every effort internally to improve their internal efficiency. The symbiosis cooperation is focussing on optimising the use of those bi-products the companies themselves cannot utilise internally.

The Symbiosis Concept:
One company’s by-product becomes an important resource to one or several of the other companies in the Industrial Symbiosis network. The outcome is reduced consumption of resources and a significant reduction in environmental strain. Cooperation generates better results and makes it possible for each enterprise to increase production without necessarily to increase the use of energy, water and new raw materials.

More than 25 different symbiosis projects are on-going to day. All projects with a positive environmental impact and a positive economic result.

We make every effort continuously to improve efficiency and environmental performance.
The basis of the Industrial Symbiosis cooperation in Kalundborg is **openness, communication and mutual trust** between the partners. The Symbiosis Institute assists and facilitates the companies identifying new activities improving the environmental performance.

The members of the Industrial Symbiosis in Kalundborg are:

- Asnæs Power Plant, the **energy** provider
- Gyproc, the **plasterboard manufacturer**
- Novo Nordisk, the **pharmaceutical manufacturer**
- Statoil, the **oil refinery**
- RGSgo, the **soil remediation company**
- Kara/Noveren, the **waste collection company**
- Kalundborg Municipality

**Examples of Symbiosis Projects**

**Energy savings**

The Asnæs Power Plant, DONG Energy A/S, is producing 10% of the electricity consumption in Denmark. Excess heat from the electricity production is utilised as process steam in some of the symbiosis enterprises, and as central heating for the city.
The excess heat from the Asnæs Power Plant electricity production is used as process steam and central heating. Statoil A/S Refinery, Novo Nordisk A/S and Novozymes A/S receives approximately 1.5 mio. GJ as process steam annually. This use of excess heat is equivalent to more than 75,000 family houses annual use of electricity and equivalent to approximately 240,000 tons CO2.

The symbiosis will optimise the process steam cooperation and return up to 150,000 m3 steam condensate to the Asnæs Power Plant. A good example of updating older and successful projects.

The symbiosis is working on attracting new and innovative enterprises to utilise more of the excess heat from the Asnæs Power Plant.

Inbicon A/S, a technology company owned by DONG Energy A/S, is erecting a 2nd generation bio-ethanol plant next to the power plant. This is a perfect example of new and innovative production joining the process steam network. The new bio-ethanol plant is operated on straw - a by-product in the agricultural sector. The use of steam and delivery of biomass as fuel in the power plant improves the overall CO2 account with more than 25,000 tons CO2 – not included the CO2 reduction from the replacement of bio-ethanol in gasoline and diesel.

Steam is received at the Novo compound and distributed to Novo Nordisk A/S and Novozymes A/S production facilities.

**Water savings:**

Recycling and reuse of water between the enterprises saves 3 mio. m3 of water from nature. The annual intake of new water is today only 7 mio. m3 each year. Groundwater and surface water from Lake Tissø is precious resources, and each company is doing their best to optimise the water efficiency.
Treated waste water is pumped to the power station for use in flue gas treatment. Water is reused 3 to 4 times between the Statoil A/S Refinery and the Asnæs Power Plant. The reuse of cooling water as process water, delivery of deionised water and steam, and the final use of treated waste water in the flue gas treatment process is an example of high efficient water usage.

Why not reuse treated waste water as process water after additional sterilisation and treatment? The cooperation between the Kalundborg WWTP and the Novozymes WWTP has resulted in a very effective and efficient treatment of waste water. The Municipal Central waste water treatment facility is the most modern and efficient water treatment facility in Northern Europe.

Using excess heat from the Asnæs Power Plant to sterilise treated waste water – adding a new step of treatment can produce clean process water for industrial processes. With the growing demand for clean process water the global market is open for export of new environmental technologies.

By-product exchange:

More than 98% of the sulphur in the flue gas from the Asnæs Power Station is removed in the desulphurisation process. The by-product industrial gypsum is produced by adding calcium and recycled treated waste water:

\[ \text{SO}_2 + \text{CaCO}_3 \rightarrow \frac{1}{2} \text{O}_2 + 2\text{H}_2\text{O} = \text{CO}_2 + \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \]

Industrial gypsum (CaSO4) is utilised by the plasterboard manufacturer Gyproc A/S and replaces imported natural gypsum.

In the Asnæs Power Plant flue gas cleaning process, calcium and water is mixed with the sulphur in the flue gas. Industrial gypsum (CaSO4) is produced and delivered to Gyproc A/S Plasterboard Company. In addition used plasterboards are collected at Kara/Noveresen collection sites and returned for reuse to Gyproc A/S. In total it means that gypsum equivalent to more than 15 million m2 plasterboards is replacing natural imported gypsum at Gyproc A/S in Kalundborg.

The insulin production of Novo Nordisk A/S also provides feed for pigs. One of the bi-products from the yeast fermentation producing insulin is converted into yeast slurry. The yeast slurry replaces approximately 70% of...
the traditional soy proteins in traditional feed mixes. In the yeast slurry facility, Novo Nordisk A/S is adding sugar, water and lactic acid bacteria to the yeast making it more attractive to the pigs.

The WWTP at Novozymes A/S a high-tech and the biggest industrial WWTP in northern Europe. Industrial waste water equivalent to 1.5 mio. PE is treated annually at the plant.

After inactivation and hygienisation, the approximately 150,000 tons of spend biomass is converted to the fertilizer NovoGro®. NovoGro® is delivered to more than 600 farmers on Zealand and is replacing up to 60% of the fertiliser needs depending on the crops produced.

RGS 90 A/S is treating 250,000 tons of oil and chemical polluted soil in their facility in Kalundborg. RGS 90 A/S is using sludge from the Central WWTP as nutrient to the bio-remediation process. After treatment the clean soil is utilised as filing material at various construction sites on Zealand. The soil remediation site in Kalundborg is the biggest and most advanced in Denmark.

Kara/Noveren I/S are the biggest waste collection company on Zealand. More than 80% of the waste collected is recycled as raw materials in paper, plastic, metal or building material production. Waste from households are collected and incinerated at the combined heat and power plant in Roskilde. Household waste from more than 150,000 families is providing heat and electricity to more than 1/3 of these families.

1.5 mio. tons of household waste is incinerated, generating electricity and central heating to the houses around Roskilde.

The Industrial Symbiosis in cooperation with nature.