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HOW TO SAVE AND RECYCLE WATER WITHOUT COMPROMISING PRODUCT QUALITY

Improving water efficiency in the food and beverage industry

INSIDE THIS WHITE PAPER

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How to save and recycle water without compromising product quality
Improving water efficiency in the food and beverage industry
Version 2.1

Front page photo
Cover photo showing water use in food industry.
Photo: Danish Crown

About this white paper
This white paper is developed by the Rethink Water network in Denmark. The work is coordinated by the Danish Water Forum and State of Green.

The Rethink Water network consists of more than 60 technology and consulting companies, water utilities, water organisations and governmental bodies. It was established to support our partners internationally in developing the highest quality water solutions.

Editor

Karsten Nielsen APS	Karsten Nielsen, karsten@karsten-nielsen.dk

Contributors

Adept Water Technologies	Michael Reidtz Wick, mw@adeptwatertech.com
ALECTIA	Martin Skytte, mask@alectia.com"
BWT HOH	Mads Maymann Jørgensen, mmJ@bwt.dk
DHI	Gert Holm Kristensen, ghk@dhigroup.com
DHI	Palle Lindgaard-Jørgensen, plj@dhigroup.com
Grundfos	Gitte Dige, gittedige@grundfos.com
Kalundborg Municipality	Mette Skovbjerg, Mette.Skovbjerg@kalundborg.dk
Mycometer	Morten Miller, mmiller@mycometer.dk
Novozymes	Henriette Draborg, hdra@novozymes.com
Silhorko-Eurowater	Jens Gjerløff, jog@eurowater.com
Billund Aquaculture	Bjarne Hald Olsen, bjarne@billund-aqua.dk

This white paper is based on the original work from previous versions 1.0 and 1.1 with Pia Klee, Danish Water Forum, as editor in chief.

For more information
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Executive summary

As the cost of resources rises, companies increasingly see the financial potential in resource efficiency. From a sustainability perspective it is obvious that water efficient solutions are interesting – but cost is the driver. We have very seldom been able to charge more for a product simply because it is sustainable.

Peder Tuborgh
CEO
ARLA FOODS

The availability of water will be a critical issue in the future, and the cost of water will rise. With higher living standards and a global population predicted to reach 9 billion people in the next few decades, the demand for water will increase significantly. Nearly three-quarters of total water consumption in the world relates to the consumption of food and drink, and the United Nations has estimated that before 2030, water consumption will rise by 30 percent. Therefore, the water footprint of food products will get more attention from consumers, and be highly visible on political agendas in the near future.

Water efficiency pays off

Sustainable use of water can be turned to the advantage of those who take steps to respond to the shortage of fresh water in the world. Frontrunners that develop high levels of water efficiency before others, and who work to specific and measurable targets with respect to reducing their water footprint, can turn water and resource efficiency into a competitive advantage. This is particularly the case in those areas of the world where problems of water scarcity and pollution are most acute. Rising water rates and wastewater discharge fees will have a much smaller economic impact on their businesses.

Great results with simple measures

Simple efficiency measures can provide great results. A utility water audit is the typical starting point for identifying water saving options. It may be followed by more comprehensive investigations, which consider the options for water reuse and recycling.

The industrial symbiosis model

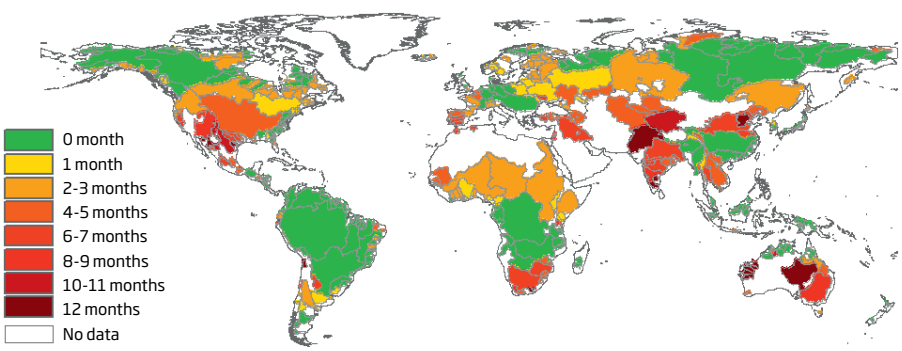
The Kalundborg Symbiosis in Denmark, established 40 years ago, is an example of a pioneering industrial park where public and private enterprises buy and sell waste products from industrial processes in a closed cycle. Annual water savings of 3 million cubic metres have been achieved by recycling and reuse. By focusing on more than just one company, industrial parks around the world have the potential to use resources more efficiently. This is of special interest to food and beverage companies, as used process water can be sold on to industries with less strict water regulation.

Denmark knows water efficiency

Water rates in Denmark are some of the highest in the world, reflecting the actual costs of water extraction, wastewater treatment and environmental protection. For decades, Danish food and beverage industries have shown their skills in developing new products and increasing production, despite facing rising water rates and stricter disposal regulations. Today Danish consultants and technology companies work with food and beverage companies in Denmark and around the world, to increase their water efficiency without compromising product quality. This white paper gives food and beverage companies a valuable insight into the possibilities of water efficiency.

Water scarcity *Water scarcity is an increasing threat to development in many regions. Trends of increasing imbalances between availability and demand, a deterioration in the quality of both ground- and surface water, intersetoral competition and regional conflicts all contribute to increased water scarcity. The current situation is illustrated by the map from UNESCO-IHE Institute for Water Education (or an interactive risk map by the World Resources Institute at http://aqueduct.wri.org). However, global analyses must always be considered with caution since available data is still limited for large parts of the world. Much of these analyses ar based on proxy data, and results differ depending on which data set is used. Smaller scale studies, an area of expertise for several Danish consulting companies, is normally required. (Courtesy: DHI)*

Number of months in the year in which water scarcity exceeds 100 percent for the world's major river basins (1996 to 2005)



Source: Hoekstra, A.Y. and Mekonnen, M.M. (2011) Global water scarcity: monthly blue water footprint compared to blue water availability for the world's major river basins, Value of Water Research Report Series No.53, UNESCO-IHE, Delft, the Netherlands

1. The need for greater water efficiency

Only 50 litres of water a day is needed to satisfy one person's basic water needs, but it takes 2,500 litres to produce the same person's daily food intake. Solving the first is a question of political will; the latter is a real, growing challenge that will affect us all, if not solved.

DR. TORKIL JØNCH CLAUSEN
Chair of Scientific Programme Committee
STOCKHOLM WORLD WATER WEEK

The availability of water will be a critical issue in the future, and water rates will rise. With higher living standards and a global population predicted to reach 9 billion people over the next few decades, the demand for water will increase significantly. Global food consumption is estimated by the United Nations to increase by 25 percent over the next two decades and water consumption will rise by 30 percent before 2030.

Pressure to reduce water usage

The food industry and especially the beverage industry are major consumers of water, responsible for approximately 20 percent of industrial water consumption worldwide. This sector will therefore face growing pressure from politicians and other groups to reduce their water usage, in order to preserve good quality freshwater. Increasingly, the situation will be that water is not available in the quality and quantity required for food processing and cleaning processes.

Wastewater disposal more of an issue

The quality and quantity of wastewater generated in the food processing and beverage industries varies greatly, due to the different production processes, and the raw materials used. In most places, companies are only allowed to dispose of limited amounts of industrial wastewater into natural freshwater or marine systems. When the capacity of these systems to process waste is exceeded, water quality declines and there is less usable water available. With increased levels of production stricter regulations are required to solve environmental problems.

Reducing water risk

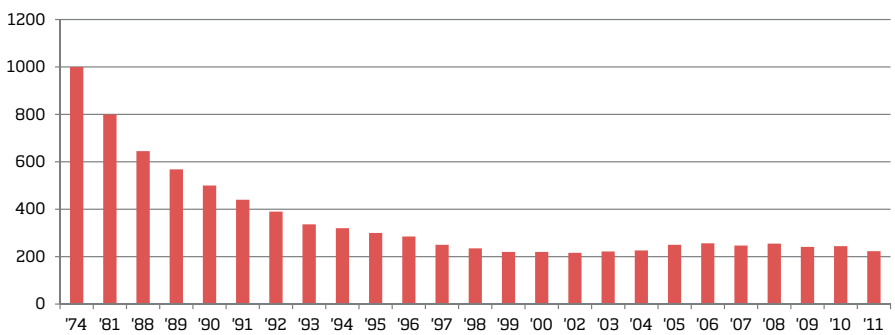
Industrial companies have long had to take into account dynamic market forces, such as changing regulation, changing customer preferences and sustainability demands. Now, increasingly, they face a new force – the challenge of local water shortages and decreasing water quality. The good news is that the strategies and the technologies do exist to effectively reduce water consumption, through water recycling. More and more companies now work intensively on water management to improve the awareness of issues related to water, to increase water efficiency and to reduce water risk.

Danish expertise in water efficiency

Food and beverage companies in Denmark have succeeded in developing new products and increasing their production despite facing rising prices for water and energy, and stricter regulations on wastewater disposal into freshwater and marine environments. They are renowned for processes and techniques which ensure a high product quality, together with efficient water use, achieved through good hygiene and by reusing and recycling water in their production processes where possible. Experience shows that a lot can be achieved with simple measures, simple changes and new strategies.

Industrial water efficiency *The Danish food industry has successfully reduced water consumption, motivated by high water prices and disposal costs. As an example, the average water consumption of a Danish slaughter house is currently around 200 litres of water per pig (50 US gallons), 80 percent lower than a few decades ago. Automation of the slaughterhouses in the last decade caused water consumption to rise slightly, but within a few years water efficiency was back on track. (Source: Danish Meat Research Institute)*

The use of water by Danish slaughter houses (litres per pig)



Water is essential to our product. Without water, no beer. We are constantly looking for ways to reduce our water consumption and to ensure a sustainable use of water wherever we operate

ESKILD ANDERSEN
Group Environmental Manager
CARLSBERG

Hectolitres of water used per hectolitre of beer

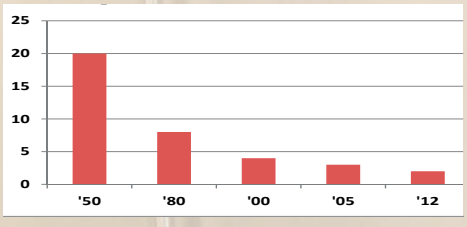


Illustration of how water efficiency of breweries has increased significantly even the last decade (illustrative graph)

2. Minimising water risk in the early stages of the supply chain

Water efficiency throughout the whole supply chain must be considered carefully. The average global water consumption to produce one kilogramme of beef, for example, is almost 19 cubic metres of water, but there can be huge variations around such global averages, just as there are huge variations in the levels of local water stress.

TORBEN FRANK
Vice Precident Water, Energy and Environment
ALECTIA

According to statistics, agriculture accounts for as much as 70 percent of total water consumption around the world. Further down the supply chain, the food and beverage industries account for one fifth of industrial water consumption. Overall, nearly three-quarters of global water consumption relates to people's consumption of food and drink. The water footprint of food products is expected to receive increasing attention from consumers, and to become highly visible on political agendas in the coming years. A product's water footprint is an indicator both of direct and indirect water use. The water footprint is defined as the total volume of fresh water used to make a product, or as consumed by a person, community or country.

Different categories of water risk

Risks related to water consumption include the physical risk to a company of encountering freshwater shortages in the supply chain or in its operations. A second category is the reputational risk if the company's handling of issues regarding sustainable water use is questioned. A third category concerns the risk of governmental interference and regulation. Finally there is the financial risk that costs will rise and thus revenues decrease since growing water scarcity is likely to affect the availability and price of certain raw materials. It may become more difficult to maintain a healthy profit, particularly if price competition in the company's market is fierce.

Minimising risk in the supply chain

Chapter 4 discusses how to start working with water efficiency in the company's own operations, which is closely linked to overall resource efficiency. But with full insight into the water footprint throughout the supply chain, and into local water stress issues, a company's overall water risk can be minimised. Most companies will find that their supply chain water footprint is much larger than their operational water footprint. As a result, they may conclude that it is more cost effective, or that it reduces risk, to shift their investment from efforts to reduce their operational water consumption to efforts to reduce their supply chain water footprint and associated risks. Improvements in the supply chain may be more difficult to achieve, however, since it is not directly controllable.

Water efficient salmon breeding, China
Strict environmental regulations have forced companies in Denmark to think differently and develop new, more water efficient technologies. An outstanding example is in the primary production of salmon, a fish highly valued in many countries. Intensive recirculation technology in salmon farms, means that salmon is now reared using only 250 litres (66 US gallons) of water per kilo of fish with a minimum of wastewater. This compares with 50.000 litres (13,000 US gallons) per kilo with traditional circulation technology, which often also pollutes the surrounding water. This salmon breeding technology is now used in Chile, Canada and Russia and will shortly be used in the Gobi desert in northwestern China, close to Mongolia, where it rains only 50-100 mm (2-4 inches) per year. (Courtesy: Billund Aquaculture)

3. Investment in water efficiency saves money

Increasing water efficiency and reducing the water footprint of a product will also lead to energy savings, reducing the payback time of water investments significantly

GITTE DIGE
Business Development Manager
GRUNDFOS

When companies take responsibility and work on their water efficiency, there are many environmental and social benefits. A dedicated effort will lessen the global strain on water resources and in a local context prevent the contamination of life-giving water, on which we all rely. However, the financial benefits are also numerous, and investments in water efficiency will, in the short or long-term, pay off in several ways.

Water as a competitive advantage

Sustainable use of water can be turned into an advantage for those who take steps to respond to the shortage of freshwater in the world. Frontrunners that develop high levels of water efficiency before others, and who work to specific and measurable targets to reduce their water footprint, can turn water and resource efficiency into a competitive advantage. This is particularly the case in those areas of the world where problems of water scarcity and pollution are most acute. In most regions water efficiency has, or will become, an important measure of a company's economic performance. A high level of water efficiency is essential, not only to ensure sufficient water resources for production processes but also in keeping production economically viable, limiting as far as possible the economic impact of rising water rates and wastewater discharge fees.

Effective control of products and water

Rising water rates and wastewater discharge fees, as well as increasingly strict regulations on wastewater treatment and discharge have forced Danish companies to reduce their water consumption to a minimum. The quality of the water is ensured by a combination of accurate measuring and control programmes. Efforts continue to develop new methods and management systems for the monitoring and control of water, to make water reuse solutions acceptable without having to compromise the quality of the products produced.

Simple means based on experience

Fortunately many food-processing companies can reduce their water consumption dramatically, through relatively simple means. The solutions and recommendations described in this white paper are based on years of research and development in the Danish food and beverage industries and in research institutes, consult-

Redesign of water streams, Latin America *A brewery in Latin America, producing 4 million hectolitres (100 million US gallons) of beer annually, has been able to save 150,000 cubic metres (40 million US gallons) of water per year by looking carefully at production processes and applying a range of simple but effective methods. One of the largest reductions was achieved by reusing 130,000 cubic metres (35 million US gallons) of water as a kind of lid to enclose a process taking place in a vacuum. The water was not contaminated and was therefore safe to recycle and use afterwards in the production process. Other reductions were achieved by optimising the flushing of product lines and by recovering and reusing steam condensate in the steam boilers. In this way, the need for using additional water was reduced; hot water being the main medium for conducting heat in brewing processes. Clean wastewater from the brew house and production utilities is recovered and returned to primary water treatment, and rainwater is harvested and recovered for cleaning processes. (Courtesy: ALECTIA)*

Energy efficiency, United Kingdom *The image features a hydro booster set for the main water supply at Accolade Wines. The company is a leading producer and exporter of wine; it bottles and distributes 120 million litres a year (31 million US gallons) from its facility in Avonmouth in the United Kingdom. When the company designed a new facility, replacing two ageing plants, investigations into energy efficiency were carried out. New systems were introduced from water supply and distribution through to boiler feeding, processing and cleaning, and all the way to effluent treatment. Energy savings at a level of 20 to 30 percent can often be achieved by replacing traditional systems of parallel-connected pumps with more efficient systems. Older systems often lack the capability to adjust the number of pumps running to provide maximum efficiency , or to compensate for changing friction losses when demand varies. Continuously optimising efficiency and pressure according to immediate demand is the key to the high efficiency of modern systems. (Courtesy: Grundfos)*

For decades consulting companies and technology suppliers in Denmark have worked with food and beverage companies around the world, using new processes and technologies to improve water efficiency without compromising product quality

Frank Hansen
Department Manager
ALECTIA

ing companies and technology suppliers. These technologies, processes and knowledge are used globally today by Danish companies supporting customers around the world in improving their water efficiency.

Water and energy are closely linked

A strong argument for investing in improved water efficiency is that it will lead to improvements in energy efficiency as well. The lower the volumes of water that must be transported, heated, cooled or treated, the less energy is required. There is for instance a tremendous potential for energy savings in switching to more efficient water pumping systems. Pumps are vital to working with improving resource efficiency because they consume large amounts of energy. Looking at the global picture, pumps alone consume 10 percent of the world's electrical energy, and mostly what they are pumping is water. Actually, calculations show that if everyone in the world switched to high efficiency pumps, global electricity consumption would decrease by as much as 4 percent.

Easier to expand production

A final important argument for improving water efficiency and wastewater treatment in food and beverage companies is that it enables companies to increase their production capacity without exceeding legal restrictions on water supply or wastewater discharge. More advanced technologies for treatment and reuse of wastewater may also be beneficial since wastewater contains several valuable substances that can be used for instance in energy production and nutrition recovery.

4. Water audits and value stream mapping reveal potential savings

Minimising industrial water consumption, and improving energy recovery and resource utilisation, will help secure a constant and reliable water source at a reasonable price

MARTIN ANDERSEN
Head of Environmental Technology Department
DHI-NTU RESEARCH CENTRE AND EDUCATION HUB

Many food and beverage processing plants have the potential to exploit flows of water, energy and chemicals from one process into another. Typically this can result in reduced costs on water, energy, chemicals and raw materials. In addition, reducing amounts of wastewater means less wastewater treatment. A utility water audit is the typical starting point for identifying water saving options. It may be followed by more comprehensive investigations, which consider the options for water reuse and recycling.

Water audits and value stream mapping

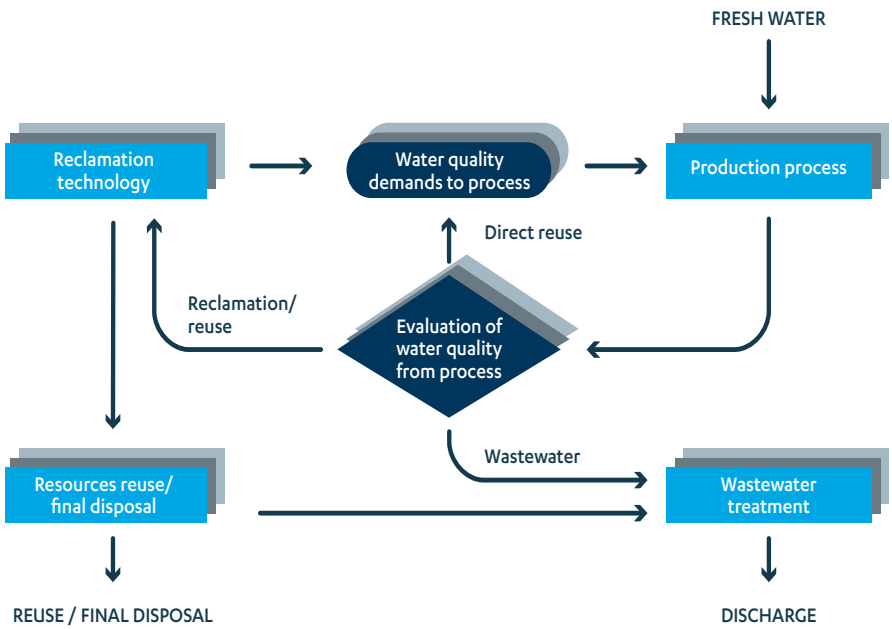
A good insight into industrial water systems is obtained with data collection (water utility load calculations and process water use), production plans, interviews with staff, mapping of the existing metering system and equipment and evaluation of technology options. Identification of the most valuable water streams can be part of a more comprehensive water audit as illustrated in the figure below. Identifying the most valuable streams and ranking these according to their value, looking at how easy it is to implement technical solutions and what costs are involved will help companies to reduce production costs and environmental impact.

Prioritising investment opportunities

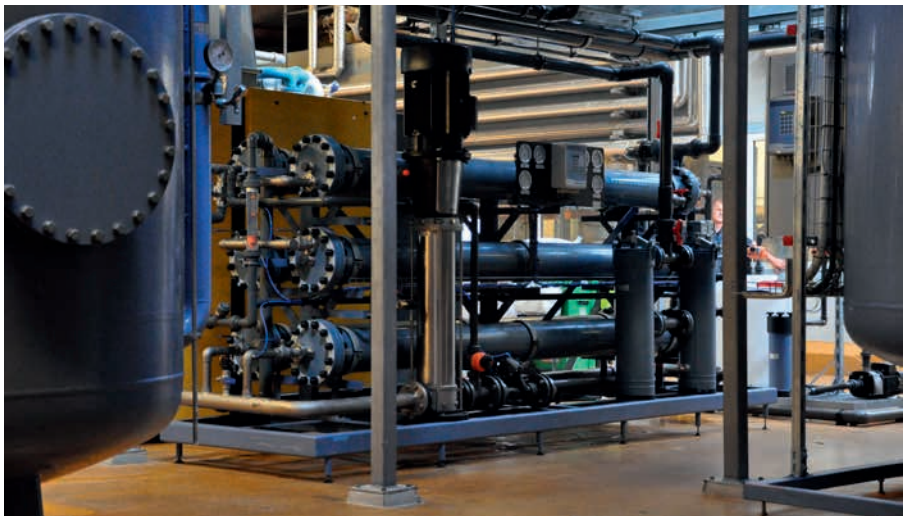
Analyses based on the data from water audits are used to develop and prioritise areas of potential improvement in the utility areas and/or within the production facilities. These analyses should also include estimates of the economic feasibility of selected saving scenarios to provide decision support for the management. In this way a strategy for reducing water consumption is developed, that includes setting targets based on new technology, new operational practices and changing behavioural approaches to water usage.

Technology and behaviour

The water conservation opportunities identified through water saving audits are technical solutions for reducing water consumption. They include optimisation of cleaning-in-place



Concept for system analysis and design through process integration
(Courtesy: DHI)



Variations in demand, Denmark *Harboe Brewery in Denmark needs 60 cubic metres (16,000 US gallons) of high-quality demineralised water per hour for the production of soft drinks and beer. The brewery achieved annual savings of 98,000 cubic metres of water (26 millions US gallons) along with savings of 89,000 kWh and 49 tonnes of salt by replacing an old water treatment plant with a new water softening plant combined with a reserve osmosis plant. Up to 90 percent of the water is utilised in the new reverse osmosis plant and the softening process is controlled by the water quality as the number of regenerations is determined by measuring the water quality. This is a good economic solution when water consumption is irregular, and this investment paid for itself in about a year. (Courtesy: Silhorko-Eurowater)*

routines, minimising water consumption for vacuum pumps and minimising blow down from boilers. There are also important saving opportunities related to the behaviour of the utility and production staff. Large savings can be obtained by encouraging simple changes in behaviour. They are often motivated by developing a water control and measurement system which communicates key performance indicators.

A water quality control system is required

In many industries, in particular the food and beverage industries, controlling water quality at every stage of the process is crucial. Therefore it also plays an important role in reducing water consumption. Establishing a system for controlling water quality based on the principles of the HACCP protocol (the Hazard Analysis and Critical Control Points protocol) has proved efficient and it is the protocol for safe food production applied in almost every food company. Additional quality issues like product quality, process water function and health and working conditions must also be considered. At the core of the approach is the identification of Critical Control Points (CCPs) in the water network which need routine control in order to manage identified risks.

Quality management systems

Water quality control methodology has been successfully applied in the water system in several companies, as part of an overall water quality management project. The methodology can be used independently but it can also be easily incorporated in existing HACCP-based quality management systems. Procedures of verification and administration are part of the system.

DRIP – Danish Partnership for Resource and Water Efficient Industrial Food Production. *DRIP is a public/private partnership focused on water efficiency in the food industry, one of the largest water-consuming industries in Denmark and globally. The partnership gathers a number of food sector companies, technology providers, universities and GTS institutes, to produce more food with less water without compromising product quality and food safety. The partnership is realised due to a deep commitment by the Danish Food Authorities, who monitors and helps with safety aspects. The ultimate goal is to reduce water consumption by 15-30 %, moving from a food safety regulatory demand of using drinking water quality for all purposes to the use of upgraded water sources, i.e. operating from a water-fit-for-purpose paradigm. The business rationale is not only water savings but also the associated energy savings, as well as possible recovery of resources in process and wastewater. New innovative water solutions will be operated long term in a number of lighthouse projects; and best practice solutions will eventually be implemented in 20-25 food companies. (Courtesy: Danish Agriculture & Food Council)*

Photo: Morten Rasmussen

An independent water supply, Poland *Like other food processing factories, the Royal Greenland fish processing factory in Poland depends on a reliable supply of good quality water. When the company investigated the options for an alternative water supply, it decided to involve independent consultants to see whether the water supply from existing groundwater wells would be adequate in volume and water quality. Test pumping from wells and extensive analyses to test water quality were carried out along with research into getting permission to establish an independent water supply, separate from the public water supply. The company eventually looked at offers from local suppliers on upgrading the plant and the calculations showed that investments in an upgrade would be paid back in only a few years. (Courtesy: ALECTIA)*

5. A reliable water supply of the desired quality

Important questions have to be asked in most places: Is there enough water? Is the supply reliable and the quality good enough?

JENS JØRGENSEN
Business Unit Director
ALECTIA

Today, in most places, a strategic approach is necessary when planning for new production sites or increasing production capacity on current sites. Food safety is of the highest importance for food and beverage companies and important questions have to be asked. Is there enough water? Is the supply reliable and is the quality good enough? The quality of the water required depends on what it will be used for.

Simple or advanced treatment options

Typically, the food and beverage industries distinguish between two raw water streams, one for production process use and one for utility use. As an alternative water supply, rain and storm water can be collected for use in non-product applications, reducing overall water consumption in the factory. The technologies used in water intake and treatment of raw water depend on the source of the water and its quality. Simple technologies include screening, filtration and softening. More advanced water treatment plants combine simple screening and filtration technologies with membrane filtration (micro-, ultra-, nano- or reverse osmosis filtration). Generally, the more advanced the water treatment, the higher the energy consumption. Quite large savings can be obtained with energy efficient technologies and control procedures for monitoring water loss.

Automatic monitoring saves water

Great potential for improving water efficiency in utility processes lies in limiting build-up of dissolved solids in boilers and cooling towers. Blow-down processes are used to control the concentration of dissolved solids. They account for a relatively large water loss when operated manually. With automatic monitoring of the dissolved solids concentration, water losses can be reduced with minimal investment.

Savings on water and salt, Denmark *Advanced monitoring technologies make a difference to the efficiency of water softening plants. Some years ago, the Tulip Food Company in Denmark invested in a new plant with a capacity of 50 cubic metres of water per hour (13,000 US gallons) and achieved annual savings of 5,000 cubic metres of water (1,3 millions US gallons) and 100 tonnes of salt over the old unit. Water consumption came down by 90 percent and the volume of salt needed per regeneration cycle was reduced by 70 percent. Salt used to be delivered every six weeks but is now only delivered every five months. Despite the low prices of salt and a water hardness level of only 13 °dH, the entire investment paid itself off in just 18 months. The accumulated savings to date are more than 130,000 euros (170,000 dollars) and 30,000 cubic metres (8 million US gallons) of water. (Courtesy: BWT HOH)*

Rapid microbiological tests *A rapid new method to estimate bacterial contamination in water systems has been invented by a Danish biotech company. This unique patented method, called Bactiquant®-water, is a tool for bacterial assessment on site. It is the only total bacteria technology verified by the U.S. Environmental Protection Agency. It was verified by the Agency in 2012 and included in the USA Water Research Foundation´s recommended toolbox for potable water monitoring. The company that invented the technology is currently working with a global beverage company for their approval of this method, and it is now in the process of being written into this beverage company´s global operations manual. It will soon be tested full scale for recycling and reuse of water at the beverage company´s test facilities in Latin America. (Courtesy: Mycometer)*

6. Building recycling into water streams and water control systems

Redesigning water streams to use the water more than once saves water, and gives a company full control over water quality throughout the process

MICHAEL WICK
CEO
Adept Water Technologies

Many companies use water only once before discharging it. This means high costs on supply and treatment of water but also on discharging wastewater. However, since the water consumption in food and beverage companies is relatively high, and since much of this water is typically used not as an ingredient but in processes such cleaning, transportation, and heating or cooling, there are often many opportunities for reusing the water.

Different ways to reuse water

With clever solutions, some water can be reused without any kind of treatment. For instance, it is possible to reuse final flush water in processes, as first flush water, or perhaps as makeup water in a cooling tower. Another approach to saving water is to keep it in the process longer. For instance, with simple filtration or disinfection, transportation water for food products can be used for longer without treatment, which leads to a lower overall water consumption. Similarly, cooling water for pump sealing can be used for longer periods by implementing water treatment in the cooling water circulation process.

A benefit and not a potential danger

Going through the different production processes, it is often possible to find water streams that can be reused, rather than being discharged, with proper water treatment. Importantly, any form of recycling must benefit production and not pose any potential danger of product contamination. But provided the used water is handled correctly, considerable savings can be made. Working with recycling water must be done with full control.

Chemical free disinfection, Denmark *Dairies in Denmark are highly water efficient today. Yet since water treatment and disinfection with chemicals is out of favour, water from the production of cheese, which often contains many microbes, is generally not reused. When the Scandinavian dairy company Arla Foods tried to reduce its water consumption in operations by a further 3 percent annually, the company decided to try a new chemical-free water disinfection technology based on advanced electrochemical treatment. Raw milk is the base for all dairy products and is concentrated as part of the production process, meaning that a lot of water is removed. By neutralising the bacteria in this water, Arla was able to reuse it for cleaning purposes, instead of continuing to discharge it as wastewater, resulting in large savings in the company's water consumption. The new system combines primary and secondary disinfection to make the water suitable for reuse as final rinsing water in the CIP-cleaning process. (Courtesy: Adept Water Technologies)*

Zero discharge of wastewater, India *As the first within the Carlsberg Group, Carlsberg India has successfully built a wastewater recovery plant for its Hyderabad Brewery. The recovery plant was commissioned in June 2011, with the ambition of saving water and natural resources. Its purpose is to treat wastewater by reverse osmosis (also referred to as ultrafiltration). In this way the water can be reused in other brewery processes such as cleaning of floors and utilities. The project aims to reduce to zero the discharge of wastewater from the brewery into the surrounding area which is mainly agricultural. Based on the plant's capacity, the annual water saving for the plant is expected to be 58,500 cubic metres (15 million US gallons). The direct saving potential is expected to be as much as 104,000 US dollars per year. The launch of the plant demonstrates Carlsberg's commitment to making a positive contribution to the environment and the society in which the company does business. The Carlsberg Group consumes on average 3.3 hectolitres of water per hectolitre of produced beer according to figures published in 2013. (Courtesy: Carlsberg)*

7. Energy efficient wastewater treatment satisfies legal demands

We have to take a different attitude to wastewater. Instead of thinking of it as waste, let's think of it as a by-product. For instance, it is possible to cover 5-15 percent of a brewery's energy consumption by using biogas from wastewater

HENRIETTE DRABORG
R&D Director
NOVOZYMES

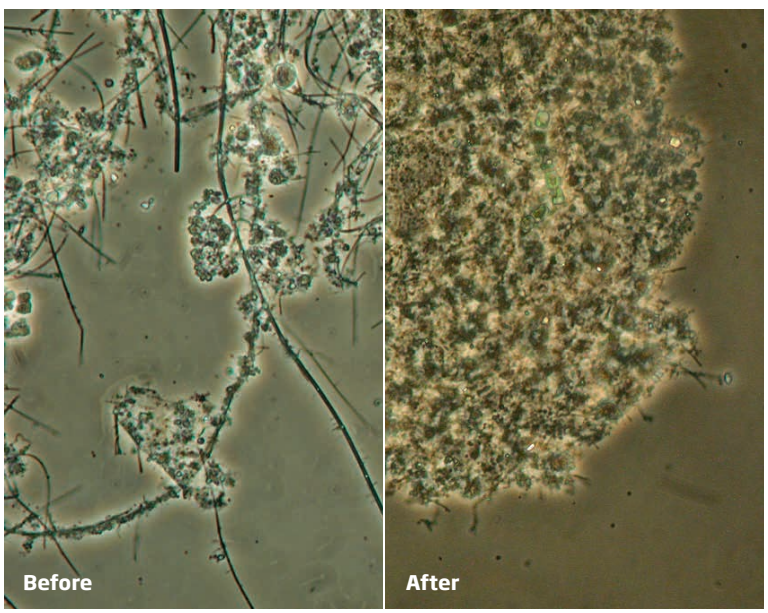
In some countries, increasing costs and stricter guidelines on wastewater discharge to municipal wastewater treatment plants are creating new challenges. Companies may not be allowed to continue their production at the current pace if sufficient wastewater treatment cannot be assured. Thus, there is an urgent need for efficient wastewater treatment technologies to reduce pollution and reuse wastewater. In Denmark, food and beverage companies have faced tough legal regulations for decades and have thus developed advanced energy efficient technologies for wastewater treatment within their own industrial processes, as well as systems for controlling and measuring wastewater discharge to municipal sewerage systems.

Reducing and reusing wastewater

When designing new, or up-grading existing, wastewater treatment plants within factories, the amount of wastewater for treatment can be kept to a minimum by selecting technologies and processes during the production process which optimise the use of water. Secondly, the operational safety design of wastewater treatment plants is important. They need to operate around the clock, and to be flexible to changes in production. Thirdly, to save on freshwater intake, applying modern technologies allows companies to treat their wastewater to higher standards and to meet requirements for water reuse.

Gaining value from nutrient recovery

Wastewater is one of many options for improving an industry's environmental footprint and recovering valuable resources from wastewater streams. Modern solutions for wastewater treatment are highly energy efficient, which means that companies can reduce their energy consumption by adopting more energy efficient technologies. Options also include the use of anaerobic digestion technologies, which bring additional value by generating biogas, reducing the CO^2 emissions of operations. The future will bring still more possibilities for gaining value from wastewater with nutrient recovery as one of them. The development is driven by the global depletion of resources such as phosphorus deposits. In that context, the development of new technologies is the next step in efficient wastewater treatment.



Savings on disposal costs *The application of microorganisms to a waste stream has allowed a dairy plant to treat concentrated waste liquor that was previously too strong to treat. An improved settling performance has led to annual savings of 85,000 euros (111,500 dollars) on chemical, disposal and labour costs. Due to changed production processes, the company was generating increasing level of fats, oils and grease. Severe settling issues required constant attention from operators and heavy use of chemical coagulants in the clarifier to meet permits on suspended solids. Trials with chlorination and later neutralisation of the influent pH were unsuccessful. The problem was identified as filamentous bulking, and a microorganism product containing bacteria that degrade the fats, oils and grease commonly found in dairies and which improves floc formation was added. The clarifier settling improved immediately and continued to improve over the next few months of the bioaugmentation programme. As a result, the use of chemical coagulants dropped almost to zero, and less manpower was needed to operate the clarifier. Observations under the microscope revealed a reduction in filament abundance and an improvement in floc size and density. (Courtesy: Novozymes)*

Waste water savings, Turkey *Türk Tuborg's brewery is located in Izmir on the Aegean Sea and produces approximately 1.8 million hectolitres of beer annually. The brewery includes a malt house which processes around 300 tonnes of barley per day. Wastewater is collected and cleaned in the brewery's wastewater treatment plant, and looking into the handling and reuse of wastewater has generated significant savings. Sludge volumes have been reduced by almost 80 percent leading to annual savings of around 500,000 euros (650,000 dollars) for sludge deposits and annual energy savings of 1 million kWh, corresponding to approximately 70,000–80,000 euros (90-100,00 dollars). In addition there was a one-off saving of 2 million euros (2.6 million dollars) when an investment in separate sludge stabilisation proved unnecessary. The ultimate goal is to use the wastewater sludge for agricultural fertilisers, which would be an ideal solution from both the economical and environmental perspective. This form of recycling is anticipated to provide further annual savings of approximately 100,000–200,000 euros (130,000-260,000 dollars). (Courtesy: ALECTIA)*

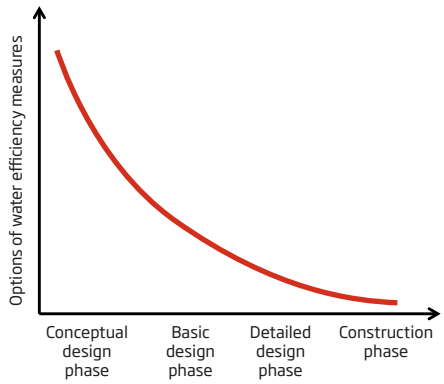
Addressing legal demands, Russia *The Russian food industry faces increasingly strict legal demands on wastewater treatment and discharge. To prepare for the future and ensure sustainable production, a large Russian meat producer is currently establishing a greenfield plant with an advanced wastewater treatment plant (WWTP). The plant has a capacity of more than 4,500 cubic metres (1.2 million US gallons) per day and is designed with special attention to operational safety and flexibility to allow for production increases. It incorporates technology for energy recovery, which brings further gains. Thus, a sludge digester generates biogas to be used for digester heating and heating of the WWTP operation building. The combination of advanced technology for wastewater treatment and energy recovery helps prepare the company both legally and financially for the future. (Courtesy: ALECTIA)*

Biogas production, USA *An American pork processing facility which processes 15-17,000 pigs per day has used biotechnology to improve the efficiency of its anaerobic wastewater basins. This has resulted in improved biogas production, reducing the need to purchase gas. The payback period for the company's investment in anaerobic treatment has shortened and will become even shorter as prices for natural gas rise. Approximately 8,700 cubic metres (2.3 million US gallons) per day (2.3 MGD) of organic-rich wastewater (up to 60,000 mg/L COD) is treated on site in two anaerobic basins and an active sludge system, and the biogas generated is used for the facility's boilers. The explanation for these impressive results is this: at the time of year when temperatures drop and methane gas generation is typically inhibited, biotechnology makes it possible to boost the biogas production. With BG Max, the anaerobic system generates on average 9,100 cubic metres (2.4 million US gallons) per day of biogas, an increase of 39 percent per pig slaughtered, without reducing biogas quality (methane content 60-70 percent). (Courtesy: Novozymes)*

8. Designing a greenfield site

It is crucial to explore both current and future access to freshwater resources before deciding on where to place a greenfield site. In addition, there are many important factors to consider at an early stage to ensure a water efficient design

PETER BREUM
Senior Utility Specialist
ALECTIA



When companies plan for a new greenfield site it is an important opportunity to significantly reduce its waterfootprint. First step is to establish a water strategy and integrate it with strategies for other sustainability parameters like energy, waste and air emissions. The water strategy sets goals for water consumption and wastewater treatment efficiency and followed by a water action plan, that is the basic tool for integrating technologies and processes in the design phase. The water action plan is reviewed at every step of the design phase from the initial concept throughout to the final commissioning of the plant.

Water efficiency degree decreases

It is vital to investigate and map opportunities as early as possible as the options for water efficiency measures will decrease with the progress of the design of a greenfield project. Opportunities for water efficiency are in the process design, the utility processes and in the recycling of process water between processes. In the preliminary design phase it is possible to investigate innovative solutions, for instance technologies for wastewater treatment, reuse and process integration presented earlier in this white paper.

Important factors to consider in order to estimate and reduce the operational water footprint of a facility include:

Legal requirements

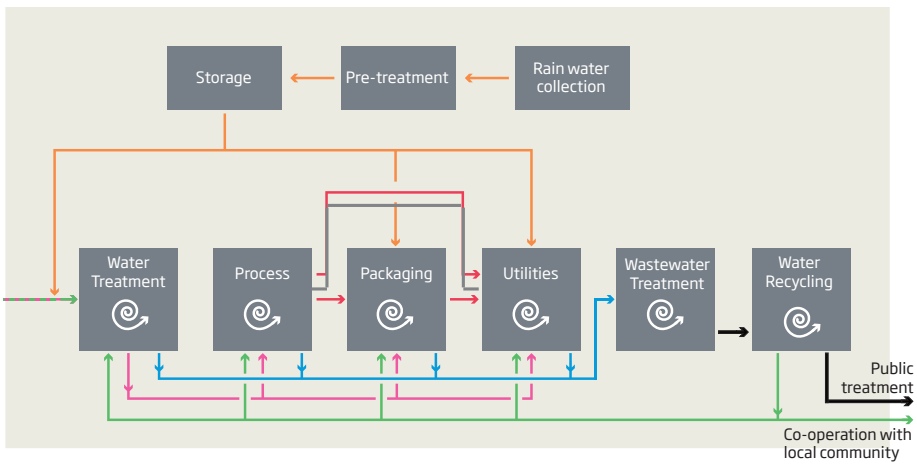
- Environmental impact assessment
- Wastewater discharge permits
- Environmental appproval
- Building permits

Mapping and design

- Freshwater accessibility
- Best practise and new technology innovations
- Mapping of utility and process water needs (amount and quality)
- Identification of optimal process integration system for water reclaim, reuse and recycling
- Wastewater characteristic and opportunities for treatment and recycling
- Energy and nutrient recovery from wastewater streams

Water management systems

- Systems and procedures for water quality control
- Systems of water meters for monitoring and control of water consumption
- Education of employees on water savings in daily operations



Closing the water loop *This concept for the greenfield design of a brewery achieves a water to box ratio of around 2 hectolitres of water to 1 hectolitre of beer. It is based on the experience gained from brewery greenfield designs around the world. Depending on the level of water scarcity, corporate or local governmental policies on water, investment budgets and targets for operational costs, streamlining the design for water efficiency, including the minimisation of wastewater treatment costs, has been reduced to a model called "closing the water loop" as shown in the figure. (Courtesy: ALECTIA)*

9. Water efficiency through industrial symbiosis

Combined industrial efficiency, Denmark
Industrial parks have a great potential for using resources more efficiently. The key to the success of the Kalundborg Symbiosis stems from the emphasis that is being placed on the combined efficiency of all the processes, instead of just the efficiency of one single process.(Courtesy: City of Kalundborg)

By engaging with some of Denmark's leading companies, the Municipality of Kalundborg is exploring new venues of water efficiency and resource optimisation through Industrial Symbiosis.

METTE SKOVBJERG
Project Manager
MUNICIPALITY OF KALUNDBORG

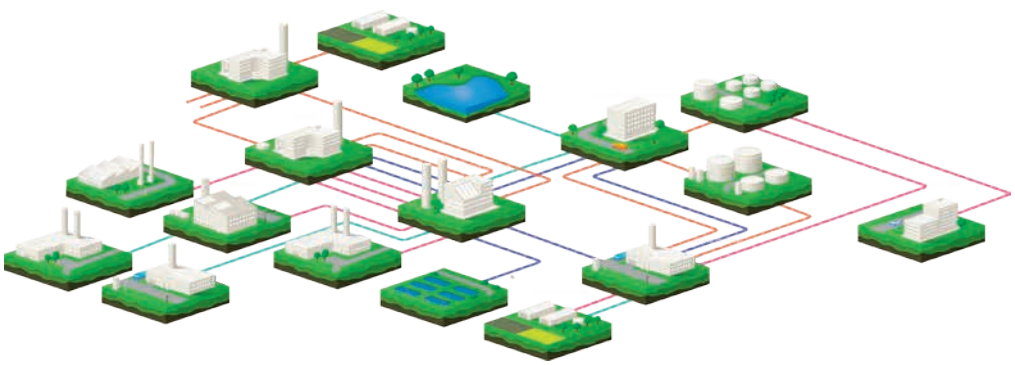
Industrial parks around the world have great potential for using resources more efficiently. Savings can be achieved by establishing shared water supplies and wastewater treatment plants. Furthermore, water and other resources can be recycled between the different factories. With the right technology and treatment, wastewater that comes from one company can be used as a resource in another. This is of special interest to food and beverage companies, since used process water can be sold on to industries with less strict water regulation.

Water savings of 3 million cubic metres

The industrial area of Kalundborg is the second largest industrial cluster in Zealand and hosts the world's first integrated Industrial Symbiosis system. The Kalundborg Symbiosis has developed over the past 40 years and is a pioneering example of private enterprises exchanging residuals and byproducts from industrial production in closed cycles. The traded residual products include water in various qualities, energy and other physical materials. As the groundwater reserve is scarce in this part of Denmark, it is of major concern for the industries and has been a key driver behind the development of collaboration between different companies. So far, recycling and reuse have led to annual savings of 3 million cubic metres of water (800 million US Gallons).

Industrial Symbiosis version 2.0

As most of the obvious potentials for industrial symbiosis projects on water have been harvested, the companies and the Municipality of Kalundborg are now exploring new opportunities in a screening and assessment exercise funded by the Danish Ministry of Environment's Eco-Innovation programme (MUDP). As part of this project, DHI has carried out water audits at all involved industrial parties, resulting in a list of approximately 20 new potential areas where water sources can be matched with new fields of applications for a more efficient use of the water resource between the companies.



If your goal is smart and efficient water solutions,Denmark is ready as your partner

Water is an increasingly scarce resource in most parts of the world and we need to rethink how we use it. Denmark holds a long tradition of integrated water management and is committed to take responsibility and contribute to solving the major global water challenges.

A long tradition of sustainable water management

As awareness about sustainable water practices has increased, Denmark has spent the past decades building expertise within water efficiency and water management. Today, our tap water is as pure as the finest spring water, water loss in our pipelines has been reduced to less than 8 percent, wastewater is treated efficiently with a strong focus on energy and resource recovery and the water in our capital's harbour is clean enough to swim in.

The knowledge we have about water resources, security and efficiency is no coincidence. Successive governments have addressed our country's limited natural resources and the Danish water sector holds a long tradition of water utilities, technology providers, consulting companies and universities working jointly together to promote integrated solutions for efficient and sustainable water management.

A shared water vision for the future

The close collaboration between multiple stakeholders has put Denmark at the forefront of research, technology development, know-how and best-practice in integrated water management, urban drainage, water supply, wastewater treatment as well as governance and ensuring public awareness and support for water policies.

Denmark is prepared to take responsibility in solving the world's major water challenges and has ambitious plans for its water sector. A water vision for 2025 has been created through dialogue between the Danish water sector and the Ministry of Environment and Food with the intention of developing Denmark's position as a water hub for intelligent and efficient water solutions. The aim is to create solutions which will increase access to clean water and sanitation, promote efficient use of water resources, improve the competitiveness of water consuming industries, lead to a cleaner global environment and protect cities from floods and storm surges.

As a country, we see great opportunity for mutual benefit in the transfer of knowledge and we aim at turning global water challenges into opportunities for sustainable growth.

Explore water solutions online or experience them live in Denmark

We invite you to explore the newest Danish water solutions, policies and news online at www.stateofgreen.com/water. You can also visit Denmark on a State of Green Water Tour where you can experience innovative water solutions first-hand and take advantage of the lessons learned by leading Danish companies and utilities.

For more information about State of Green Water Tours, please visit:
www.stateofgren.com/tours

"Danish water companies, utilities and organisations have shown that by working together, it is possible to create more innovative solutions which lead to added value for both their customers and society as a whole. This is a great example of how Denmark contributes to finding solutions to the major water challenges the world faces"

ESBEN LUNDE LARSEN, Minister for the Environment and Food, DENMARK

the international water association

Join us in Copenhagen for the IWA World Water Congress & Exhibition in 2020

Denmark is proud to host IWA Congress and Exhibition on 18-23 October 2020. Proposed Congress topics are "Water for smart liveable cities", "Water – Energy – Food Nexus" and "Recruitment and career development in the water sector". The proposed topics address future water challenges all over the world. Before, during and after the conference, a united Danish water sector looks forward to demonstrating smart water technology, system solutions and discussing governance and policy in order to secure resilience in the future in towns, basins and cities around the world.
Read more at www.iwa2020copenhagen.dk

Download this white paper and other related publications at:

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UltraAqua	ultraaqua.com
Wavin	wavin.com
Aarhus Geophysics	aarhusgeo.com
Per Aarsleff	aarsleff.com

Research institutes & demonstration projects

Danish Technological Institute	teknologisk.dk
DHI	dhigroup.com
Geological Surveys of Denmark and Greenland	geus.dk
Kalundborg Industrial Water Demonstration Site	symbiosis.dk

Water utilities

Greater Copenhagen Utility	hofor.dk
VCS Denmark	vcsdenmark.com
North Water	nordvand.dk
Aarhus Water	aarhusvand.dk

Organisations related to water

Association of Waterworks in Denmark	fvd.dk
AquaCircle	aquacircle .org
Copenhagen Cleantech Cluster	cphcleantech.com
Confederation of Danish Industry	di.dk
Danish Water Technology Group	dk-water.com
Danish Water and Wastewater Association	danva.dk
Danish Water Forum	danishwaterforum.dk
Danish Water Services	danishwater.dk
State of Green Consortium	stateofgreen.com
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