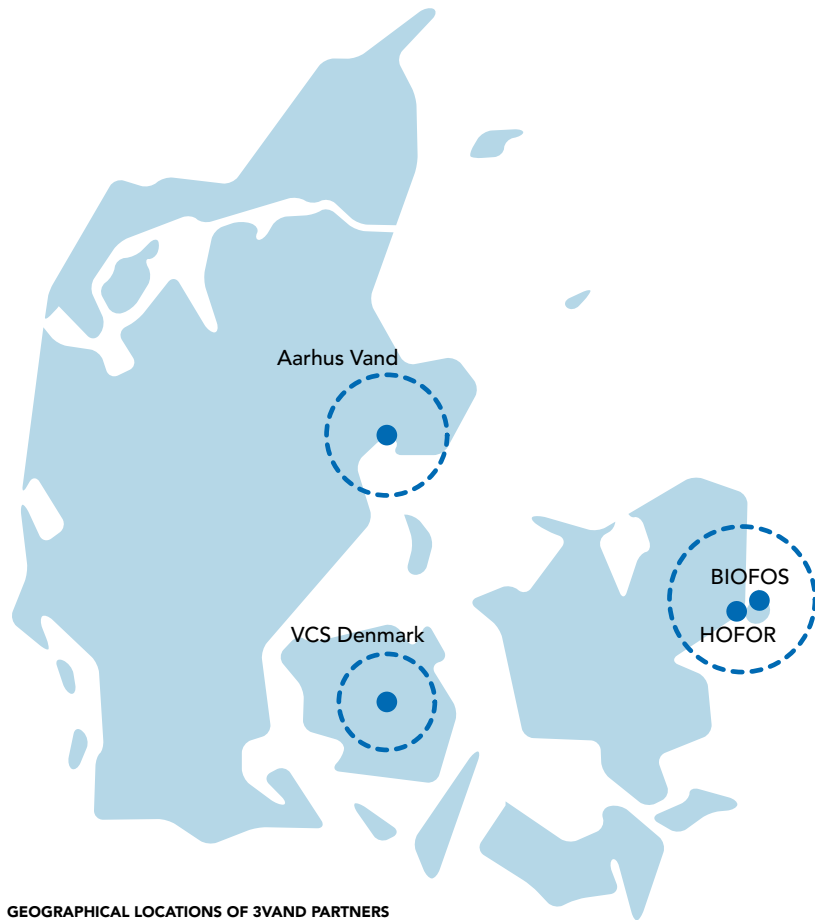




SUSTAINABLE WATER, WASTEWATER MANAGEMENT AND CLIMATE



GEOGRAPHICAL LOCATIONS OF 3VAND PARTNERS

3VAND - FACTS AND FIGURES

The Danish water sector is undergoing change, and companies and authorities in the Danish water sector are experiencing new and portentous challenges. This is the basis upon which we have entered into strategic cooperation under the name 3VAND. 3VAND includes the water utilities HOFOR (Greater Copenhagen Utility), BIOFOS, Aarhus Vand and VCS Denmark. These water utilities are located in the three largest urban areas in Denmark – Copenhagen, Aarhus and Odense, and together we provide water-related services to 2 million Danes.

3VAND – a clear vision

- We create the best possible framework for our work. We work actively towards sustainable regulation for the operation of water utilities, continued prioritisation of the environment, risk management, improved services and prices as key evaluation points.
- We focus on customer needs and provide high quality services that are affordable and sustainable.
- We contribute to value creation in society through safe drinking water and sanitation, clean beach waters, climate adaptation and climate mitigation.



BIO-RETENTION SYSTEM FOR SURFACE RUN-OFF AT LANGELINIE, ODENSE – PHOTO BY VSC DENMARK



WATER ACTIVITY IN AARHUS HARBOR
– PHOTO BY VISIT AARHUS



BRØNDBY BEACH, WINTER SWIMMING
– PHOTO BY HVIIDPHOTOGRAPHY

- We are the water utilities of the future and front-runners in innovation and technological development.
- We believe in sharing knowledge, new information and inspiration.

Facts about 3VAND:

- We provide water services to 2 million people
- Combined turnover: more than EUR 900 million/year
- Total fixed assets: EUR 6 billion
- Investments: EUR 400 million/year
- More than 1,800 employees

ABOUT 3VAND

3VAND is the result of close cooperation between four of the largest utility companies in Denmark, located in the three largest cities – Copenhagen, Aarhus and Odense. The four utilities provide a broad range of water-related services, including: abstraction and distribution of drinking water, treatment of wastewater, groundwater protection and solutions for climate adaptation.

The environment ranks at the top of the political agenda in Denmark, and we maintain a strong focus on sustainability from a broad perspective - including supporting the Sustainable Development Goals of the United Nations. 3VAND is leading the way in the efforts to develop sustainable towns and cities. We work closely together with local authorities, and with national and international research institutes, universities, private companies and environmental organisations.

We have been working consistently on sustainability in the water and wastewater sectors for the past 30 years, and with climate changes in particular (adaptation and mitigation) for the past 20 years. We think long term, taking into account both the environment and security of our drinking water supply. We think in terms of development and innovation to ensure that new technologies are tested and implemented to benefit society and the environment as quickly as possible. We want a sustainable future for the next generations, and it is essential that we develop sustainable solutions for our towns and cities.

3VAND would like to share our knowledge and knowhow with the world, and to engage in dialogue with others that may lead to new knowledge and inspiration. In this brochure, 3VAND has chosen five main categories, all indicative of how we work with sustainability both short and long term – these are key areas in which we may contribute with our experience and expertise:

- Clean drinking water
- Circular economy in utilities
- Climate change mitigation
- Climate change adaptation
- Water-based recreational areas in cities
- Automation in urban water management

KAYAKING ON EMIL HOLM'S CANAL – PHOTO BY MARTIN DYRLØV



THE GLOBAL GOALS OF UN



REFERENCE PLANTS

- TRUELSBJERG WATERWORKS - sets new technological, architectural and operational standards
 - DALUM WATERWORKS – intelligent well-field modelling tool
 - MARBJERG WATERWORKS – a fully automated plant
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CLEAN DRINKING WATER

Globally, water scarcity, changing demographics and operational efficiency are top priorities for the water sector, and the existing challenges are amplified by the unpredictability of climate changes.

The need for sustainable water management is incontrovertible - and Denmark is well ahead in making use of the opportunities arising from data-driven insights into our

investments, infrastructure and daily operations. One of the most significant results generated from data-driven investments and operations is the gradual reduction of non-revenue water in the 3VAND utilities to currently levelling out at only 6 %.

We are also focused on reducing our energy consumption. In Copenhagen, the energy consumption for supplying one

TRUELSBJERG WATERWORKS IN AARHUS – PHOTO BY OLE HARTMANN SCHMIDT



INTERIOR AT THE MARBJERG WATERWORKS
– PHOTO BY MARTIN DYRLØV



cubic metre of tap water has consistently been 0.3 kWh – one of the lowest consumption ratios for a capital city anywhere in the world.

In Denmark, the average water consumption per capita has been reduced to about 100 litres per day. The main contributing factors to the reduction in the general consumption of drinking water include: individual metering; a water price policy encouraging water conservation; water saving campaigns targeting consumers etc.

Danish utilities use groundwater as their source for drinking water. This is a clean and available resource – but groundwater abstraction entails challenges of its own. As large water utilities, we are all involved in projects that protect primary catchment areas - and the hydrological cycle - from the impacts of human activities.

OUR SOLUTIONS

Low NRW

Water loss (non-revenue water) is at a steady 6 %, due to improved pressure control in the distribution system; dividing the distribution network into districts (separately metered zones); monitoring and operating the network via SCADA systems; a systematic use of leakage detection programs and internal policies for prompt intervention and response to bursts. Furthermore, the distribution network is continuously renewed based on long-term renovation strategies.

Low energy consumption

We use a well-field modelling tool

to design and operate our well fields. The software automates and optimises operations and is fully compatible with all types of SCADA systems controlling operations-based processes. The tool is simply integrated as an add-on in the existing SCADA system.

All pump installations are designed and operated to optimise energy efficiency.

Clean water

Waterworks operate as completely closed systems with no uncontrolled access to the water.

Our drinking water supply is based

on groundwater. This means that we do not need to use disinfectants such as chlorine – and this ensures a high degree of chemical purity and improves the taste of our tap water.

Considerable investments are made to protect the catchment areas of the well-fields, especially vulnerable and critical locations. The means to obtain groundwater protection include afforestation and compensation schemes for farmers who are encouraged to refrain from using pesticides.

CIRCULAR ECONOMY IN UTILITIES

The objective of a circular economy is to improve both the environment and the economy of activities by retaining and recovering all valuable resources in circulation. Planet Earth has limited resources, and we have reached the point at which recycling of valuable resources is of paramount importance, if we wish to maintain a balanced environment while also maintaining sustainable economies. This is reality for all national and corporate economies – including the utilities.

3VAND is dedicated to finding ways to recover the valuable components in the residuals from water production and wastewater treatment.

At our wastewater treatment plants, we are already net producers of energy – and, what is worth noticing is that the energy that we produce is CO₂ neutral. From the wastewater we recover nutrients that can be used as fertilisers in agriculture – including, most prominently, phosphorous, an essential component in produce farming.

PRODUCTION OF BIOGAS AT BIOFOS WATERWATER TREATMENT PLANT "LYNETTEN" – PHOTO BY HVIIDPHOTOGRAPHY



REFERENCE PLANTS

- ÅBY WWTP – turns wastewater into valuable fertiliser, “PhosphorCare”
 - EJBY MØLLE WWTP – net-positive energy production
 - BRØNDBY WATERWORKS – first central drinking water softening plant in Denmark
 - BIOFOS WWTP LYNETTEN – surplus on the energy balance as a result of bio-refinery
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PRODUCTION OF PHOSPHORCARE AT AARHUS VAND WATERWATER TREATMENT PLANT “ÅBY”
– PHOTO BY OLE HARTMANN SCHMIDT

OUR SOLUTIONS

Residuals recovery

We actively work on making use of residuals from the treatment of wastewater. We develop and implement new technologies for recovery of nutrients, e.g. phosphates from sludge ash, and by recovering phosphates in the form of struvite from wastewater. Ash from the incineration of sludge is currently reused in the construction industries.

Softening of drinking water is beneficial both to the environment and the economy. In Copenhagen, precipitation of calcium that is formed into pellets is used to produce soil improver.

Energy production

We produce biogas from the organic matter in our wastewater treatment plants – and are able to successfully convert waste into green energy.



DISTRICT HEATING AT BIOFOS WASTEWATER TREATMENT PLANT “LYNETTEN”
– PHOTO BY HVIIDPHOTOGRAPHY



SOLAR PANELS AT WATERWORKS – PHOTO BY VCS DENMARK

REFERENCE PLANTS

- MARSELISBORG WWTP – a bio-refinery with energy production
- EJBY MØLLE WWTP – using new sensors to reduce emissions
- BIOFOS WWTP – emission reductions resulting from sludge incineration and bio-refinery



AFFORESTATION FOR PROTECTION OF GROUND WATER – PHOTO BY OLE HARTMANN SCHMIDT

CLIMATE CHANGE **MITIGATION**

Climate change caused by CO₂ emissions above a sustainable level pose a very real threat to the world. Only a few years ago, wastewater treatment was part of the energy consuming statistics. Today we actively contribute as net energy producers of green energy and are actively participating in reducing the CO₂ emission problems.

Our goal is quite clear: we wish to become carbon neutral and obtain energy neutral production. Furthermore, Copenhagen has set the ambitious goal of becoming the world's first carbon neutral capital city by 2025.

To reach these goals, the companies in 3VAND are working on both reducing energy consumption and producing environmentally friendly energy. The overall objective is to contribute positively, both as regards the climate and the environment.

In terms of energy production, we are reducing CO₂ emissions through a number of solutions across the different utilities and industries. In recent years, our largest wastewater treatment plants have all become net energy producers with 150 % self-sufficiency or more.

When it comes to energy consumption, we are streamlining operations to ensure energy savings in general, e.g. through flexible energy consumption.



SLUDGE INCINERATION, BIOFOS – PHOTO BY HVIIDPHOTOGRAPHY



MARSELISBORG WASTEWATER TREATMENT PLANT IN AARHUS
– PHOTO BY AARHUS VAND



WELL-FIELD, AARHUS – PHOTO BY AARHUS VAND

OUR SOLUTIONS

Producing green energy

We produce biogas from our wastewater and convert it into CO₂ neutral electricity in gas engines. In Copenhagen, biogas is upgraded to utilisation in the natural gas network.

We produce surplus heat - e.g. from sludge incineration - that is used in the district heating network as a significant contribution to the positive energy balance.

Solar panels at waterworks and wastewater treatment plants contribute to the companies' green energy consumption ratio.

Using less energy

The secret to successful energy reductions is to systematically review all processes. In Copen-

hagen, for example, the switch from surface rotors to bottom aeration has resulted in a 50 % reduction in power consumption.

In Odense improved sludge settling properties increases the energy efficiency of the facility by reducing operational requirements for nutrient removal.

Introduction of sidestream deammonification has significantly improved our energy balance, because it offers more efficient wastewater treatment and an opportunity to utilise more carbon for energy production.

Intelligent controlling of water and wastewater networks optimises energy consumption in operations.

Reducing CO₂

Other emissions than CO₂ also pose a problem. Achieving great energy results via deammonification has a potential negative side-effect in the form of increased emission of nitrous oxide (laughing gas). Odense has participated in the development of a sensor to measure these emissions and are implementing operational strategies in the wastewater treatment processes, to minimize emissions.

Afforestation – aimed at protecting our well-fields – contributes positively to our CO₂ footprint by continuously absorbing and reducing the content of CO₂ in the atmosphere.

CLIMATE CHANGE **ADAPTATION**

The long-term impact of climate change is unpredictable. We will continue to see more heavy rains, rising sea levels and increased average temperatures. Planning for the effects of climate change is difficult, as historic statistics no longer suffice as a basis for predicting future precipitation. Many experts expect the changes to exacerbate the complexities of watershed planning and render existing water infrastructures even more vulnerable to extreme weather conditions.

In Greater Copenhagen, Aarhus and Odense, we meet the challenges with a combination of solutions – larger pipes, sustainable urban drainage and surface solutions for collecting or detaining storm water and controlled discharge of surface run-off. We are innovative in our approach to new projects in the urban environments, and apply a holistic assessment to determine which solutions generate the most value for our customers, citizens and society as a whole.

The combination of traditional solutions and surface solutions generates opportunities for urban space improvements and the establishment of a new blue-green infrastructure, such as rainwater lakes and green areas where the disconnected rainwater can soak away.

The need for climate adaptation is acute. Therefore, 3VAND also collaborates with authorities and private companies, and participate actively in development projects focusing on new approaches to climate-related challenges.

CLOUDBURST GRATE AT NYBODER – PHOTO BY HOFOR



STORMWATER RETENTION LAWN AT SANKT ANNÆ SQUARE – PHOTO BY SØREN SVENDSEN/KVÆSTHUSPROJEKTET



REFERENCE PLANTS

- RISVANGEN – climate change adaptation through surface solutions
 - GLISHOLM LAKE – recreative value of rainwater basin
 - SCT. ANNÆ SQUARE – urban renovation project with cloudburst mitigation and green areas
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OUR SOLUTIONS

Disconnecting rainwater

We disconnect rainwater from the combined sewer system to ensure optimal capacity, and maintain water quality.

We enter into partnerships, development- and innovation projects. For example, we have initiated a citizen participation project aimed at encouraging property owners to establish soakaways, rain beds etc. for handling private property surface run-off, so the volumes of surface run-off entering into the sewer system are reduced.

Planning ahead

Establishing of a climate adaptation plan and a cloudburst plan. Copenhagen has received several international awards for the climate adaptation plan. The plan forms the basis for a very positive business plan for the implementation of more than 300 projects over 20 years, amounting to a total value of approx. EUR 1.5 billion.

In the Copenhagen area, 10 municipalities and 6 utilities are working together to secure the hydrologic capacity of Harrestrup

stream that traverses all 10 municipalities.

Blue-green infrastructure

Lakes, parks and other recreational areas that make practical and creative use of rainwater are prevalent all over Denmark. These solutions create areas with one set of features in dry weather and another in wet weather.

CONCRETE PIPES FOR STORMWATER TUNNELS – PHOTO BY CARSTEN ANDERSEN



WATER-BASED RECREATIONAL AREAS IN CITIES

Just a few decades ago, in Denmark, you could only dream of swimming in the harbours or using the lakes and streams for recreational activities such as canoeing. The water was heavily polluted from sewage and industrial pollution generated by the urban growth over many decades. Discharge of wastewater from combined sewers, wastewater treatment plants and industrial companies had a major negative impact on water quality and, consequently, on the possibility for using sea water or lakes for swimming or for other recreational purposes.

Today our wastewater treatment complies with the EU Waste Water Treatment Directive. In some parts of Denmark, even stricter rules apply due to the vulnerability of the natural environment. Together with the municipalities in Copenhagen, Odense and Aarhus, 3VAND has worked successfully towards improving the water quality, transforming the harbours, beaches and streams into clean recreational areas for the increasing urban population. The aim is also to ensure continued improvement of the water

quality to improve the aquatic habitat for fish and other marine animals living in and from our streams.

Copenhagen was the first city in Europe, where swimming in the harbour was made possible. This was possible due to the many implemented projects that reduce pollution into the water environment.

Aarhus opened up the old stream running through the city, so that people are once again able to enjoy the open water areas in the centre of Aarhus. Furthermore, the water quality in the upstream lakes was also significantly improved, transforming the water bodies into accessible and safe areas for recreational use.

The water quality in Odense Stream has been improved significantly. Today the stream meanders through beautiful recreational areas, where people can enjoy the stream itself and the fish frolicking in it.

The excellent water quality and the new possibilities for using the water

has also resulted in an increase in property values, new hotels near the water bodies, increasing revenue from tourism, new restaurants and offices and modern city accommodation.

OUR SOLUTIONS

Improving water quality

Online monitoring of water quality in the harbours, streams and fiords and a new water quality model developed for harbour areas.

In Odense we conduct ion selective measurements of the ammonia content in Odense Stream. Combining the collected data with other types of data constitutes an integrated approach to the optimisation of wastewater treatment.

Reducing sewer overflow

Reduction of sewer overflows into the harbours, streams and fiords through construction of large retention basins, sustainable urban drainage systems and intercepting sewers.

Real-time control system based on radar forecasts and data interfaces between the sewer system, the wastewater treatment plant and the recipients.

Implementation of storm water management at wastewater treatment plants have been established.

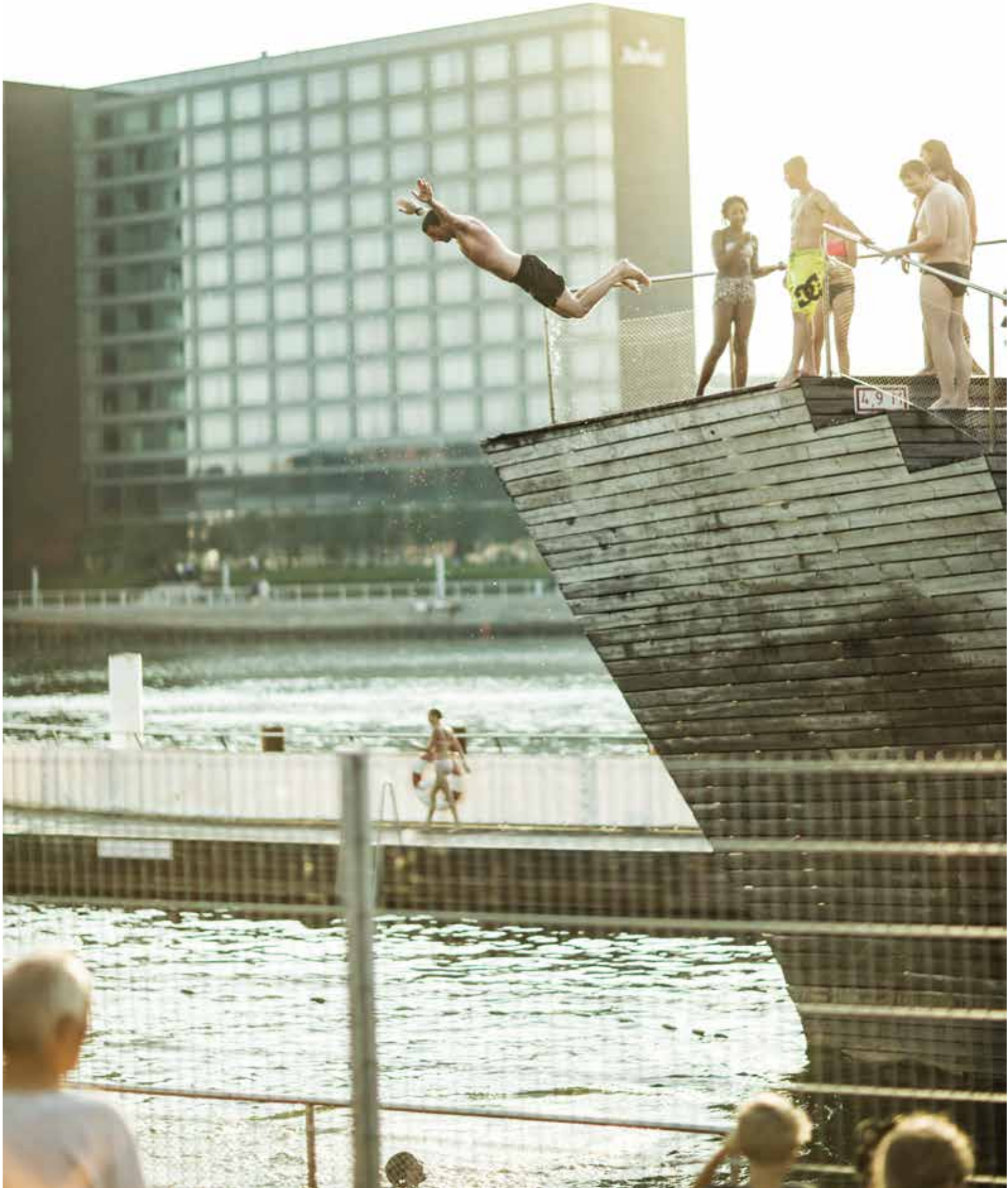
FISHWAY AND RECREATIONAL OPPORTUNITIES AT ODENSE STREAM – PHOTO BY VCS DENMARK



DIVING AT ISLANDS BRYGGE HARBOUR BATH
– PHOTO BY SERGIO CALERO

REFERENCE PLANTS

- THE AARHUS STREAM PROJECT
– improvement of water quality in lakes, streams and the harbour
 - ISLANDS BRYGGE HARBOUR BATH
– recreational swimming facilities along the waterfront of Copenhagen
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CONTROL CENTRE IN AARHUS
– PHOTO BY OLE HARTMANN SCHMIDT

REFERENCE PLANTS

- COORDINATED MANAGEMENT IN AARHUS - improved rainfall monitoring and integrated control of sewer and WWTP
 - DALUM WATERWORKS – systems to minimise non-revenue water (NRW)
 - BIOFOS/HOFOR – SAMDUS: visualisation platform shared by utilities in the Greater Copenhagen Area
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AUTOMATION IN URBAN WATER MANAGEMENT

Improved efficiency is essential in preparing for the future challenges facing the water sector – and a means to obtaining the required levels of efficiency is automation. Denmark is a front-runner as regards IT solutions for operating water facilities, where waterworks in Copenhagen, Aarhus and Odense are operated solely with computer technology.

All processes at our wastewater treatment plants are also controlled and operated using IT technologies. This means that the number of employees is low, and that those employed are primarily allocated to the monitoring of advanced IT systems. As a secondary benefit generated from the implementation of IT solutions, the risk of human error in relation to operations is also reduced.

The aim of 3VAND is to ensure that water and wastewater infrastructures are operated as efficiently as possible, from production and transport of drinking water to treatment and discharge of waste water. The primary tool to ensure optimisation of operation processes is automation. Automation links all processes, motors, pumps and plants in both water plants and wastewater treatment plants respectively.

Efficient processes form the basis for optimising water management in our urban areas – this allows us to save money, protect the environment and minimise the risk of flooding.

In general terms, automation facilitates the transmission of relevant data from the wastewater treatment plant to the discharge systems – and in the drinking water areas, from the waterworks to the distribution systems. Copenhagen, Aarhus and Odense are among the world leaders as regards automation of water-related infrastructures. Our knowledge and knowhow concerning water-related processes and our years of experience with applying new technologies in our production have been pivotal to the position that we currently hold in the global water sector. We dare experiment, we embrace new technological advances, we have established a culture based on collaboration with both internal and external partners and we actively support and engage in innovation projects. The result is that we have acquired comprehensive knowledge and insight both into cutting-edge developments and into the efficacy of a number of innovative and second-generation solutions.



WEATHER RADAR IN AARHUS – PHOTO BY OLE HARTMANN SCHMIDT

OUR SOLUTIONS

Real-time adjustment

In the Copenhagen area, we have developed a visualisation system (SAMDUS) that allows us to obtain a real-time overview of rainfalls and flows in the sewer system.

Significant investments have been made in weather radars that measure precipitation types and volumes. Data collected from the radar is transmitted to the advanced IT systems that operate and control wastewater treatment plants, wastewater basins and the discharge systems in general, enabling us to optimise capacity management.

We apply advanced software solutions to set and adjust network pressure. A simulation program carries out online calculations based on real-time data from various sections of the water distribution system. The real-time calculations ensure the maintaining of steady pressure throughout the network. The result is a reduction in the number of bursts and also a reduction of the energy costs.

Intelligent software

In Odense we have contributed to the development of software that intelligently controls abstraction

from well fields. The system is developed as an add-on and is compatible with all types of SCADA systems.

Control systems

We are world leaders as regards non-revenue water. One of the reasons is partitioning of the water distribution system (DMA), that provides the basis for using our control systems in an even more intelligent way, as we are now able to ensure a prompt and targeted response to actual leakages.

INTRODUKTION TO OUR COMPANIES

HOFOR

HOFOR, Greater Copenhagen Utility, is the combined utility for the metropolitan area. Every day of the year, our employees provide our customers with visionary utility services. We provide services to more than a million customers in eight municipalities in Greater Copenhagen. We supply consumers with drinking water, district heating, natural gas and district cooling, and we discharge rainwater and wastewater. We establish wind farms and we are converting "Amagerværket" - a combined heat and power plant - into a biomass-fired facility, from being a traditional coal-fired one. Everything we do - down to the very last detail - is all about developing sustainable solutions for our towns and cities.

BIOFOS

BIOFOS is the largest wastewater utility in Denmark. We treat the wastewater from 1.2 million people living in

the Greater Copenhagen Area at our three treatment plants: "Lynetten", "Avedøre" and "Damhusåen". We use the resources in wastewater to produce climate-friendly energy in the form of electricity, biogas and district heating.

VCS Denmark

VCS Denmark is located a couple of hours west of Copenhagen. Our history dates back to 1853, where the first waterworks was established in successful response to a nationwide epidemic. We provide high-quality drinking water, protect the groundwater, contribute to innovative climate solutions and ensure sustainable wastewater treatment. Our largest wastewater treatment plant "Ejby Mølle" is located in the city near the old water mill of Odense. Today, it is a fully updated, energy producing facility. In the area of drinking water, we are world leading in reducing leakages in pipe systems

- our total water loss (non-revenue water) has been reduced to only 6 %.

Aarhus Vand

Aarhus is the second largest city in Denmark. Aarhus Vand supplies about 85 % of the inhabitants of Aarhus Municipality with clean drinking water. We operate eight waterworks and we treat more than 30 million cubic metres of wastewater per year, deriving from 350,000 customers. We actively contribute to improved public health and a steadily improving aquatic environment.

Our activities also include rainwater management - including climate adaptation projects - as well as safeguarding a balanced and healthy water cycle. Our four wastewater treatment plants are bio-refineries producing green energy and valuable fertiliser from wastewater.

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