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DANISH MINISTRY
OF THE ENVIRONMENT

Copenhagen is placed at Zealand (by the red dot) in Denmark.

The city within the highlighted square is Ørestad. Here shown in the context of the centre of Copenhagen.

Ørestad – the blue and green economic driver in Copenhagen

A new urban district in the centre of the Danish capital Copenhagen has been built around a dense blue and green city with a sophisticated transport network.

1. Introduction

Ørestad is built with water. It is a new urban district placed between the historic centre of Copenhagen and the protected meadows on the island of Amager. This unique location has been inspirational in the design of Ørestad: a dense blue and green city with a sophisticated transport network.

Some twenty years ago, Copenhagen and indeed all of Denmark was in economic recession. The country needed a cure, and Ørestad became part of that cure. The idea behind this new urban development is to speed up the transformation of the Danish economy from one based on industrial production to one based on knowledge intensive products and services.

Having attracted a number of investors, Ørestad has so far been successful in boosting the economy. Public life is still lacking in the open spaces and along the canals, but the hope is that this will change when the area is fully developed at some time within the next 20 to 30 years. In an area of 0.6 km by 5 km (310 ha) Ørestad will have 3.1 million indoor square metres, house 20 000 inhabitants, provide 60,000 jobs and offer education to 20,000 students. Parts of Ørestad already appear as fully developed and around 5000 people have moved in.

Ørestad represents an innovative approach in terms of water. Here, the distinct use of water for aesthetic purposes is directly linked to the stormwater management. Thus, storm water runoff is the main supply for the 10 km of canals that form the unique blue structure of Ørestad. The relatively clean runoff from rooftops is diverted directly to the canals, while the less clean runoff from roads is collected in a separate system. A new treatment technology called Dual Porosity Filtration is being developed for the cleaning of road runoff, which will allow that water to supply the canals too.

The Metro is the backbone of transport in Ørestad, running every 5 minutes. It is elevated, to make it visible and to minimize impact at ground level. Photo: Lene Skytthe/By og Havn.

2. The idea of Ørestad

2.1 Economic recession called for action

The economic recession of the 1970s and 80s in Denmark called for action, and in 1991 the Danish parliament decided to try strengthening the role of Copenhagen as a national and international economic centre. The aim was for the capital to become an appealing international city, capable of attracting new knowledge intensive investment and labour force, and in this way make it a driving force for the national economy.

Major traffic investments, including a bridge linking the Danish capital to the 1.2 million people living in the Southern part of Sweden made up half of the plan, while the development of Ørestad, including a new railway and motorway to Sweden, made up the other half. The Ørestad Development Corporation, (today, CPH City & Port Development) owned by the Danish state and the Municipality of Copenhagen, was established and put in charge of the development of Ørestad.

2.2 The selling point of Ørestad

In 1994, architects from all over the world were invited to express their opinions on the new urban development in an open ideas competition. The public debate that followed pointed to a proposal by ARKKI, a Finnish architect team. The Finnish master plan was developed further in collaboration with the Ørestad Development Corporation, and in 1996 the principals for Ørestad were stated in an appendix to the Copenhagen municipal plan.

Ørestad is built on reclaimed land with low value. The first building sites were sold in the late 1990s. This income helped finance the first phase of the Metro. The creation of an impressive infrastructure before the majority of the plots was sold increased the attractiveness of the land, and the building sites were then able to be sold for better prices to ambitious contractors.

Later on, the economic growth made it possible to develop the infrastructure further, which included the second phase of the Metro system, as well as the new connections to Sweden.

2.3 Integrated infrastructure systems for urban quality

The urban drainage system consists of open canals which, with the parks and other green areas, form the overall blue and green infrastructure of the area. Open water and a near-perfect transport system are the key issues for the area and are the genus loci of Ørestad.

Ørestad is divided into four districts, developed in sequence and linked by The Metro, creating a holistic urban area. The Metro tracks are elevated, so the physical impact on ground level mobility is reduced. At the same time, the Metro has a distinct visible and guiding character. The Metro is the backbone in Ørestad's traffic system and symbolizes the importance of good public transport.

3. Water is used to structure the city and give identity

Water has always been a key issue on Amager. Ørestad is built on former marshland and since the reclamation of the land was completed in 1964, waterholes, ponds and canals have been characteristic elements of the area. From an early stage, the Finnish master plan suggested the use of open water to provide character and identity to the vast area.

The key concept in the Ørestad Master Plan is a continuous body of water, flowing along the full North-South axis of the city. Like the Metro, it connects the four districts and in one stretch it meanders into the neighbouring meadows (see textbox). A secondary system of district canals, running East-West,

links up the neighbourhoods and open spaces. In this way, a network of public open spaces – roads, squares and parks, evolves around the blue elements and presents a structure for buildings and architecture, as well as for public life.

By linking the visible water network to the technical management of stormwater, water has definitely been a decisive and significant element in the Ørestad development plan from day one.

It should be noted, that the water bodies are without safety restrictions. This is only possible because the water elements were established before people moved in. With no fences and barriers, the canals provide opportunities for living with water, not only "close to" water. The various edges of the canals provide different ways to enjoy the water, ranging from quiet contemplation, to lunch with a scenic view. Direct interactions, such as swimming, are, however, not the intention.

A system of primary and secondary canals links up green areas and open spaces in one complete network. Photo: Ole Ziegler/By og Havn.

The four districts of Ørestad and their characteristic water elements

Ørestad Nord (the most Northern part) evolves along the broad *University Canal*. The edges of this canal are constructed from granite curbs and at one point broad steps invite a longer stay right next to the water.

The *Landscaped Canal* runs through the western part of **Ørestad Nord** and meanders into the protected meadows. Here the edges change from granite curbs to a graded, planted bank that naturally connects the city to the meadows.

The *Landscaped Canal* looses its meandering appearance inside the next district, **Amager Fælled,** which is a wetland into which the water infiltrates.

The *Urban Canal* has a square and right-angled appearance. It runs in parallel to the Metro through the central district, **Ørestad City,** as an ever-changing counterpart to the Metro. The soft graded grass edge of the canal is in some places intervened by granite curbs, forming an urban edge. The *Urban Canal* also contains a long cascade.

The water flow from the *Urban Canal* is planned to continue throughout the most Southern district, **Ørestad Syd.**

4. Working for sustainable urban development

During the last 25 years the heaviest storms have intensified some 20 %, both in frequency and intensity, causing problems of flooding all over Denmark. This climate pattern is expected to increase in the future and it is therefore necessary to increase the overall urban drainage capacity and flood control.

Similarly, there is an increasing awareness of the problematic contaminant profile of storm water runoff. This calls for action to be taken to assure appropriate quality of storm water, whether it is discharged into rivers and streams, or designated as recreational water for the general public.

The challenge posed by climate change requires innovation in terms of new techniques and devices, as well as overall strategies for dealing with water in the city. These strategies need to become an integrated part of the planning and the decision-making process. This has successfully been achieved in Ørestad, where the open water network constitutes the storm water management system and at the same time gives structure and recreational values to the area.

To ensure enough water in longer dry weather periods, the canal system can be further supplied with drainage water from a neighbouring development. In total, the water bodies are estimated to retain 178 000 m3.

4.1 Advanced strategy for stormwater management

Today, the canals in Ørestad are supplied with storm water runoff from roof tops. If an appropriate treatment technology can be identified, water from trafficked surfaces will in the future also be used for supply.

The separation of stormwater into roof and road runoff, followed by treatment of the road runoff fraction for use in the

In Ørestad the storm and wastewater system is branched into three separate systems:

The **sewerage** from households and businesses is led off to the sewer system running to the Lynetten *treatment plant* and is never mixed with storm water runoff.

Water from **non-traffic areas** (roofs etc.) is considered clean (restrictions in the municipal guidelines control the choice of roofing materials, e.g. the use of copper is restricted) and is *discharged directly* to the canals of Ørestad

Runoff from roads, car parks and the Metro is collected in its own pipe system and if an appropriate *treatment method* is identified, this water will be subjected to treatment and also discharged to the canals.

urban environment has never been seen before in Denmark and is presumably also new to the world. An overview of the full storm and wastewater management in Ørestad is given in the textbox.

4.2 High quality storm water runoff

The Danish public expects all the benefits of access to clean water and there is a growing demand for the quality of urban water elements to be high.

Together with the municipality of Copenhagen, CPH City & Port Development directly supports the development of a treatment technology targeting road runoff. Today, a new IPR-protected concept for road runoff treatment, entitled "Dual Porosity Filtration" is being tested in the Ørestad area.

The treated water needs to meet high standards in terms of suspended solids, heavy metals and organic micropollutants. A DPF-plant is constructed from several layers of filter materials, through which the road runoff passes in a horizontal flow.

In Ørestad, the DPF-plant is comprised of high-porosity nylon nets of a few millimetres thickness, separating layers of 1 cm thick filtering mats. The water flows freely through the open nylon layers and while passing the filter gravity forces suspended solids downwards towards the underlying limestone filtering mat, where the hydraulic conductivity is low and the water almost standing still. Here the suspended solids, which may include dust, rubber and asphalt, will settle, and in this way be removed from the water. Dissolved phosphate, lead, zinc, copper, chromium and organic micro-pollutants are removed from the water by adhering to the surface of limestone, pure or modified with humic substances.

Clogging is avoided in DPF because the particles are collected in a different compartment to the primary flow, and the entire retention capacity of the limestone mats can be used before replacement or regeneration is necessary.

The method cleans solely by natural physical-chemical and biological processes and is not dependent on the addition of polymers or precipitation agents. The filter can be placed underneath the soil surface, for example under the city's green recreational spaces. Although the proof of the concept is still on-going the first results are promising. The greyish and dirty runoff water from the roads is turned into clear water (see photo) with a low content of heavy metals and organic micro-pollutants. The technology appears to be robust, easy to operate and with an expected life span comparable to other traffic-related infrastructures such as road pavings.

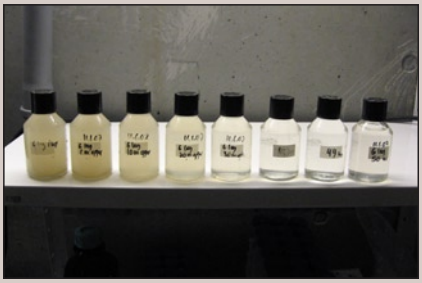
The general aim for the water quality is that flora and fauna should thrive in the water bodies. Fish, frogs and other amphibians are already thriving and various species of submerged plants create a vigorous flora. The hope is for the fragile habitats in the water bodies to continue flourishing and evolve into clear-water robust aquatic habitats. This requires stringent control of toxic algae and pollutants. Accordingly, the amount of phosphorous in the canals should not exceed 0.1 mg total-P/L.

5. The emerging result: a thriving economic centre in the Øresund region

5.1 Ørestad today

The developing of Ørestad is structured in four phases, starting with Ørestad Nord which today is almost fully completed. The second phase, Ørestad City, is almost half built. The next phase, the development of Ørestad Syd, has just begun. The final phase will be Amager Fælled.

Ørestad Nord is today a busy area during daytime, with students hanging out on the promenade along the University Canal, or having lunch on the large steps close to the water surface. Ørestad City is still affected by some construction sites and unfinished buildings, although 'Fields', the largest shopping centre in North Europe, is completed, as is most of the residential area around the city park. The first cafés and restaurants have recently opened (2008). Ørestad Syd is still a vast construction site, where only



Samples of road runoff before, during and after treatment in a 50 m long Dual Porosity Filter located belowground in a park in Ørestad. Bottle 1 (most left) contains inlet water, while bottle 8 is the treated outlet water. The 6 bottles in between are sampled after passage of 1 m, 10 m, 20 m, 30 m, 40 m and 49 m of the filter. Photo: Marina Bergen Jensen.

To keep the open water systems attractive it is important that the quality is high. Litter needs constantly to be removed, and the water used to supply the canals must be free of pollutants like heavy metals and suspended solids. Photo: Ole Ziegler/By og Havn.

parts of the major infrastructure and no buildings are completed. Currently, the completion is progressing slowly due to the unstable world economy.

5.2 The challenges ahead

Ørestad is a city in transition. At present some 5,000 people have moved in, or in other words, a quarter of the full population of 20,000 expected when Ørestad is fully built. A number of sporting and cultural events have been organised by CPH City & Port Development in cooperation with developers and their partners, to help create a pleasant living environment during the years in which the population is relatively small, and the large scale of the site may seem overwhelming. There have been more than 40 events per year, in which people are invited to participate in sports games, music events and nature walks. Later on, cafés, shops and events arranged by the local residents are expected to emerge and take over.

In order for the water surfaces to fulfil their visual purpose as beautiful architectural surfaces that mirror the sky above Ørestad, they need to be litter-free. This requires a great deal of maintenance.

To decrease the often strong winds in Ørestad and improve the existing tree plantings, CPH City & Port Development has engaged landscape architects. With the trees acting as living, medium-scaled buffers between the large buildings and the inhabitants, the open spaces can appear as sheltered environments with a more human scale.

5.3 The success

The city of Copenhagen has benefited from the development of Ørestad in many ways. As an economic bastion, developed with water, nature and sustainable urban aspects, Ørestad has already strengthened Copenhagen as an international city and centre of the Øresund region. Today the Metro that was financed from sale of building sites in Ørestad, reaches all parts of the city and the trains to Sweden run around the clock. Copenhagen has been given a new heart that helps keep the national economy alive. The integrated planning process, where the basic values for the new urban area were decided at an early stage and kept vigorous throughout the process has so far been a success. Hopefully Ørestad will keep contributing new aspects to urban life and continue to be an asset to the existing city of Copenhagen, the Øresund Region and the international community.

6. Perspectives on Danish research and urban development

Ørestad is a new suburb, built on undeveloped land. The use of water as an integrated element for the creation of structure, identity and sustainable drainage solutions was an option from the early beginnings. A more complex situation is the retrofitting of existing cities with designs for stormwater management to increase drainage capacity and enhance urban life quality. This subject is currently a field of much debate and research in Denmark. The research concerns development of tools to design

Today, the canals are supplied with stormwater runoff from roof tops and drainage water from a neighboring development. In the future also rain water from trafficked areas will be used for supply, if appropriate water quality can be achieved, e.g. by use of Dual Porosity Filtration. Photo: Lene Skytthe/By og Havn.

sustainable urban drainage systems (SUDS) to ensure appropriate quality of stormwater runoff and to exploit the assets that can be obtained by linking stormwater management to other urban functions. The hope is that the ongoing Danish research and scientific work will lead to improved integrated solutions with water in urban areas.

The use of water as an integrated element in fulfilling basic functions in a new urban area has so far been a success in Ørestad, and there are aspects of water management that may be taken even further, for example, the utilization of stormwater for heating and cooling of buildings. Some experience of this potential has already been gained as the new home of DR (The Danish Broadcasting Corporation) in Ørestad Nord is utilizing groundwater for cooling purposes. Furthermore, the successful development of the Dual Porosity Filter has meant that the developers of Ørestad have contributed to a technological achievement that can also be used in other urban areas and perhaps even become adapted for the treatment of secondary water sources for more sensitive supply purposes. The filter provides clear water with low content of contaminants and could – in combination with hygienic treatment – be used for drinking water supply in other parts of the world, where clean water is an absolute need.

7. Lessons learnt

1. Financing of a new regional traffic infrastructure by developing a new urban district that is attractive to international businesses and young families looking for knowledge intensive jobs can turn economic recession into economic growth.

2. Exploring the potential of water in the city holds a strong innovative power and presents a frame for development of new relationships between developers, contractors, architects and scientists in terms of taking joint responsibility for the quality of urban life and for realizing urban development goals of wealth and sustainability.

3. Exposure and utilization of storm water runoff in urban areas can provide character, identity and special ambience, as well as aesthetic and recreational values. This can be in harmony with sustainable drainage solutions.

4. For it to thrive, public life needs a pleasant and friendly environment. Water can be an attractive element in open spaces, but is usually not in itself, enough to generate public life. Places where people can meet and interact with each other and the surroundings need to be designed to a human scale and be sheltered from wind to make people feel comfortable. Additional attractions related to buildings in close vicinity to the open spaces can provide extended public life and create reasons for staying in them for longer.

5. High expectations and requirements of recreational water and environmental protection in a rich country like Denmark can generate technological innovation and perhaps provide life-saving solutions in terms of urban water in other places in the world. This is indicated by the development of the Dual Porosity Filtration technology.

6. Implying new qualities in urban areas by using water is not a question of a single technology, but the result of political will, environmental regulation, technologic development and strategic planning.

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