



Water in the City

Opening up the river through Århus, the second largest city in Denmark created a new vibrant city centre. Similarly, major improvement of the waste water system in the Copenhagen region made the seawater in central Copenhagen completely clean, giving the citizens the possibility of swimming in the harbour and at the same time contributed to the regeneration of an otherwise slightly down at heel area of the city. In both cases, political will and stamina has been the guiding light.

Introduction

In the late 1990s the city of Århus decided to daylight the small river that used to run through the city centre but which had been covered up by buildings over the years.

Almost immediately the plan proved successful. Cafés sprang up alongside the now daylighted river, and street musicians moved in, detracting attention from the noisy and heavy traffic and bringing a vibrant and joyful atmosphere to the city-centre. The river daylighting is still expanding.

The decision to re-open the piped river includes initiatives to ensure clean water. A major factor is also more efficient treatment of waste water and the restoration of the natural aquatic environment in the lakes from which the river originates.

The creation of a clean and attractive urban environment has become a key in the ongoing transformation of many Danish cities from industrial to urban centres in the modern knowledge-based economy. As most Danish cities are situated close to the sea, fjords or rivers, their waterfronts often constitute a significant element in their physical appearance.

1. Challenges – Water and Urban Transformation

Many Danish cities are located at the sea, or by an inlet which can support water transport. When the industrialisation of Denmark began in the middle of the 19th century, many of the factories, warehouses and shipyards were located close to water transport, at the harbours and close to the centres of the cities.

By the late 1960s however, the use of the harbour areas began to come to an end, shipyards began to close one by one and traditional warehouses became obsolete. Much regional transport shifted from coasters to trucks and many industries moved from the harbour areas to new industrial parks with access to high class roads, leaving behind deserted factories, obsolete piers, railway tracks and derelict shipyards.



Hundred years of heavy industrial production had also left its mark on the environment. The soil was polluted with chemicals, groundwater was unusable for drinking, streams had been transformed into piped sewers and the water in the harbours was devoid of fish and underwater plants, and completely unsuited for any kind of recreational use.

The rise and fall of Danish Shipbuilding

For many years, the Danish ship building yards played a major role for the Danish economy. The largest industrial company in Denmark was Burmeister & Wain Shipyard and the majority of the industrial export was generated by the shipyards. However, during the beginning of the 1980s the shutdown of the majority of the main shipyards accelerated:

- * 1912 † 1983 – Helsingør Shipyard, Helsingør
- * 1916 † 1986 – Nakskov Shipyard, Nakskov
- * 1479 † 1991 – Orlogsværftet, København
- * 1858 † 1996 – Burmeister & Wain Shipyard, København
- * 1958 † 1997 – Nordsø Shipyard, Ringkøbing
- * 1912 † 1998 – Aalborg Shipyard, Aalborg
- * 1913 † 1999 – Danyard, Frederikshavn
- * 1945 † 1999 – Århus Flydedok, Århus
- * 1867 † 2001 – Svendborg Shipyard, Svendborg
- * 1938 † 2007 – Holbæk Shipyard, Holbæk
- * 2009 – Odense Steel Shipyard Group, the largest remaining Danish shipyard which in 2007 delivered the world's largest container carrier, decided to focus on constructing smaller ships.

For many Danish cities, this transformation, away from traditional industrial society, had severe economic and social consequences. Young families moved to more attractive areas outside the cities and unemployment, an aging population and falling tax-income characterized the situation in the industrialised cities.

The semi-public company Copenhagen Harbour previously owned 1/8 of the land in the municipality of Copenhagen. This area was perceived as an industrial area, and as the industrial era came closer to its end, scrap-dealers and second-hand car dealers moved in between the derelict industrial buildings, making the waterfront almost inaccessible and un-attractive. At the same time, few of the people living in the Municipality of Copenhagen were in employment. It was a city of students, unemployed and retired people – more than 30 % of the citizens were over 60 years old. Young people left the city and moved to the suburbs when they graduated from university and had children. At the end of the 1980s, the Municipality of Copenhagen was virtually bankrupt – something had to be done. Without a strong capital the rest of Denmark would suffer too.



2. Solutions

The Danish answer to the economic recession and deteriorated environments has been to transform cities from places with decaying industrial areas and unattractive urban environments into clean and healthy cities with well-functioning infrastructures, capable of attracting resourceful and skilled citizens and international knowledge-intensive businesses. This transformation is ongoing.

Today, the link between attractive urban areas and a strong economy is embodied in the planning processes reflected in the National Spatial Planning documents, which are published every four years. Since 1992 their focal points have changed from rural areas to specifically targeting the economic development of the big cities and to Danish competitiveness in an international economy.

The Danish response to the deteriorating environment has been comprehensive and shows a high degree of responsibility. In 1971 the Danish Ministry of Pollution Control was established in response to strong public pressure, to combat the very visual pollution of the 1960s and 1970s. In 1973, this became the Ministry of the Environment. During the 80s and 90s, the Ministry initiated a major programme to control the discharge of pollutants into the environment, not least in urban streams and rivers. Gradually, industries became cleaner and cleaner and municipal wastewater treatment plants emerged. Today, sewage from industry and households is controlled to a high level. However, major problems do still exist in terms of the quality of urban runoff. In addition to storm water runoff causing municipal treatment plants to perform poorly, Danish cities encounter problems with combined sewer overflow and there are fears as to the impact of contaminants in the storm-water runoff itself.

The demands of the urban population for a safe and healthy environment, rich in cultural and educational opportunities are continuously increasing, and the ability of urban planners and decision makers to meet these expectations is increasingly being considered an important factor in the international competition to attract a skilled labour force as well as economic investments. In this never-ending exercise it is essential to exploit the possibility of achieving multiple goals whenever major investments are to be made. The role water can play in this is illustrated in the following examples.

In the late 80s, selling land for new developments was part of the solution to Copenhagen's immediate economic problems. At first, it was hard to find investors willing to develop the harbour areas, which is perhaps why there was apparently more focus on selling land than on developing an attractive waterfront that could be of benefit to all the inhabitants of Copenhagen. Eventually the quality of the urban development in the former harbour areas came in focus, as can be seen in the new development of the southern part of the harbour area.



The new developments are mostly residential buildings and office buildings, many of them directly on the waterfront. In some cases, brand new harbour branches have been built to elongate the waterfront. Here, you can find apartments with a bicycle parked on one side of the building and a kayak lying in the water on the other side.

3. Results

To swim in completely clean seawater in the middle of a large city represents a unique urban experience, and on the 15th of July 2002, the first Copenhagen jumper jumped into the Harbour Pool in the centre of the city. Many people appreciate the excellent design of the bathing facility at the Harbour Pool, although it is about much more than this. It is the story of a political drive and a perception of clean water being more than a merely environmental question. As expressed in the political statement preceding the establishment of the Harbour Pool by several years: *The water in Copenhagen harbour has to be clean enough to swim in!* As a result of this decision, the waste water system in the region has been much improved and real-time models for ensuring and controlling the quality of water in the Harbour Pool have been developed by Danish Hydraulic Institute. The Harbour Pool illustrates the interaction between regional and local considerations and the interaction between different sectors in public urban management.

'Ørestad' is a large urban development in Copenhagen that does not have immediate access to the sea. Water has, however, been a decisive element in the planning of the area. Ten kilometres of sculptured canals are being used to structure and connect the different urban areas and provide a characteristic atmosphere even before people move in. The water in the canals is to be clear and free of contaminants and different activities such as picnicking on steps which go down to the water have been prepared for. In order to conserve water resources, the canals are supplied with storm water runoff from the roof tops of the buildings and the plan is also to use storm-water runoff from streets as the water supply for the canals. The developers, By & Havn and the municipality of Copenhagen both support the development of appropriate treatment technologies. This has resulted in the development of an IPR-protected new technology entitled Dual Porosity Filtration.

Water can be used for swimming, kayaking, sailing, motorised water-sports, floating stages for concerts, fishing and other kinds of activities. Houseboats can also be situated on the water. It is, however, important to be aware of the conflicts between some of the activities. Swimming and motorised water-sports should, for instance, be separated. Houseboats can also be seen as a barrier between the public and the water. It is also important to be aware that blue space can supplement, but not replace green areas. Integrated planning is therefore needed which takes both the blue and the green space into consideration.

As illustrated by the case of the day lighting of Århus river urban assets can be increased with clean and accessible urban water elements. This is widely recognized today both by developers and urban planners, and several investigations point to marked increases in excess of 40% in the price of dwellings located near water, or with a view of water. Thus, the creation of an attractive blue structure and exploitation of the options for ensuring access to clean water elements may be considered a driver for economic development.



The innovative power arising from visionary thinking such as the idea of harbour baths, should be underestimated. Thus, the exploring of the amenity values associated with urban water elements holds a strong innovative power, both in terms of the development of new drainage and treatment technologies and also in terms of developing tools for integrated urban planning and decision making.

Challenges for the future

Climate change

The future major urban water response will most likely be triggered by climate change. It will involve both a mitigation strategy and an adaptation strategy targeting heavy storms and temperature increases.

An effort to reduce the use of fossil energy needs to penetrate all sectors and all activities, including those involving water. The emerging mitigation strategy appears to concern energy savings in the water supply and discharge management, i.e. less pumping, less aeration, better insulation of buildings and also on the options for using water to cool and heat buildings.

The necessary adaptations include a significant increase in urban drainage capacity in both new and existing urban areas as well as ways of compensating for temperature increases in order to maintain an appropriate human comfort factor.

Examples of mitigation already in use in Denmark

Reduced groundwater consumption – ‘Stenløse Syd’

In the new urban development ‘Stenløse Syd’, a Copenhagen suburb, roof runoff is passed through a hydroclone and collected in tanks, to be used for laundry and flushing of toilets, which reduces the long-distance supply of fresh water. Even though the water used for toilet flushing has been reduced from six litres to three litres per flush, toilet flushing and laundry still represents a large part of the domestic water use. This represents a considerable reduction in the use of groundwater. Excess runoff from approximately 350 houses is being infiltrated into the soil locally, minimizing the drainage infrastructure. 350 more new houses are to be built in the area, using the same water treatment methods.

Use of water for cooling – ‘DR-byen’

The expected temperature rises may accelerate the heat-island issue of urban areas, making cities hotter and hotter. Even in Danish cities, heat islands can become a problem. Water evaporating from plants can play a major role. It is well known that in contrast to paved areas, areas with large trees and other green elements can help to cool down the spaces between the buildings in a town lowering the outdoor temperature by up to 2 degrees Celsius. The greening of roofs and other elements of the building can also be a part of reducing the need for artificial cooling.



Changing trends in architecture, new standards for working conditions and climate change have made the cooling of buildings more common in Denmark, especially in new office buildings. Seawater has been used for cooling buildings like 'IDA-huset' in Copenhagen. Water running down the façade was an essential part of the cooling system in the Danish Pavilion in Seville in 1992.

In 'DR-byen' in Ørestad, the Aquifer Thermal Energy Storage principle is used for cooling during summer and heating during winter. 'DR-byen' is the new headquarters for the national Danish broadcasting company, and has a specific need for cooling due to all the electronic equipment and artificial light in the TV-studios. The need for cooling of office buildings could, however, be more or less eliminated by an intelligent building design, such as demonstrated in the 4D project in Ørestad.

Examples of adaptation in Denmark

In addition to conventional enlargement of the sewer systems, the Danish approach to gaining more drainage capacity, involves better exploitation of existing sewer capacity, low impact development (LID) and the retrofitting of existing urban areas with sustainable urban water designs (SUDS). Strategies for dealing with extreme storm events, i.e. storms exceeding the capacity of the systems are also very much in focus.

Conventional methods include retrofitting of the existing sewer system with large underground detention tanks and detention pipes, as well as the construction of pumping stations to lift the excess storm water runoff from one sewer system to a neighbouring system which has free capacity. These options are supported by the development of real-time computer models of the sewer systems that are linked to weather forecasts, local weather radar and rain gauges to route the runoff between the different sewer elements in an intelligent way. (www.wastewaterinformatics.dk).

The non-conventional methods are mainly applied in new urban developments. Denmark has several examples of new urban areas with zero, or limited discharge of stormwater runoff, for instance, Trekroner at Roskilde, Markhaven in Odense and Stenløse Syd in Furesø County. Here retention in swales and ponds are combined with infiltration through surface and subsurface trenches. Although Denmark does not have any examples of retrofitting of existing sewer catchments with similar designs for delay and infiltration, retrofitting is a subject of much debate and research (www.2BG.dk, www.19k.dk). The research concerns the development of primary tools to design and size SUDS. Additional tools are developed to ensure the appropriate quality of the storm water runoff before it is infiltrated to groundwater reservoirs, or is discharged to receiving waters and also to exploit the assets that can be obtained by linking storm-water management to other urban values and functions. As the development and introduction of non-conventional adaptation measures is a complex process, these projects also deal with the planning- and decision making process itself and includes research goals for improved knowledge sharing and generation of innovations.



Contaminants in storm-water runoff

In addition to climate change, the concern about heavy metals and organic contaminants in stormwater runoff from urbanized catchments is likely to change urban water management in Denmark. This is emphasized by the EU-Water Frame Directive and by the rising expectations of the general public for clean aquatic environments both inside and outside the city.

The implementation of the EU-Water Frame Directive may directly target specific substances in storm water runoff and call for action.

As already mentioned, the Dual Porosity Filtration technology is being developed as a direct response to the public's expectations of clear water (www.orestad.dk). In addition, Denmark is leading an EU-LIFE project entitled LIFE-TREASURE, in which several mechanisms for stormwater treatment are being tested (www.lifetreasure.dk).

Danish Lessons Learnt

A driving force for economic development: Access to the waterfront

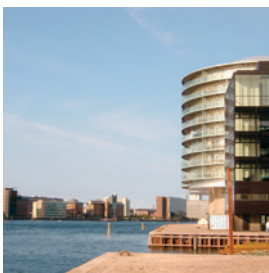
Access to water for amenity purposes is essential in urban development. In Denmark, structural changes in industries have transformed the harbour areas and provided access to water for the ordinary citizens. Access to the waterfront and the possibility of swimming in clean sea water in the centre of the city gives the city an extraordinary urban quality – for the benefit of the inhabitants and for the attraction of a labour force, innovative power and investments.

A driving force for economic development: Use storm water runoff

If the sea is not at hand, other forms of access to water can be used. Stormwater runoff is used, creating canals that are the backbone of Ørestad, the new urban development in Copenhagen. Many other new urban developments are doing similar things, Trekroner near Roskilde, Stenløse Syd, and Markhaven in Odense are just few examples.

A driving force for technological development: Expectations and standards

The high expectations of the general public and high environmental standards for water quality drive the development of new stormwater treatment technologies. Problems with combined sewer overflows have made it essential to develop technologies to handle stormwater in new ways, including methods for making water an amenity asset in the city, and for closing the urban water cycle.



Climate change leads to the demand for more urban drainage

Climate change leads to more intense rainfalls and thus to an increased demand for urban drainage. The answers to this are not necessarily larger sewers but rather, using a number of different elements in a sustainable urban drainage design, including different ways of infiltrating and delaying stormwater. It is worth mentioning that even a simple technology like stormwater infiltration can still be a subject for technological innovation.

Integrated planning is needed

The integrated sustainable urban drainage systems are complex and do not only provide solutions for handling water but also provide a number of opportunities for improvement of the urban green/blue spaces. It is therefore vital to develop integrated planning models in which water is not a problem, but an opportunity. The research and development project 2BG addresses this.

Water as a cooling element

Water has been used for cooling buildings and urban areas for many years, but much of the knowledge of how to do this has been forgotten in the modern urban design. As the climate gets hotter, it is becoming more and more important to use well known ways of using water for cooling, but also to innovate new technologies using the cooling potential of water.

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