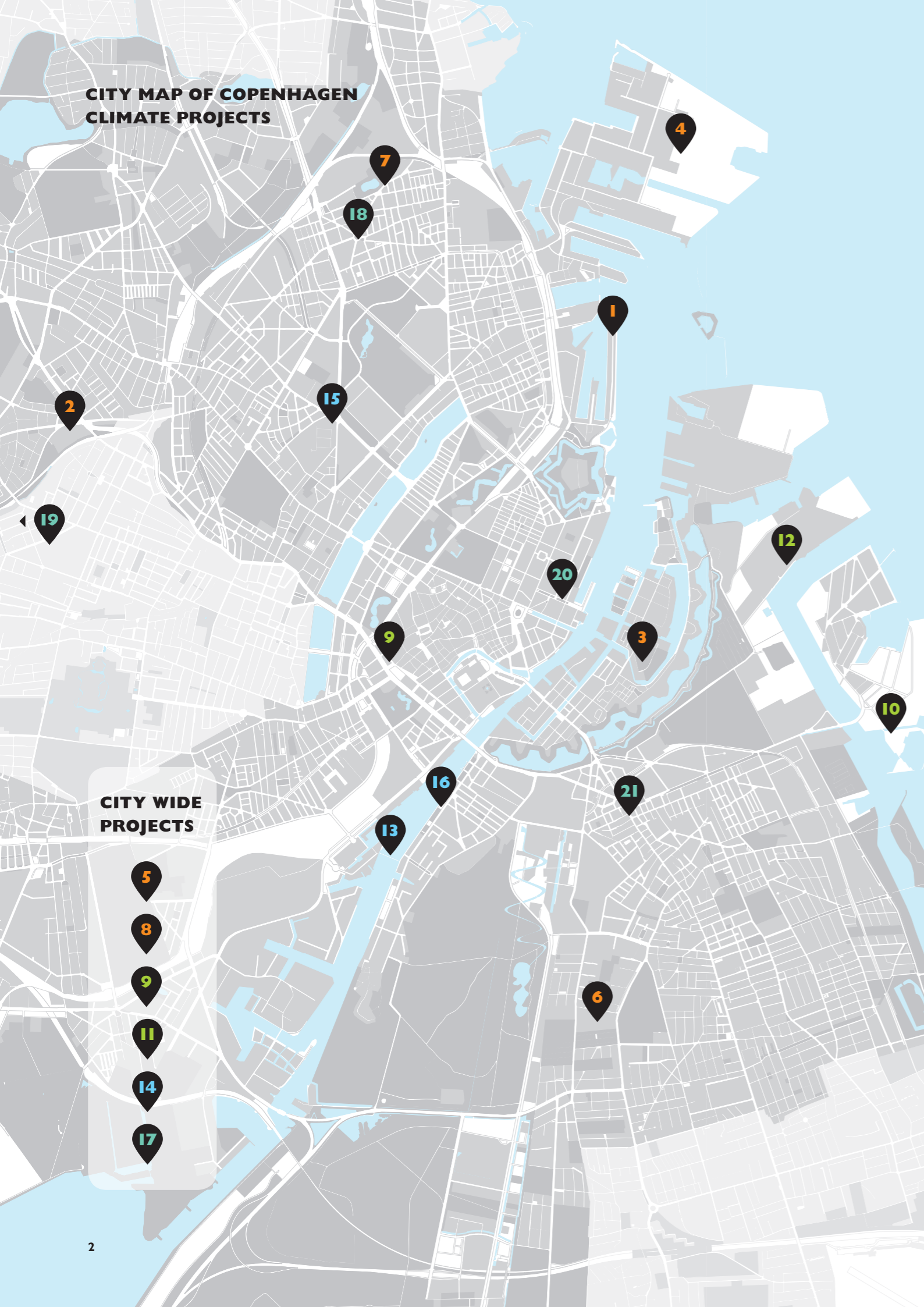


ANNUAL REPORT 2014

COPENHAGEN CLIMATE PROJECTS





**CITY MAP OF COPENHAGEN
CLIMATE PROJECTS**

**CITY WIDE
PROJECTS**

PREFACE	4
INTRODUCTION	6
ENERGY EFFICIENCY AND SAVING	10
1 THE FUTURE OF OFFICE BUILDINGS	12
2 AFFORDABLE AND GREEN HOUSING	13
3 GETTING LIGHT WITHOUT LOSING ENERGY	14
4 NEW URBAN DEVELOPMENT GETS GOLD CERTIFICATION	15
5 SAVING ENERGY WITH NEW ENERGY MANAGEMENT SYSTEM	16
6 SUSTAINABLE SCHOOL	17
7 RETROFITTING WITH PUBLIC FINANCIAL SUPPORT	18
8 SHEDDING NEW LIGHT ON THE CAPITAL	19
ENERGY PRODUCTION	20
9 CLIMATE FRIENDLY DISTRICT HEATING	22
10 WIND TURBINES PUT DOWN ROOTS IN COPENHAGEN	23
11 GETTING VALUE FROM THE CAPITAL'S PLASTIC	24
12 ENZYMATIC TREATMENT OF MUNICIPAL WASTE	25
MOBILITY	26
13 CYCLE SERPENT CONNECTS THE CITY	28
14 NOW THE MAILMAN IS ELECTRIC	29
15 DEDICATED BUS LANES	30
16 COPENHAGEN IS INVESTING IN GREEN TRANSPORTATION	31
CLIMATE ADAPTATION	32
17 RESPONDING TO THE EXTREME WEATHER OF THE FUTURE	34
18 THE FIRST CLIMATE RESILIENT NEIGHBOURHOOD	35
19 CURB EXTENSIONS COMBATING HEAVY RAIN	36
20 HISTORIC SQUARE DELAYS 21 MILLION LITRES OF RAIN	37
21 SHOPPING STREET PREPARES FOR CLOUD BURSTS	38
CONTACT INFORMATION/LINKS	40

PREFACE BY MORTEN KABELL

STAYING ON COURSE FOR AN INCLUSIVE GREEN ECONOMY

During 2014 the City of Copenhagen has had the honour of being European Green Capital. We have done so in a particular way, we call it "Sharing Copenhagen", because to us sharing is the key to create a more sustainable world. We do some things with success, but we are very aware that we need to learn from each other. We need to examine successes and failures, we need to discuss, dissent and disagree, and we need to inspire each other. In short: we need to share our experiences. We wish to share challenges and opportunities and learn as much as we can from stake-holders, citizens and other cities. We also wish to expand our collaboration with key partners in order to make progress, including both government, the private sector and research institutions. We need all the help we can get to make the transition towards a green economy.

This idea of sharing should function on all levels. The economy should not only be green but also "inclusive". No matter how good our plans are, we will not go anywhere without having everyone on board. This is why we work very hard to engage citizens and local communities actively in the process. For instance, the City of Copenhagen has collaborated with companies and research institutions in a public-private innovation partnership in order to test and develop new intelligent traffic solutions on the basis of early feedback from citizens and the users themselves. This kind of collaboration holds great promise not only as a means to improve traffic flows and reduce carbon emissions. It can also improve quality of life for citizens, improve the city itself and even to develop markets for better solutions.

Sharing and cooperation pays off. It shows us new potentials and challenges we would otherwise be blind to.

This annual report contains many more examples of how we work and what we are trying to accomplish. An overarching goal of our effort is to make the ongoing transition of the economy both green and inclusive and to me it is very important that we maintain a social balance in all the solutions we develop. From energy and resource efficiency to increased mobility and climate adaptation. I will leave to the reader to judge whether we succeed. And I strongly invite you to be inspired as well as critical in your reading.



Morten Kabell, Mayor of Technical and Environmental Affairs



LET'S
SHARE

INTRODUCTION

A KNOWLEDGE LED GREEN ECONOMY

The City of Copenhagen has set itself ambitious goals for the city's social, economic and environmental development. Copenhagen is to be carbon neutral by 2025 as the first capital in the world. We will achieve these goals through a transition of our energy supply, building retrofits, waste management, public infrastructure and mobility, as well as other key initiatives to support the transition on both a short-term and long-term basis.

At the same time, the city needs to prepare for climate changes expected in the future, such as heavier and more frequent rainfall, storm surges and heat waves. It is our vision that the ambitious goals are implemented in a way that secures and improves the quality of life in Copenhagen and creates opportunities for innovation, jobs and green growth.

The transition to a green economy in Copenhagen cannot happen in one year or through the efforts of each individual stakeholders alone.

ANNUAL HIGHLIGHTS OF THE COPENHAGEN CLIMATE ACTION PLANS (1)

CPH 2025 CLIMATE PLAN

- During 2013 the City of Copenhagen accounted for about 2 mio. tons of CO₂ equivalent (CO₂) emissions, corresponding to 3,6 tons CO₂ per capita
- Major sources of CO₂ emissions include electricity consumption (48%), district heating (24%) and traffic/mobility (24%)
- Annual reductions of CO₂ emissions from energy production (electricity and heating) based on renewable resources such as wind and biomass correspond to 16% of total emissions, leading to a total of 3,3 tons CO₂ per capita in Copenhagen
- CO₂ emissions in 2013 are up with approximately 79.000 CO₂ or about 4% compared with 2012, due mainly to an increase in emissions factors for electricity and heating (since less wind power was produced in 2013, Danish power plants imported more fossil-based electricity)
- Overall electricity consumption in Copenhagen declined by approximately 6% in the same period

Therefore, Copenhagen is collaborating with companies and knowledge institutions to find new solutions to specific challenges. The City of Copenhagen is also striving to increase documentation of its green efforts and to target new initiatives based on available data and evidence.

Earlier this year, the London School of Economics showed in a report based on extensive analysis why they consider Copenhagen to be a "green economy leader". Even to those familiar with the Copenhagen story, it makes impressive reading. Among many other things, the report shows that Copenhagen has managed over a long time horizon to develop into a very compact and transport-effective city, even compared with other cities such as Stockholm and London.

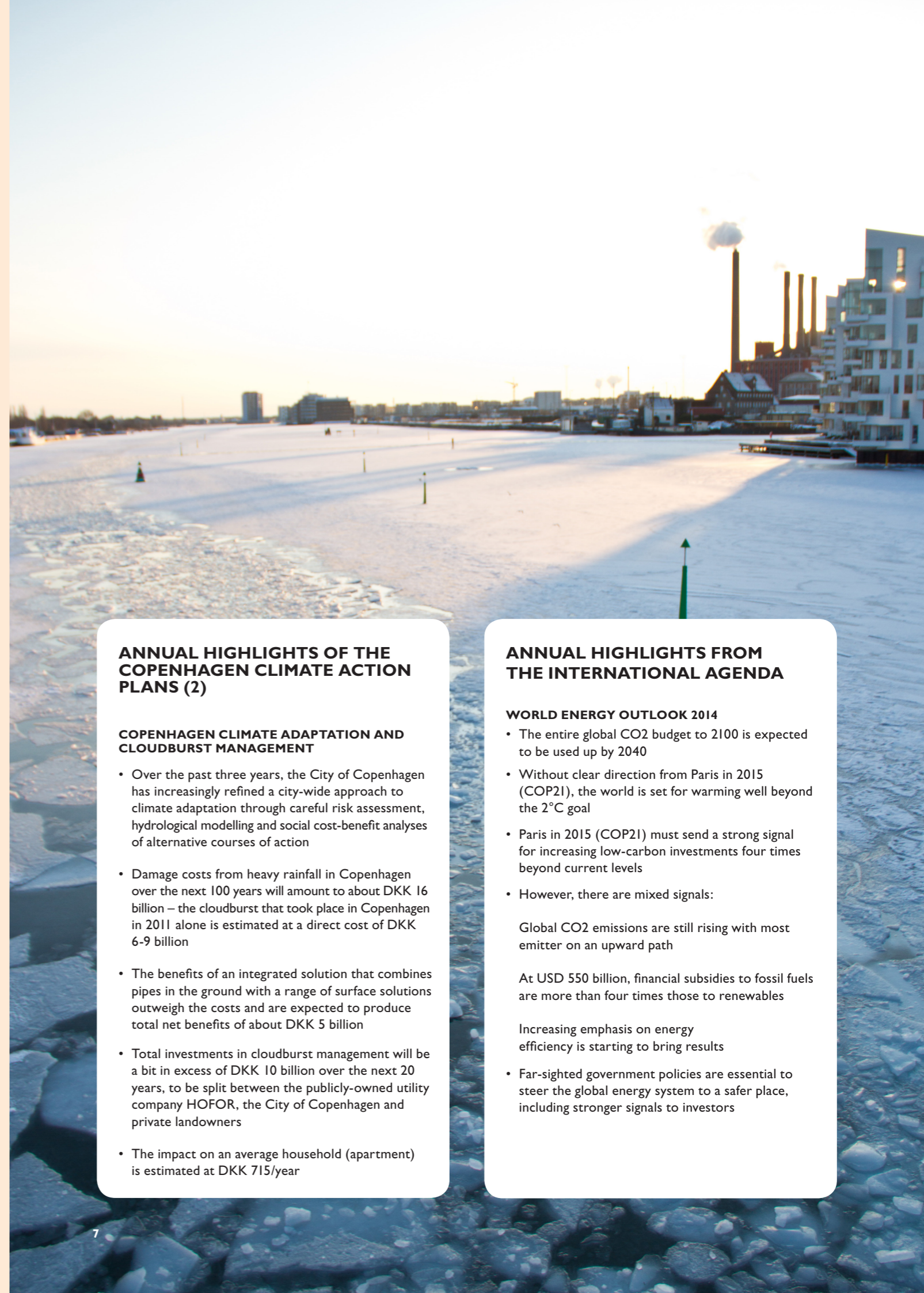
INTERNATIONAL OUTLOOK

During 2014, a number of high-level reports were launched showing the potential economic benefits from early action. They include among others the 5th IPCC Assessment Report presented in Copenhagen, the Global Commission's report on the "New Climate Economy" by the Global Commission on Economy and Climate, and the World Energy Outlook 2014.

The "New Climate Economy" shows how cities can play a significant role in the global transition towards a green economy, if done well:

- More compact and connected urban development could reduce global urban infrastructure requirements by more than USD 3 trillion over the next 15 years, while creating a fertile environment for innovation in ideas, technologies, and processes
- Investments in cities which save money could reduce total global greenhouse gas emissions by up to 18% by 2025
- Adopting low-carbon technologies - such as new building technologies and electric buses - in 30 world megacities could create more than 2 million jobs, while avoiding 3 billion tons of cumulative CO₂ emissions and 3 million tons of local air pollution by 2025.

The "New Climate Economy" also shows that a number of leading cities such as Copenhagen are paving the way for new forms of urban development better aligned with nature and with the quality of life of its citizens.



ANNUAL HIGHLIGHTS OF THE COPENHAGEN CLIMATE ACTION PLANS (2)

COPENHAGEN CLIMATE ADAPTATION AND CLOUDBURST MANAGEMENT

- Over the past three years, the City of Copenhagen has increasingly refined a city-wide approach to climate adaptation through careful risk assessment, hydrological modelling and social cost-benefit analyses of alternative courses of action
- Damage costs from heavy rainfall in Copenhagen over the next 100 years will amount to about DKK 16 billion – the cloudburst that took place in Copenhagen in 2011 alone is estimated at a direct cost of DKK 6-9 billion
- The benefits of an integrated solution that combines pipes in the ground with a range of surface solutions outweigh the costs and are expected to produce total net benefits of about DKK 5 billion
- Total investments in cloudburst management will be a bit in excess of DKK 10 billion over the next 20 years, to be split between the publicly-owned utility company HOFOR, the City of Copenhagen and private landowners
- The impact on an average household (apartment) is estimated at DKK 715/year

ANNUAL HIGHLIGHTS FROM THE INTERNATIONAL AGENDA

WORLD ENERGY OUTLOOK 2014

- The entire global CO₂ budget to 2100 is expected to be used up by 2040
- Without clear direction from Paris in 2015 (COP21), the world is set for warming well beyond the 2°C goal
- Paris in 2015 (COP21) must send a strong signal for increasing low-carbon investments four times beyond current levels
- However, there are mixed signals:

Global CO₂ emissions are still rising with most emitter on an upward path

At USD 550 billion, financial subsidies to fossil fuels are more than four times those to renewables

Increasing emphasis on energy efficiency is starting to bring results

- Far-sighted government policies are essential to steer the global energy system to a safer place, including stronger signals to investors



ENERGY EFFICIENCY AND SAVING: RETROFITTING, SMART CITY AND STREET LIGHTS

The City Council has set aside budget funds for retrofitting 32 out of 72 public schools, but the current rate of retrofitting existing buildings in the city needs to be accelerated and energy-efficient management has to be implemented city-wide. The City intends to use Smart City tools to support the efforts to improve quality of life, growth and energy efficiency, for example by giving the public access to data on buildings. Furthermore, 2015 will mean that energy consumption by streetlights will be cut in half thanks to new energy-efficient LED lights.

A huge part of Copenhagen's attraction is the city's beautiful and historic buildings. Many were constructed years before the world had ever heard of global warming or energy efficiency.

To deliver on its ambitions to become the world's first carbon-neutral capital, Copenhagen needs an ambitious rate of retrofitting of these buildings. It is estimated that developers will invest about DKK 80 billion before 2025.

At the same time, Copenhagen is growing at an impressive rate. On average the capital welcomes 1,000 new citizens every month. By 2025 the city will have grown by 100,000. That means an increased need to develop and construct new buildings to house these new inhabitants.

An estimated DKK 140 billion is expected to be spent on new housing in Copenhagen up to 2025.

NEED TO ACCELERATE BUILDING RETROFITS

The current rate of retrofitting existing buildings needs to be accelerated and ambitious if the goal is to be met.

One way the City of Copenhagen is pushing for accelerated retrofitting is by applying its own building muscle. The City runs five percent of the total building mass in the capital. From schools to libraries, sports arenas and daycare centres. Copenhagen believes it can contribute to promoting the market for energy-efficient buildings.

Therefore, the City has set an ambitious goal to reduce energy consumption in municipal buildings by 40 percent by 2025.

In recent years, the City Council, for example has granted funding for full retrofits with ambitious energy efficiency targets of 32 schools out of a total of 72 public schools. Needless to say, ambitious energy-efficiency requirements also apply to new municipal buildings such as the many new public daycare centres.

GETTING BUILDING OWNERS ON BOARD

Nevertheless, for a major change to happen, several more large and small building owners must take part in the necessary "deep" and holistic renovation of their buildings in the forthcoming years. They should also create the right basis for retrofitting by securing efficient energy operation of the buildings.

The City of Copenhagen will make an effort to establish a dialogue and facilitate partnerships with other large building owners, private companies, financial institutions, etc. to make this happen, and to influence the shaping of much stronger incentives for building owners to invest in energy-efficiency initiatives at national level.

SMART CITY GETTING SMARTER

The future energy supply needs to be smarter in order to better integrate increasing levels of renewable energy from wind turbines in the grid. That means installing Smart Meters for electricity, heat and water consumption, as well as a range of other different initiatives

Copenhagen is currently ranked as number one on the list of European Smart Cities. Over the next five years the City also intends to promote energy efficiency by giving the public access to data on buildings and energy consumption and by carrying out tests on systems for private



The school yard at the Dyveke school after a deep and holistic retrofitting. Photo by Tine Juel.

houses that automatically adjust ventilation and energy consumption to create an optimal indoor climate.

Finally, Copenhagen wants to develop smart solutions within the field of transportation (Intelligent Transport Solutions). For example to reduce congestion and improve traffic safety by allowing the maximum number of busses, cars and cyclists to pass unhindered.

To further promote the use of Smart City technology, Copenhagen helped establish Copenhagen Solution Lab (CSL) that will be the venue for innovation of Smart City solutions in partnerships between public and private actors.

THE CAPITAL IN A NEW AND ENERGY-EFFICIENT LIGHT

Copenhagen has signed a contract with the French company, Citelum, to replace 20,000 old lighting fixtures with energy-efficient LED lighting and to replace 8,000 lamp posts.

It has been estimated that the move will cut the city's electricity consumption on lighting in half. This is equivalent to the consumption of more than 4,500 apartments. Finally, the City will obtain operating savings of more than DKK 17 million per year.

Furthermore, the change will mean that the citizens will see their city literally in a new light. The current street lighting primarily ensures light on roads for motorists. From now on, the light will be spread over a larger area, to make it easier for cyclists and pedestrians to find their way through the city at night.

40 PERCENT: THE REDUCTION TARGET IN ENERGY CONSUMPTION IN MUNICIPAL BUILDINGS BY 2025.

THE MAJOR GOALS FOR ENERGY CONSUMPTION BY 2025 IN COPENHAGEN

- 20 percent reduction in heat consumption.
- 20 percent reduction in electricity consumption in commercial and service companies.
- 10 percent reduction in electricity consumption in households.

INSTALLATION OF SOLAR CELLS CORRESPONDING TO 1 PERCENT OF ELECTRICITY CONSUMPTION IN 2025.

- 40 percent reduction in energy consumption in municipal buildings.

1. THE FUTURE OF OFFICE BUILDINGS

When Danish pension provider, ATP, were planning a new office building on one of Copenhagen's most prestigious addresses, their priority was to keep operating costs as low as possible. That meant turning the building into one of the most energy-efficient office buildings in Denmark.

Right on the waterfront and close to the Danish national symbol, The Little Mermaid, sits the new office building, Pakhuset (The Warehouse). Built to resemble the classic warehouses on the harbour front, the building is big enough to house up to 700 employees.

"Our primary activity is to maximise investment returns for the members of our pension fund; ATP Livslang Pension (Lifelong Pension). So we were looking for durable solutions with low maintenance and operating costs," says project manager with ATP Properties, Mette Munkedal Tange.

The result: An office building with impressive energy savings.

SOLUTION: THE SECRET POWER OF FRESH AIR

The office building keeps energy costs at a minimum by employing a number of well-known solutions to make a unique ecosystem.

The building is heated by district heating supplied with a heat pump that captures heat from the used air in the building. The excess heat is then used to heat the slabs between the office floors.

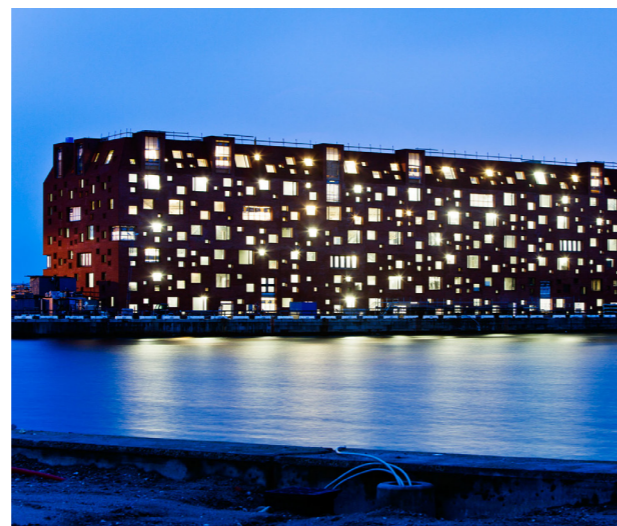
"The building sits right on the waterfront and we are therefore able to put the fresh air to good use in the building. We pull fresh air through noise-reducing vents into the building and thereby save energy on mechanical ventilation," says Mette Munkedal Tange. In terms of cooling, the building sits right on top of its supply of cooling. Through four wells drilled beneath the building, groundwater is pumped 115 meters to the surface to cool the building and its employees. The groundwater resource is salt water, so it is not suitable for consumption.

RESULTS: IMPRESSIVE SAVINGS

What is more, the new tenants in the office building can look forward to very manageable energy bills.

The building is expected to use up to 70 percent less energy on heating, and up to 80 percent less energy on cooling.

80 PERCENT: THE AMOUNT OF ELECTRICITY SAVED IN THE OFFICE BUILDING ON COOLING BY USING GROUNDWATER COOLING.



The Warehouse at dusk. Photo by Kontraframe.

FACTS ABOUT PAKHUSET, ATP'S OFFICE BUILDING PAKHUSET (THE WAREHOUSE) WILL BE READY IN EARLY 2015.

The office building can house up to 700 employees and the building can be divided into three sections or rented to one company alone.

ARCHITECT: Lundgaard & Tranberg

THE BUILDING:

- Office space: 16,500 sq m
- Basement: 11,700 sq m
- Price: Office space costs DKK 1,925 per sq m per year
- Heating: District heating supplied by heat pump. The heat pump covers 30-40 percent of heating.
- Cooling: Groundwater cooling.
- The solution saves up to 80 percent electricity on cooling.
- Ventilation: Hybrid ventilation using mainly fresh air.
- Lighting: Skylights in the roof combined with low-energy fluorescent lights and LED lights.

2. AFFORDABLE AND GREEN HOUSING

"We just want to build good houses for our target groups." The housing company, KAB, were not actually looking to make energy-efficient housing when they started planning the Grøndalsvænge-neighbourhood. It just had to be good and affordable housing. However, energy savings soon followed because it made good financial sense.

With the rising prices on the housing market in Copenhagen it is becoming increasingly difficult for people on low or medium incomes to find housing. Therefore, the housing company, KAB, set out to provide affordable housing.

"We wanted to build high-density, industrially manufactured townhouses," says Rolf Andersson, Building director at KAB.

SOLUTION: EMPOWERED RESIDENTS

Building houses close together was one way KAB tried to keep expenses low. Another was to industrially manufacture the houses at factories in Lithuania and Denmark. A third way was to keep operating expenses low by making the houses as energy efficient as possible.

"The houses have state-of-the-art insulation and heat exchangers. But where we're really keeping expenses down, is by eliminating costly technical installations such as public elevators and laundries," says Rolf Andersson.

Furthermore, the residents have agreed to a binding neighbourhood community without janitorial services, and each resident is tasked with keeping his or her property in good condition.

RESULTS: A NEW GENERATION OF LOW-ENERGY HOUSING

The results in the Grøndalsvænge townhouses have been good. One important indicator is the fact that vacancy rates are low.

"People like living here. And our estimates of energy consumption have been accurate," says Rolf Andersson.

Furthermore, the neighbourhood is such a success that Copenhagen now has ten similar housing projects and there is one in the city of Aarhus.

"We are planning the next generation of this concept and will be setting our sights on reaching the strictest criteria for low-energy buildings," says Rolf Andersson.

ENERGY CLASS 2015: THE LOW ENERGY CRITERIA THAT THE BUILDINGS IN GRØNDALSVÆNGE MEET.



Row of townhouses in Grøndalsvænge. The residents are responsible for maintenance of their own house and the common areas. Photo by ONV Architects.

FACTS ABOUT GRØNDALSVÆNGE IN COPENHAGEN

The townhouses in Grøndalsvænge are so-called Public Housing +. The concept has been designed to provide affordable housing for families.

ARCHITECT: ONV Architects
MAIN CONTRACTOR: Kodumja A S (Estonia)
ENGINEER: Viggo Madsen A/S
LANDSCAPE: Ahlgreen & Bruun

- Grøndalsvænge consists of 83 townhouses with an average of three residents.
- The buildings meet the criteria for low-energy buildings (2015 standard).
- KAB have a total of 12 Public Housing + projects and ten more are on the way with a total of 1,400 dwellings.

3. GETTING LIGHT WITHOUT LOSING ENERGY

It seemed like an impossible task: Building an energy-efficient sports arena with plenty of daylight without increasing the need for heating or cooling. However, the unique new public sports facility, the Multi Arena, manages just that.

Public sports arenas are essential to modern cities that want to improve the quality of life for their citizens. But sports arenas can also be energy guzzlers, as the large rooms require a lot of heating, cooling or both. Furthermore, sports arenas use huge amounts of electricity, as athletes require sufficient light for their sports.

“The City of Copenhagen wanted a sports arena that met strict criteria for energy efficiency. A notoriously difficult task is lighting, as athletes require at least 700 lux (unit for luminance of an area). But if we install too large panes of glass on the front of the arena, we need cooling during summertime and we lose heat during winter,” says Michael Christensen, architect and director of architectural firm, Christensen & Co. A further challenge was to design an arena that fitted into a unique historical area that once primarily served as a naval base.

SOLUTION: SKYLIGHTS AND SHUTTERS

Amazingly, the architects came up with a solution that meets all demands.

“We installed skylights in the northern part of the arena to allow plenty of daylight to illuminate the playing courts. Along the arena we have giant shutters that block out the direct sunlight but allow an indirect and soft glow to pass into the arena,” says Michael Christensen. The shutters are reminiscent of the area’s historical naval barracks.

The arena also features an energy-efficient ventilation system, and the building also has a green roof to collect rain and direct it to the nearby canals.

RESULTS: MEETING STRICTER CRITERIA THAN EXPECTED

When the project was first commissioned, the goal was to build an arena that could be certified as a low-energy building. The category is called “Low energy class 2015” and these buildings are considerably more energy efficient than what is required as a minimum.

The new Multi Arena ended up exceeding all expectations and now meets the even stricter criteria set out in “Low energy class 2020”.

700: THE AMOUNT OF LUX (ILLUMINATION OF AN AREA) THAT ATHLETES REQUIRE IN A SPORTS ARENA. AN AMOUNT THAT IS MET MOSTLY BY DAYLIGHT IN THE MULTI ARENA.



Daylight illuminates the Multi Arena. Clever use of daylight saves electricity on lighting. Photo by Adam Mørk.

FACTS ABOUT THE MULTI ARENA

The Multi Arena has been built to house both athletes and cultural events.

- Size: 2,500 m²
- Construction of the arena began in 2012 and ended in august 2013.
- Budget: DKK 38 million
- Architect: Christensen & Co Architects
- Engineer: Rambøll
- Landscape: I:| Landscape Architects

CONTRACTOR: BNS

4. NEW URBAN DEVELOPMENT GETS GOLD CERTIFICATION

If one low-energy building makes a positive contribution to cutting carbon emissions, what can an entire sustainable new neighbourhood achieve? The new urban development of Nordhavn is an example of what can happen when sustainability is included from the outset.

Copenhagen is growing – and at a rapid rate. The population will grow by around 20 percent by 2025, equivalent to 100,000 new residents, or 1,000 new residents every month. The capital therefore needs to expand with new neighbourhoods and with new opportunities to live and work. But growth also presents a number of challenges. The increasing number of commuters in the region has already put Copenhagen’s traffic system under pressure. The new neighbourhood, Nordhavn (the northern harbour), will provide some of the answers to these challenges.

“Nordhavn, will counteract the trend towards increasing levels of commuting in the region by creating new local homes and workplaces. This will allow people to cycle to work or commute by train to centrally located workplaces. One can say that Copenhagen is growing inwards instead of outwards,” says Kirsten Ledgaard, chief consultant at CPH City & Port Development, an urban development company established by Danish statute.

THE LEVEL OF AMBITION FOR NORDHAVN IS SKYHIGH

CPH City & Port Development participated in a pilot project led by the Danish Nature Agency and the Danish Green Building Council (DK-GBC). The goal: to develop the most ambitious urban development plan possible. In 2013 the effort paid off, when Nordhavn was awarded a gold precertification under the DGNB certification system.

“Among other elements, we obtained our gold certification for our green transport solutions, our use of rain water and our requirements for energy-efficient buildings,” says Kirsten Ledgaard.

The green transport solution consists of a metro link, cycle super highways and excellent conditions for pedestrians. A key component of the urban development plan is a requirement for developers to meet at least a bronze standard when constructing new buildings. This means buildings that are more energy efficient than the requirements in the standard building code.

Finally, the development plan requires integration of climate adaptation measures into the new building;

for example by greening the roofs and by disconnecting rainwater from the sewage system.

A GOLD CERTIFICATE THAT NEEDS TO BE EARNED

The certification for Nordhavn is a precertification, meaning that CPH City & Port Development will have to report its progress to maintain the certification. When 25 percent of the infrastructure for the district is in place, CPH City & Port Development will have to submit documentation to DK-GBC that the area is meeting its own ambitious goals. And when 75 percent of the buildings have been completed, the company will also have to submit documentation in order to achieve permanent certification.



Rendering of the urban development in Nordhavn that has been awarded a gold precertification. Photo by COBE, SLETH, Polyform and Rambøll.

FACTS ABOUT NORDHAVN

The area is being transformed from an active industrial port into a modern residential and business neighbourhood.

- 40,000 residents will be able to live in Nordhavn – with just as many work-places.
- The first development is taking place in the Århusgade area. The area will contain 165,000 sq m residential buildings and 140,000 sq m commercial buildings.
- The first residents and employees will be moving in in 2014.
- CPH City & Port Development will be extending Nordhavn by 100 hectares over the next 10-20 years using the soil being excavated for the Metro, the Nordhavn’s road and other projects.
- CPH City & Port Development is jointly owned by the City of Copenhagen and the Danish state.
- The DGNB standard is a German building standard that has been selected as the standard for sustainable areas and buildings in Denmark.

5. SAVING ENERGY WITH NEW ENERGY MANAGEMENT SYSTEM

How do we effectively reduce energy consumption in large residential, office, and public buildings in Copenhagen? In 2014, a new tool to measure and visualize heat consumption in buildings with district heating was ready for broad-scale implementation. This empowers building managers to save up to 10 percent of energy use.

Especially in large buildings such as apartment blocks, offices, and public buildings, the energy-saving potential is huge. In Copenhagen these buildings account for more than 80 percent of the city's total heat consumption. Nevertheless, the only monitoring is often solely based on the gut feeling of building managers and a yearly heat-consumption report.

A COMPLETE SOLUTION FOR INTELLIGENT ENERGY MANAGEMENT

In 2014, a new complete solution for intelligent energy management has come to their rescue. The solution consists of three elements:

First of all, it consists of a web-based management tool that monitors the heat consumption (from a distance) and analyses it against budgets and outside temperatures. This tells the building manager on a daily basis if, where and when he can optimize energy consumption, - e.g. by turning down the heat in offices at weekends when no one is working.

“In lots of buildings, we already have data showing the heat consumption. The new system connects the data to the weather forecast and visualizes where there is a potential for saving energy. This of course has to be supplemented by training for the system users, so they know how best to convert the insight into saved energy,” says Morten Skov, chief engineer at HOFOR.

RESULTS: UP TO 10 PERCENT ENERGY SAVINGS

The new solution has been developed in close collaboration between the Greater Copenhagen utility, HOFOR, and the Danish Building and Property Agency. HOFOR has collected and analysed data on heat consumption from 30 buildings on Slotsholmen – an area in the centre of Copenhagen that houses the Danish Government administration and other public buildings. The Danish Building and Property Agency has trained building managers to use the tools and involved the senior management and employees who work in the buildings.

The result is a cut of 15 percent on the heat consumed by the total 145,000 sq m buildings on Slotsholmen.

“The strategic collaboration between a property owner and a utility is a model with great potential if we want to meet our ambitious goals for energy savings. One example: A building from the 18th century has reduced its energy use by 20 percent. It is very positive that we now have concrete experience that can be implemented at a larger scale,” says Bjarne Dalgaard, technical consultant at the Danish Building and Property Agency.



The development in heat consumption at Folketinget as illustrated by the Heat Label. Folketinget is a building at Slotsholmen that houses the Danish Parliament. The upper label shows total adjusted annual heating consumption, while the lower label shows the trend from 2012-2013. Picture by Danish Building and Property Agency.

FACTS ABOUT INTELLIGENT ENERGY MANAGEMENT

The new solution for intelligent energy management is a complete system that empowers building managers to optimize heat consumption on a daily basis.

- Daily data from district-heating meters is analyzed and connected to meteorological data.
- The system informs building managers by e-mail if more heat than expected is being used and if the district-heating water is being in adequately cooled.
- In addition, a Heat Label visualizes annual trends in the heat consumption.
- In properties with several buildings, a visualization of the total heat consumption is also illustrated, using a traffic light system: alarmingly high (red), a little too high (amber), or energy efficiently low (green).

6. SUSTAINABLE SCHOOL EDUCATES NEW GREEN GENERATION

A run-down school from the 1960s has been completely renovated with LED lighting, solar cells and a light, heating and ventilation management system. This saves energy and teaches the pupils about new green solutions and technologies.

What does energy retrofitting and climate adaptation have to do with teaching?

In Dyveke School on Amager, the old skeleton of a classic 1960s school has been transformed into an inspiring learning environment. Here pupils are being taught about new climate and energy solutions using their new surroundings.

SOLUTION: A NEW SUSTAINABLE PROFILE

The ambition to give Dyveke School a new sustainable profile has been reached in many ways: both technically, in terms of design, and by integrating the new solutions in teaching.

In technical terms, the energy consumption of the school has been lowered by replacing the roof and all the windows with energy-efficient solutions. Solar cells have been installed on part of the roof. A new management system that controls the heating, ventilation and lighting has been installed to cut down 70 percent of the energy used before. Moreover, electric lights have been changed and integrated with the natural lighting, so areas near windows receive less electric light than the areas away from natural light sources.

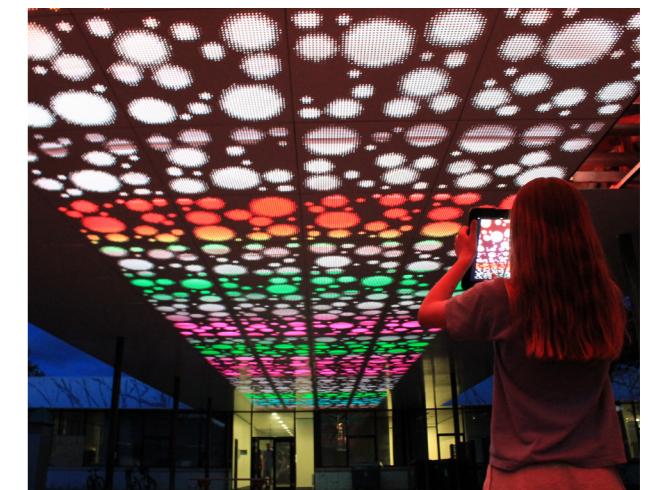
“The sustainable solutions have been integrated into classroom teaching. In math, pupils learn about the energy use of the school. In science, they use the new learning terrace to explore how the school handles rainwater locally. And in their breaks they play in outside environments designed with a focus on sustainability,” says the project leader from the City of Copenhagen, Rikke Sode.

RESULTS: A BRIGHT FUTURE FOR DYVEKE SCHOOL

Now every classroom in the school consumes less energy. For example, electricity consumption on lighting per room is now less than 1/5 of the electricity used before.

“The school exemplifies how renovation, energy retrofitting, modernization and climate adaptation create synergies. Now less energy is consumed and more pupils are prepared to contribute to the future of tomorrow,” says Rikke Sode. The success shines bright from an artistic LED light motive that surrounds the school and contributes to creating a safety zone on the murky pathways leading to and from the school.

1/5 – THIS IS THE AMOUNT OF ENERGY CONSUMED PER CLASSROOM TODAY COMPARED WITH THE AMOUNT OF ENERGY USED TO LIGHT UP THE ROOMS BEFORE THE RENOVATION.



The new entrance at Dyveke School. Photo by KANT.

FACTS ABOUT THE ENERGY RETROFITTING AT DYVEKE SCHOOL

This school has been completely renovated with great success – integrating new energy-efficient technologies and creating a modern teaching profile.

- Dyveke School was built from 1968 to 73 and represented a classical Copenhagen public school before the renovation.
- From 2011 to 2014 the school was completely renovated (ground floor area: 10,500 sq m).
- To optimize the energy use solar cells, LED lights and a new management system that controls the heating, ventilation and lighting were installed.

TOTAL COST: approx. DKK 100 mill.

CONTRACTOR: The City of Copenhagen in cooperation with KANT design and consulting, Cowi engineers, Kragh & Berglund landscape designers, Enemærke and Petersen entrepreneurs, Grontmij acoustics consultants and Ulla Kjærvang process consultant.

7. 50 PERCENT REDUCTION IN ENERGY CONSUMPTION WITH PUBLIC FINANCIAL SUPPORT

What should be done with all the run-down concrete buildings from the 1960s in Copenhagen? The answer is: support the much-needed renovation with financing to give a 50 percent reduction in energy consumption. This is the case of Bellmanskade.

The problem is well known in many places in Copenhagen. The concrete buildings from the 1960s and 1970s are seriously damaged and are not looking good. The buildings are calling out for immediate renovation.

“These buildings are at the lowest end of the energy classes, so there is a huge potential to reduce the energy consumption. Given that the buildings are to undergo a full renovation anyway, it is good value for money to incorporate energy retrofitting in the project. Therefore the City of Copenhagen has passed a new by-law, which enables all renovations of recent concrete buildings – from the 1960s to 1970s – to receive public funding,” says Nils Lund from the Department of District and Urban Renewal in the City of Copenhagen.

SOLUTION: A NEW ENERGY COVERING ‘FRAME’

A concrete building comprising 242 apartments and built in 1961 on Bellmanskade, a street in Copenhagen, is a good example of a renovation project which has made a huge profit because energy retrofitting was integrated into the much-needed renovation work.

The privately owned property has received financing from the Danish State and the City of Copenhagen for half of the renovation costs. The building now has a new light covering ‘frame’, that protects it and gives it a more contemporary look. Furthermore, the ‘frame’ covers a 20-centimetre Rockwool insulation in the walls and up to 45 centimetres on the roof to help the building retain heat inside. All the windows have been changed to a more energy sufficient design. Furthermore all the apartments have been improved with new balconies with windows which can be opened and closed. Finally, 430 sq m solar cells have been installed on the building’s rooftop. All these solutions have not only made the building look more attractive and repaired the cracks in the facade, they have also secured the building for the future. This project is the first in Copenhagen to receive financing the new public financing for energy retrofitting.

RESULTS: ENERGY CONSUMPTION CUT IN HALF

The energy retrofitting of Bellmanskade has reduced the building’s energy consumption on heating and hot water

by 50 percent. There have also been electricity savings. In 2010 total consumption was 2800 megawatt per hour, which gave a ‘D’ energy ranking. Today a new energy report states an annual consumption of around 1300 megawatt per hour, corresponding to a ‘B’ ranking; the best category for existing buildings.

According to the new energy report, the solar cells are producing more electricity than required for the property’s common consumption for lightning, laundry etc. “By integrating energy retrofitting into the renovation project, we have secured the buildings for the future. And happily it has also resulted in a cost saving due to large reductions in energy consumption. Finally the energy retrofitting has also had a positive influence on CO2 emissions, which have been reduced considerably,” explains Nils Lund.



The apartments at Bellmanskade after energy retrofitting. Photo by NCC.

FACTS ABOUT THE ENERGY RETROFITTING OF BELLMANSGADE

Integrating energy retrofitting into a much-needed renovation project for a 1960s concrete building has cut the energy use of 242 apartments in half.

- Builder: The owners of the building (A/B Bellmanskade 7-37) in collaboration with 4 architects and engineers and NCC Construction Denmark.
- The project was made possible with financial support from the City of Copenhagen.
- The buildings now meet the best energy ranking an existing building normally can obtain (2015 standard).
- The 242 apartments are located on the street, Bellmanskade, in the Østerbro district in Copenhagen.
- Period of renovation and energy retrofitting: March 2012 to October 2013
- Total cost of construction: DKK 129 mill.

8. SHEDDING NEW LIGHT ON THE CAPITAL

How long does it take to change a lightbulb in Copenhagen? Hopefully not long, because by the end of 2015 around 20,000 of the city’s aging street lights have to be replaced by modern and highly efficient LED lights.

If you’ve wandered the streets of Copenhagen after dark, you will no doubt recognise the orange glow of the city’s street lights. Installed nearly 40 years ago, the capital has more than 10,000 high-pressure sodium lamps – and they are ready for retirement.

“Apart from the sodium lamps, we have about 700 electrical gas lamps and even some mercury-vapour lamps,” says Thomas Maare, project manager at the Department of Lighting at the Municipality of Copenhagen.

And the old luminaries are energy consuming. In 2010 Copenhagen needed 19.5 Gigawatt hours (GWh) to light the city.

“We want to cut that figure in half by 2016,” says Thomas Maare.

SOLUTION: 20,000 LED LUMINARIES BY 2015

To reach that goal, the capital aims to change about 20,000 luminaries with specially designed LED counterparts. The LED luminaries have a number of benefits, the obvious one being that they deliver the same light for fewer watts (lumen). However, the LED lights will also have a much more noticeable difference for the residents of Copenhagen.

“The current sodium-vapour lamps only achieve 20 to 30 percent colour rendering. That’s why the streets of Copenhagen are orange at night. The new LED lights have the ability to render 70 to 80 percent of the colours. So people will notice a huge difference,” says Thomas Maare.

RESULTS: EASY AND AUTOMATED CONTROL OF THE CAPITAL’S LIGHTING

Copenhagen is aiming to cut its electricity consumption on lighting in half by 2016 compared to 2010. However, the French company awarded the contract, CiteLum, promises to deliver a 57 percent reduction.

Furthermore the new system will be completely automated and remote-controlled. The operators will even be able to dim the lights in certain neighbourhoods.

57 PERCENT: THE ESTIMATED REDUCTION IN ELECTRICITY CONSUMPTION BY 2016 COMPARED TO THE CONSUMPTION IN 2010.



Photo by Ursula Bach, City of Copenhagen.

FACTS ABOUT RENEWAL PROCESS (THE LED PROJECT)

The renewal process is the process of changing 20,000 lighting fixtures in 2014-2015.

BUDGET: DKK 266 million
MAIN CONTRACTOR: CiteLum (France)

THE PROJECT

- 20,000 street lighting fixtures, 8,000 poles and 1,140 electrical cabinets to be replaced.
- Fixtures have been specially designed to fit the Nordic design tradition.
- For fixtures and poles the system should be basically maintenance free for 25 years.
- The fixtures are monitored, controlled and dimmed individually and 24,000 fixtures are monitored, turned on and off at cabinet level.

ENERGY PRODUCTION: THE FIRST TURBINES START TO TURN

Has a city with a population of over a million got room for 128-meter wind turbines? Copenhagen can, and in 2014 the capital started in earnest to invest in the renewable energy base that is to lead to CO2 neutrality in 2025.

The 22nd of January 2014 marked a special occasion for Copenhagen, as three brand new wind turbines started to turn on the small peninsula, Prøvestenen, at the entrance to the harbour.

The turbines have been erected in a heavily industrialized area, and each turbine has an output power of 3.6 MW.

Copenhagen needs to install a total of 360 MW by 2025, so the three turbines could seem like a drop in the ocean. However, the symbolic effect of a modern capital being able to erect wind turbines within the city limits is hard to underestimate.

Through its utilities company, HOFOR, Copenhagen is working in other areas to boost its wind energy capacity.

Another project in Copenhagen, for an additional three turbines, is currently being investigated by the conservation authorities.

In other parts of Denmark, Copenhagen has successfully invested in two land-based wind farms – one on the island of Lolland and the other near the town of Billund in Jutland.

Furthermore Copenhagen is working hard to get involved in major offshore wind farms to boost its wind production.

HEATING FROM BIOMASS

Another pillar of Copenhagen's energy production ambitions is to make district heating carbon neutral. These ambitions gained a major boost in 2014 when Copenhagen's public utilities company, HOFOR, acquired the local combined heat and power plant, Amagerværket. Amagerværket currently has two different units for creating heat – one runs on coal and the other on biomass from wood pellets. Copenhagen wants to change this and is currently running the numbers on what it would take to convert the entire plant to run on biomass. The new unit would be running on wood chips that are less energy consuming than pellets.

One issue to address is to secure that the plants run on biomass from sustainable sources. There are currently no national or international standards for sustainable biomass for energy production. Therefore, Copenhagen's utilities company, HOFOR, has signed a voluntary industry agreement with sustainability criteria for biomass.

Finally, Copenhagen has also been investigating the possibility of installing a full-scale geothermal heating facility in the new development, Nordhavn.

However, the project is temporarily on hold as the risks involved in extracting geothermal energy are still too great. The drills need to reach depths of 2 to 3 kilometres and the operating costs are considerable.



The three new wind turbines at Prøvestenen on the day of their inauguration. Photo by HOFOR.

GETTING VALUE FROM WASTE

Regarding waste, the City of Copenhagen is looking into the promising results of the REnescience technology. The technology is able to separate organic waste from solid household waste and turn it into a high-yield biofuel. The technology thus eliminates the need for source separation.

So far the national energy company, DONG Energy, has been running REnescience at a demo facility, but Copenhagen wants to take the technology to the next level and the municipal authorities are currently looking for adequate locations for a full-scale facility.

However, for the new site to be successful a few regulatory hurdles need to be cleared.

Copenhagen currently has an application with the Danish Environmental Protection Agency to approve the use the organic by-product of the process to be used for fertilizer on farm land.

In addition, Copenhagen is set to give the green light for a project for a new separation facility for plastic waste.

The project aims to develop new technologies for better plastic-waste separation and it will be a public-private partnership between researchers, private companies and the City of Copenhagen.

10.8 MW: THE COMBINED EFFECT OF THE THREE WIND TURBINES THAT WERE PUT INTO OPERATION IN COPENHAGEN IN 2014.

THE MAJOR GOALS FOR ENERGY PRODUCTION BY 2025 IN COPENHAGEN

- District heating in Copenhagen is CO2 neutral.
- Electricity production is based on wind and biomass and exceeds total electricity consumption in Copenhagen.
- Plastic waste from households and businesses is separated.
- Biogasification of organic waste.

9. TWO STEPS TOWARDS CLIMATE-FRIENDLY DISTRICT HEATING

Can Copenhagen reach CO2 neutrality in 2025? Yes, is the answer according to new a comprehensive scenario planning project. The project sets direction for how district heating can be fossil-fuel-free and sustainable within the next 15 years.

If citizens of Greater Copenhagen are to stay warm from sustainable and CO2-neutral heating in 2025, two things are critical: thorough analyses as well as good collaboration between all relevant stakeholders. Therefore, in 2008 a common project was initiated by the major heating companies in Greater Copenhagen, CTR, HOFOR and VEKS, assisted by the consultancy Ea Energy Analyses.

In 2014 the third stage of the project was finished, with a common plan for the energy system. The newly released Heat Plan Greater Copenhagen shows that the district heating system can be CO2-neutral by 2025. Two main questions are answered in the plan: What major investments ought to be made in the district heating grid and in energy production over the next 10 to 15 years? And what are the possibilities for interaction between the district heating system and an electricity system with increasing amounts of wind power?

SOLUTION: SUSTAINABLE BIOMASS AND RENEWABLE ENERGY

Based on comprehensive scenario planning, as well as involvement of 17 municipalities in Greater Copenhagen and other stakeholders, Heat Plan Greater Copenhagen has come up with a two-step model to answer the questions. The first step is to convert the combined heat and power plants from coal to sustainable biomass such as wood pellets, wood chips and waste. New standards to define sustainable biomass have been drawn up to meet this goal.

The second step is to substitute and supplement the sustainable biomass with the development of new technologies like large electrically driven heat pumps based on wastewater and seawater, heat storage and geothermal heat production. This can contribute to the more flexible energy system necessary in a system with large wind generation, where the energy from e.g. wind turbines can be produced, stored and used when demand is highest.

NEXT STEP: TECHNOLOGICAL EVOLUTION AND MUNICIPAL INVOLVEMENT

Heat Plan Greater Copenhagen demonstrates that district heating in Greater Copenhagen can be CO2-neutral and

sustainable in 2025. It also shows actual scenarios of how this can be done without putting the economy or the security of supply at risk.

“This plan is an important common platform to take the next steps towards green energy production in Greater Copenhagen. Investment in renewable energy and new technologies will increase. In the long run, the results will be a more flexible energy system based primarily on renewable energy,” says energy planner Nina Holmboe, who is a project manager at HOFOR, one of the companies behind the Heat Plan. In addition, the municipalities are important drivers, both in setting the goal for CO2 neutrality and in carrying out the measures required to meet ambitious climate and energy goals.



Sustainable biomass and new energy technologies – two of the ingredients for future climate-friendly district heating. Photo by HOFOR.

FACTS ABOUT HEAT PLAN GREATER COPENHAGEN

Heat Plan Greater Copenhagen deals with future district heating in Greater Copenhagen

- 17 municipalities in Greater Copenhagen have been involved. Copenhagen has a central role because 55 percent of heat consumption from district heating comes from Copenhagen.
- Project contributors: The analysis was initiated by the major heating companies in Greater Copenhagen, CTR, HOFOR and VEKS. The study has been carried out by these companies, assisted by the consultancy firm Ea Energy Analyses.

10. WIND TURBINES PUT DOWN ROOTS IN COPENHAGEN WITH GREAT SUCCESS

In 2009 it was decided that wind turbines in Copenhagen were the key to a more flexible and CO2-neutral energy system. Today three wind turbines have been erected close to the city centre at the industrial harbour area called Prøvestenen. After just ten months, they are already producing enough electrical energy to supply 3,400 households for a whole year.

Most people have a positive view about wind turbines and renewable energy. But that view tends to change once the turbines are planned near residential areas, and people start to voice their concerns about the turbines' noise levels and visual impact. Therefore, they are usually located out at sea or in the countryside where fewer people live. Not anymore! Three new wind turbines have now been erected on an industrial area less than 5,000 meters from the city centre as a living proof of the future for green energy production in cities.

SOLUTION: SAY HALLO TO THREE NEW CLIMATE-FRIENDLY COMPANIONS

The three turbines are 107 meter tall. This puts them at the larger end of the scale for turbines, a few meters taller than city hall tower in the centre of Copenhagen. Yet the public and stakeholders in the area have welcomed the turbines even more than expected. “Building wind turbines in city areas is quite a challenge. Many factors have to be taken into account. That is why we initiated extensive research before even starting construction. As a result the most important interests have been met – especially regarding the strategic location of the turbines on a harbour area with mostly industry,” says Jesper Pedersen, head of Wind and Energy Trading at HOFOR – the utility company which has erected the turbines in collaboration with the City of Copenhagen.

Besides the strategic location of the turbines, the public, companies and organizations in the area have been invited to purchase a 33 percent share in the wind turbines. By making this investment, not only do they benefit from green energy, they also reap financial benefits.

RESULTS: COVERING THE NEED OF 3,400 HOUSEHOLDS IN 10 MONTHS

The wind turbines were connected to the grid just before the beginning of 2014. Today, after about 10 months, they have produced enough electricity to cover the annual consumption of 3,400 households. Therefore the turbines are a good way to push forward the further development of another seven wind turbines in Copenhagen harbours up to 2018. A beautiful spearhead for a future with more green energy production in Copenhagen.



The three wind turbines at Prøvestenen.

FACTS ABOUT THE WIND TURBINES AT PRØVESTENEN

The three wind turbines located on Prøvestenen – less than 5000 meters from the city centre of Copenhagen.

ABOUT THE WIND TURBINES

- The turbines have been realised in a collaboration between the City of Copenhagen, HOFOR, CPH City & Port Development (By & Havn) and Copenhagen Malmø Port.
- Construction began in October 2013 and the turbines were connected to the grid at the end of December 2013.
- The turbines are 107 meters tall – a few meters taller than the city hall tower in the centre of Copenhagen.
- The turbines produce energy at wind velocities between 4 - 23 meters per second and they will last for about 25 years.

ABOUT THE EFFECTS

- 13,600 MWh: this is the amount of energy produced by the three wind turbines from end of December 2013 to beginning of November 2014.
- 3,400: so many households' energy consumption can be covered by the electricity produced from the turbines so far.
- The turbines are part of Copenhagen's goal to install 360 megawatt of the energy from 100 wind turbines by 2025. This makes wind turbines one of the largest contributors to achieving CO2 neutrality by 2025.

11. GETTING VALUE FROM THE CAPITAL'S PLASTIC

The citizens and companies of Copenhagen produce around 35,000 tonnes of waste plastics each year, and most of it ends up in waste incinerators. A recent project has found new ways to get more value from plastic.

Plastic is a marvellous material for packaging, household products and vehicles. It is light, it can be moulded in different shapes and it is relatively cheap. However, it also poses many challenges in the recycling process. Plastics are in fact many types of polymers that need to be separated before they can be recycled.

"In Copenhagen we are collecting waste rigid plastics from households in multi-storey buildings. We have discovered that the current sorting facilities separate around 50 percent of the plastics into polymers," explains Mette Skovgaard of the Technical and Environmental Administration in Copenhagen.

The presence of black plastics, e.g. from meat trays, is just one of the obstacles to reducing carbon emissions from plastic waste. In Copenhagen alone, this waste fraction accounts for 100,000 tonnes of CO₂ each year – or what corresponds to 8 percent of the total reduction needed for Copenhagen to become CO₂ neutral by 2025.

SOLUTION: PLASTIC ZERO

To uncover new ways to get more value from waste plastics, Copenhagen launched the Plastic ZERO project with funding from EU's Life programme.

"An important part of the project has been to engage stakeholders in the value chain," says Mette Skovgaard. Through a series of meetings we have identified challenges and solutions for prevention and recycling.

One part of the project focused on design for recycling. Often, designers of packaging have no real understanding of what criteria packaging has to meet, if it is to re-enter the materials cycle. Therefore, Copenhagen engaged major retailers to take part in developing a guideline for plastic packaging. The project also developed guidelines to prevent waste plastics through public procurement.

NEXT STEP: A SEPARATION PLANT FOR PLASTIC WASTE

Plastic ZERO was finalised in August 2014, but new plastic projects are already taking shape.

"We do not have facilities to separate waste plastics from household waste in Denmark," says Mette Skovgaard. Copenhagen is currently working on plans to establish an innovative separation plant.

We are also working on projects that aim at improving the quality of waste plastics and making it better suited for turning it into a raw material for new products.



Separating waste plastics with a Near Infra Red scanner.

FACTS ABOUT PLASTIC ZERO

Plastic Zero was led by the City of Copenhagen and had six European partners:

- City of Hamburg (Germany)
- City of Malmö (Sweden)
- Aalborg University
- Amager Resource Center
- The Latvian municipal waste company Liepajas RAS Ltd.
- The Finnish company Tampere Regional Solid Waste Management Ltd.

The total budget of Plastic ZERO was 2 million euro.

12. RENESCENCE – ENZYMATIC TREATMENT OF UNSEPARATED MUNICIPAL WASTE

What if there was a technology that could turn solid waste from households into high-yield fuel while perfectly separating recyclable resources? You needn't wait. REnescence does just that.

Most of the solid waste from households in Denmark is currently being incinerated. In return, society gets heat and electricity to power its homes and industries. But as resources are getting scarcer and prices of raw materials are climbing, the appeal of recovering more value from waste is becoming ever stronger.

"On a global scale, major cities around the world are increasingly facing challenges to constantly improve urban infrastructure in order to accommodate their increasing demographics. One issue is how cities manage municipal solid waste and how much value is extracted from it," says Lana Sukhodolska, Commercial Manager at REnescence Commercial. The company is a subdivision of the Danish energy company; DONG Energy.

SOLUTION: RENESCENCE – ENZYMATIC TREATMENT OF WASTE

The process behind REnescence is continuous and fully automated. After unloading, unseparated household waste is prepared in a reactor by adding water and heating it to temperatures of around 50°C. Then it is transferred to the REnescence bioreactor where enzymes and thriving bacteria break down organic fractions and separate the biodegradable portion from the solid fraction of the waste. This makes it possible to separate metals and plastics and produce a storable energy-rich fuel in the form of bioliquid.

"The bioliquid is particularly suitable for biogas production, and residue from the biogas production process can potentially be used as a fertilizer. Furthermore, the non-organic waste is separated into two categories: 2-dimensional, including textiles, plastic and metal foils, and 3-dimensional, such as plastic containers and metal cans etc. These well-segregated product streams form the basis for an effective recycling process," says Lana Sukhodolska.

NEXT STEP: TAKING IT TO A COMMERCIAL SCALE

So far REnescence has delivered firm technological proof at the demonstration plant in the southern part of Copenhagen. The plant attracts numerous delegations from abroad and REnescence is working to establish itself as a technology provider in foreign markets.

"We have developed an effective technology that meets the standards of modern society. It is sustainable, efficient and we have shown that it works. We are very close to demonstrating operationally a plant of commercial scale," says Lana Sukhodolska.

90 PERCENT: THE PART OF THE BIODEGRADABLE MATERIAL THAT ENDS UP IN THE BIOLIQUID.



Samples taken at the REnescence bioreactor. Photo by DONG Energy REnescence.

FACTS ABOUT RENESCENCE

REnescence is a ground-breaking technology that uses enzymes to liquefy biodegradable material in unseparated municipal solid waste (MSW) and effectively separate valuable recyclable materials.

- Operational since 2009
- Background: The REnescence process was developed and patented by DONG Energy

EFFECTS:

- 90 percent biodegradable material recovery
- 65 percent plastic recovery
- 90 percent metals recovery

SPECIFICATION:

- The plant has three outputs
- Bioliquid: producing 130-170 Nm³ biogas per tonne of waste
- Recyclable materials: Plastics, metals, gravel for road-filling, digestate with fertilizer properties
- Solid fuel: Storable, high calorific value and low alkali content

MOBILITY:

THE BICYCLE CAPITAL SHOWS THE WAY IN MOBILITY

41 percent of the inhabitants in Copenhagen ride their bicycle to work. That is unparalleled, but the City wants to do better. Therefore, the City of Copenhagen is continually working to improve and develop reliable, effective and sustainable transport solutions. Last year, that meant improving infrastructure for cyclists, establishing rapid transit systems for public busses and replacing most of the City's own fleet of vehicles with electric ones.

When the elderly of Copenhagen are visited by a municipal health care assistant, the assistant arrives in a white Nissan Leaf. The electric car is very visible proof of Copenhagen's commitment to reducing CO2 emissions from transportation. Today the City of Copenhagen has 166 electric cars in operation, and by the end of 2015, 85 percent of the City's fleet of light vehicles will be electric.

This move has had effects beyond reducing emissions. Copenhagen has learned valuable lessons on fleet optimization and reductions in operating costs.

Therefore, the City of Copenhagen is now advising other municipalities and authorities in the capital region about the benefits and pitfalls when procuring electric vehicles. The City is now also hoping that it can inspire private companies with large fleets of vehicles to make a similar transition.

However, greening professional transportation is just one of Copenhagen's priorities. The main goal is to make taking a bicycle anywhere the proverbial "no-brainer" for Copenhageners.

KEEPING CYCLISTS HAPPY

Copenhagen is already the best city in the world for people riding a bicycle and the Danish capital already boasts one of largest cycling populations in the world, with 41 percent of commuters and 55 percent of Copenhageners taking their two-wheeler to work or education.

But to achieve the ambitious cuts to CO2 emissions, Copenhagen needs to convince even more of its citizens to choose their bike over their car. One way to do this is by continually developing the infrastructure so that the bicycle fairytale doesn't turn into a congestion nightmare. Therefore, the City of Copenhagen is working hard to close the gaps in the network of bike lanes throughout the city.

When a "Missing link" is connected, it can have an overwhelmingly positive effect on the rate of cycling commuters. This has been the case in 2014, when Copenhagen established the so-called Bicycle Serpent.

This is an elevated bike lane that allows cyclists to get quickly from the harbour to the busy neighbourhoods of Vesterbro. The Bicycle Serpent increased traffic on the nearby Bryggebro bridge by 25 percent, and today more than 11,500 cyclists use the shortcut daily.



The new bridge for cyclists in Copenhagen – The Cycle Serpent. Photo by Mike Dugenio Hansen.

PUBLIC TRANSPORTATION: SOLUTIONS ACROSS MUNICIPAL BORDERS

Copenhagen's goal by 2025 is to make public transportation CO2 neutral. To achieve this, the capital needs to work closely with its neighbours.

Most of the capital's bus lines run through neighbouring municipalities, so close cooperation is the key to finding common sustainable solutions to public transportation.

Another way to make public transportation greener and more attractive to commuters is to implement intelligent traffic systems (ITS). As you can read from the case on dedicated bus lanes, a system has recently been implemented with success, giving busses easy green lights through the busy morning and afternoon traffic.

55 PERCENT: THE PERCENTAGE OF COPENHAGENERS TAKING THEIR BICYCLE TO OR FROM WORK IN 2013.

THE MAJOR GOALS FOR MOBILITY BY 2025 IN COPENHAGEN

- 75 percent of all trips in Copenhagen are on foot, by bike or public transport.
- 50 percent of trips to work or school in Copenhagen are by bike.
- 20 percent more passengers use public transport.
- Public transport is carbon neutral.
- 20-30 percent of all light vehicles run on new fuels such as electricity, hydrogen, biogas or bioethanol.
- 30-40 percent of all heavy vehicles run on new fuels.

13. CYCLE SERPENT CONNECTS THE CITY TO ATTRACT MORE CYCLISTS

For every time people in Copenhagen go to work and study, the city has a goal that half of them are to go by bicycle. To reach this goal, biking in the city has to be made easy, fast and fun. In 2014, cyclists got their very own elevated bike lane, connecting two districts in the city centre.

Copenhagen is aiming to be the world's best city to bike in by the year 2025. The goals are ambitious:

- 50 percent of all trips to work and study to be by bike.
- 90 percent of the cyclists to feel safe in traffic.
- 15 percent of the travel time is to be cut.

In June 2014 the city took an important step towards reaching its ambition. As a part of Copenhagen's new and greater infrastructure for bicycles, from this date, the well over 10,000 cyclists transporting themselves across the harbour from Vesterbro to Amager no longer have to push their bikes up and down steep stairs to reach a bridge (Bryggebroen) connecting the two areas. Nor do their have to vie with pedestrians in the narrow space – or take ridiculous detours to avoid it.

SOLUTION: AN ELEVATED TWO-WAY BIKE LANE

The Cycle Serpent is Copenhagen's new elevated two-way bike lane. Like a serpent it winds its way above the water, seamlessly connecting the road and the harbour bridge. The bridge contributes to Copenhagen's bicycle strategy by improving passability and comfort for cyclists, as it leads cyclists away from pedestrians, traffic and steps.

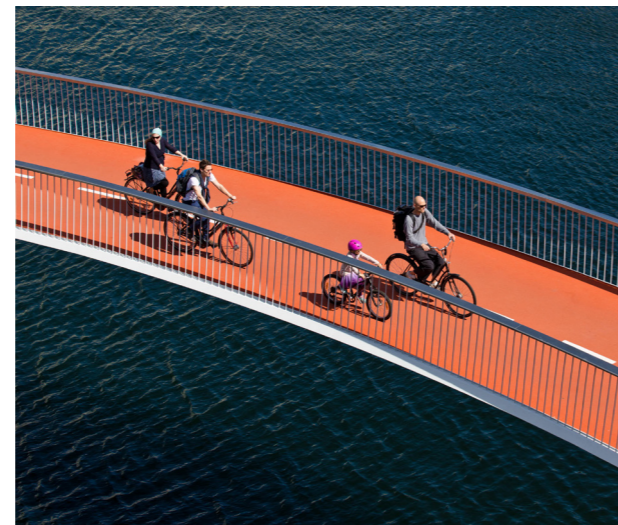
"The Cycle Serpent provides a shortcut for the ride through the city. It is fun for cyclists to use, while also making their ride easier, faster and safer," says Anja Larsen, programme manager from Mobility and Urban Space at the City of Copenhagen.

RESULTS: HEADING FOR A FUTURE WITH LESS CO2 EMISSIONS

On a regular weekday in October 11, 500 cyclists use the Cycle Serpent. On the connecting bridge, Bryggebroen, cycle traffic has increased by 23 percent compared to two years ago, before the serpent was built, and this figure is expected to grow.

It is estimated that every cyclist saves one minute using the Serpent instead of the stairs on their ride to work and study. Converted into working hours, this means society will save DKK 5 million a year. Thus, the investment made in the Cycle Serpent will be recovered in only seven years.

It has been estimated that if half of all trips to work and study are done by bike, a total of 20-40,000 tonnes of CO2 emissions can be saved.



The Cycle Serpent on a summer day. Photo by Ursula Bach, City of Copenhagen.

FACTS ABOUT THE CYCLE SERPENT

The Cycle Serpent is Copenhagen's new elevated lane for cyclist only. It has become a trade mark for Copenhagen's mission to be the world's best city to bike in.

THE PROJECT

- Contractor: the City of Copenhagen
- in collaboration with DISSING+WITLING architectures, Rambøll engineering, and MT Højgaard construction.
- Duration: Planning began in 2010 and construction began at the end of 2012.
- Total cost: DKK 38 million (the Danish government has supported the project with DKK 6 million)

THE CYCLE SERPENT

- Length: 230 meters long with 190 meters of bridge and ramps of 30 meter.
- Width: 4 meters with a two-way bike lane, wide enough for two cargo bikes to pass one another.
- The route: From Dybbølsbro on Vesterbro to Kalvebod Brygge.

14. NOW THE MAILMAN IS ELECTRIC

The Danish national postal company, Post Danmark, is trimming its business to meet future challenges, where mailmen and women have to cover longer distances carrying heavier loads. The solution has three wheels and runs on electricity.

Imagine having to cycle 50 kilometres every day. Now imagine having to transport an added 130 kg of dead weight on your bicycle, and your days start to look pretty exhausting.

A couple of years ago, mailmen and women on ordinary two-wheeled cargo bikes were increasingly riding longer and longer routes, as the amount of mail people sent began to change. This meant an increasing need to return to the depot to refill with parcels and letters, as the bike's capacity was limited. Therefore, vans were needed to deliver the mail to different locations on the routes so that the bikes could be refilled.

"We needed to make changes to adapt to the demands of the future mail system," says environmental manager at Post Danmark, Henrik Michelsen.

SOLUTION: THE MAILMAN'S NEW BEST FRIEND

Post Danmark is a part of the international mail and logistics group, Post Norden, and the group has made an ambitious commitment to cut CO2 emissions by 40 percent by 2020.

"We started development of an electric cargo bike solution. And it paid off. Today we have about 1,800 electric cargo bikes in operation and have won awards for our solution. Even the specially designed cargo box is a patented solution of ours," says Henrik Michelsen.

Regular visitors to Copenhagen have no doubt noticed the numerous three-wheeled cargo bikes populating the streets and bike lanes. It is a specially designed cargo bike like these that Post Danmark developed together with Danish bike vendor Nihola.

RESULTS: EFFICIENCY, SAVINGS AND EMPLOYEE WELFARE

The electric bikes have numerous benefits. "Our employees love their new bikes. The bikes make delivering the mail much easier than before, and a mailman who could previously work 20 km routes carrying 40-50 kg mail can now cover 50 km with up to 130 kg," says Henrik Michelsen. On top of that, the bikes reduce Post Danmark's diesel

consumption by 1.3 million litres a year, and the company estimates that the bikes mean savings in fuel and wages totalling around DKK 40 million a year.

1.3 MILLION LITRES: THE AMOUNT OF DIESEL FUEL SAVED ANNUALLY BY POST DANMARK AS A RESULT OF SWITCHING TO ELECTRIC BICYCLES.



One of Post Danmark's 1,800 electric cargo bikes in operation. Photo by Post Danmark.

FACTS ABOUT POST DANMARK'S ELECTRIC CARGO BIKES

The mail company began the transition to electric cargo bikes in 2011.

- 1,800 electric cargo bikes are in operation in 2014.
- In Copenhagen Post Danmark have 230 bikes.
- One bike can service a 50 km route on a single charge and carry 130kg of mail.
- The cargo box is a patented solution.
- The electric bike and the logistical solution to distributing mail with it have won two international awards.
- The electric bikes mean estimated annual savings on fuel and wages of around DKK 40 million.

15. DEDICATED BUS LANES WITH 1 MILLION EXTRA PASSENGERS

From the centre of the capital to the university in the northern part of town in nine minutes. 2014 saw a new unique solution to congestion and air pollution. Dedicated bus lanes (named “Quick Way”) are now transporting 30,000 students and employees on a daily basis.

Getting from Nørreport – the northern hub for public transportation – to the university campus could be a daunting task before Quick Way. Although busses had stretches of bus lanes, they would usually get stuck in the same queues as cars and lorries. This created delays and discouraged some of the 15 million annual bus passengers from using the bus route.

SOLUTION: BUS RAPID TRANSIT

Quick Way is a Bus Rapid Transit (BRT) – the first in Denmark – and the goal is ambitious: The best bus service in Denmark.

Five kilometres of road were completely rebuilt and busses now have their very own lane in the middle of the road for three kilometres. To ensure no delays, intelligent traffic signals have been implemented on the bus route and boarding has been made easier for passengers by elevating the bus-stop platform.

“The solution is relatively inexpensive and fast to implement compared to other solutions to make public transport in cities faster and more attractive. A solution like this can be implemented anywhere you have a bus route with mainly wide roads,” says Simon Baadsgaard, project manager at the City of Copenhagen. Separating busses from lanes with cars and cyclists improves the transport conditions for all road users. Finally, the busses can now run on schedule with no more than 3 minutes between busses. So if a passenger misses one bus, the next is on its way.

RESULTS: 10 PERCENT INCREASE IN PASSENGERS

On 19 September 2014 the first bus took the Quick Way. Travel time is reduced by 20 percent, and the goal is to raise the numbers of passengers by 10 to 20 percent.

“By improving the travel time and the regularity of departures, we hope to get more people to use public transport and save them time on their journey to and from work or study,” says Simon Baadsgaard.

The result of Quick Way should be 15 million passengers saving up to three minutes to and from work or study.



Busses using the Quick Way.

FACTS ABOUT QUICK WAY

Quick Way is the first Bus Rapid Transit in Denmark. The system employs both dedicated bus lanes, intelligent traffic signals and fast boarding.

- Total cost: DKK 130 million
- Contractor: The City of Copenhagen in collaboration with local stakeholders and the transport company, Movia.
- Duration: Planning began in 2011 and construction began in the summer of 2013.
- 30,000: The number of students and employees travelling between the city centre and Science City every day.

THE PROJECT:

- Reconstruction of roads and intersections on five kilometres of road.
- Reconstruction of nine traffic signals and establishment of one brand new one.
- Upgrade of bus stops for easier boarding and alighting.
- Upgrade of information service at bus stops

16. COPENHAGEN IS INVESTING IN GREEN TRANSPORTATION

The City of Copenhagen plans to use only electric or hydrogen cars (up to 5 persons) in 2025. It is an ambitious goal. However, the shift is already on track – in 2013 close to half of all cars were powered by hydrogen or electricity.

Transportation counts for a large amount of CO2 emissions. The number of cars is rising due to more residents and workplaces in the city of Copenhagen. By changing to alternative transportation such as electric and hydrogen cars, it is possible to reduce air pollution, noise problems and CO2 emissions.

“It is important for the City of Copenhagen to contribute actively to a greener city. That’s why we are converting all the city’s own cars to alternative fuels before 2025,” says Julie Lynge, project manager at The Technical and Environmental Administration in the City of Copenhagen.

SOLUTION: JOINT PURCHASE AND FLEET MANAGEMENT

Our goal is to have replaced 85 percent of the City of Copenhagen’s small passenger cars with hydrogen or electric cars by 2015, and 100 percent by 2025. Other vehicles are expected to be replaced with vehicles powered by a mix of alternative fuels.

“The aim is also to make the transition at the same or even lower costs. We’ll do this by simultaneously reducing the total number of cars and purchasing electric when it is time to replace an old car with a new,” says Julie Lynge. Initially, the reduction in the number of cars was driven by the individual departments in the City, but it was decided to enhance this by establishing central data collection of the usage of the cars. The fleet management is therefore being supplied with a GPS-based system to make it easier to use the full potential of the cars and make it easier to decide which type of transport or model of car fits the actual transport needs in the greenest possible way.

Purchasing electric or hydrogen cars can be very expensive for a single city. The City of Copenhagen has found a neat solution:

“We are the largest city in Denmark, which gives us some advantages when investing in new climate-friendly transportation. We have invited other cities to join our procurement process, and this will ensure lower prices because of the advantage of large-scale purchases. In 2014 we count 14 public partners,” says Julie Lynge.

RESULTS: FRONT RUNNER IN GREEN CLIMATE TRANSPORTATION

The City of Copenhagen has saved up to 30 percent of the full price through joint procurement of new hydrogen and electric cars.

Furthermore, the number of the city’s green cars has more than doubled; from 2012 to 2013, the percentage of green cars increased from 15 percent to 43 percent, or from 62 units to 135. During 2013 a purchasing contract with Nissan was signed, adding 60 Nissan Leafs to the fleet.



Photo by Ursula Bach, City of Copenhagen.

FACTS

CONTRACTOR: The City of Copenhagen.

THE PROJECT:

- The project started in 2011/2012 and will be an ongoing process when purchasing cars up to 2025 and beyond.
- The goal for 2025 is to have alternative fuels in the fleet of the City.
- The City is also investing in infrastructure for its electric cars.
- The data from the GPS-based management system will support the transition to greener transportation.
- The City of Copenhagen will also instruct personnel in green driving.
- The range of electric and hydrogen cars can be doubled by improving driver skills.

CLIMATE ADAPTATION: MAKING NECESSITY BENEFIT THE CITY

It will cost close to DKK 10 billion to secure Copenhagen against the extreme weather of the future; and the 300 projects necessary to achieve that goal are ready. However, can this huge investment be used to make the capital even more liveable as well? Copenhagen says yes, and has developed a framework to ensure urban improvements as the climate adaptation projects are realized.

When the historic square of Sankt Annæ (Saint Anne) needed restoration, Copenhagen city planners were quick to realize the project's potential for including climate-adaptation initiatives.

The square is now a green oasis in the heart of Copenhagen that also serves to direct rain away from the neighbouring historic buildings.

You can read more about the Sankt Annæ Square project in the following case article, but the project is a fine example of integrating climate-adaptation measures with urban improvements.

The City Council of Copenhagen has made a decision to make sure that investments in climate adaptation also benefit people and the urban quality of life.

MOVING FROM PURE HYDRAULICS TO URBAN IMPROVEMENT

The challenges arise from the way climate adaptation initiatives are funded.

This is because the money doesn't come from the budget of the City of Copenhagen. Instead, climate-adaptation initiatives are financed by the public waste water companies that add a charge on their customers' bills.

Municipalities can then apply for partial or complete funding of their climate-adaptation projects. On the other

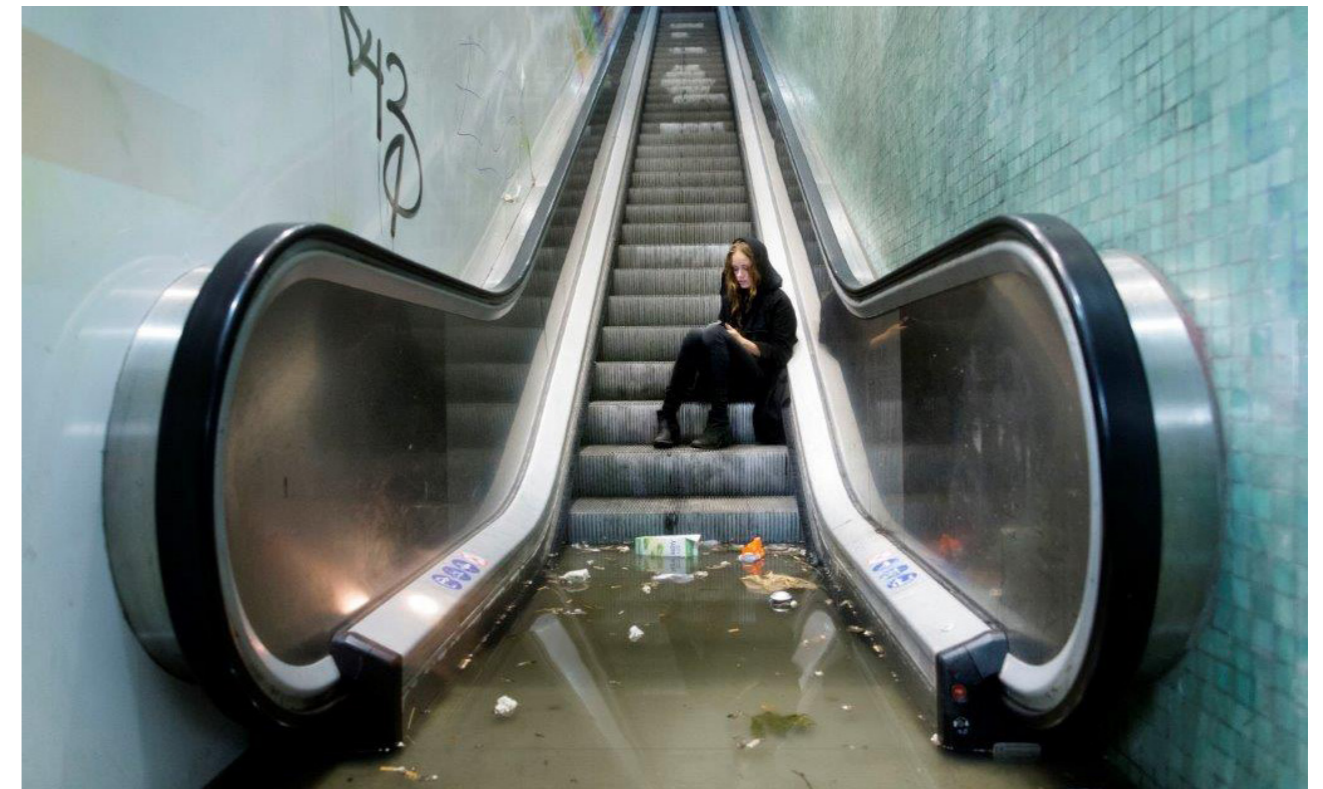
hand, the municipalities have to provide the funding for urban improvements initiatives themselves.

This means that the City's politicians continually have to prioritize and find funding for turning pure hydrological solutions to climate change into urban improvements.

A FIVE-STEP PROCESS FOR URBAN IMPROVEMENTS

In Copenhagen a climate-adaptation project is carried out like this:

- Climate-adaptation statement: This statement details the status of the current climate-adaptation efforts and suggests future projects.
- Political negotiations: On the basis of the climate-adaptation statement the City's elected officials discuss and prioritize between the suggested projects.
- Prioritized projects and waste-water plan: The political discussions result in a list of prioritized projects that are introduced into the waste-water plans.
- Citizen Involvement: When the prioritized projects are ready, the public is invited to comment and make suggestions. It's also in this phase that ideas for urban improvement initiatives related to the climate-adaptation projects are presented.
- Budget proposal for urban improvement initiatives: At this final stage the elected officials pass the suggestions for urban improvements in the climate-adaptation projects.



Flooded escalator after a cloudburst in Copenhagen. Photo by City of Copenhagen.

This procedure stood its first test in 2014 when the climate-adaptation statement was presented in October and the Environment Committee convened shortly afterwards for political negotiations and prioritization of the projects.

HOW THE CITY OF COPENHAGEN PRIORITIZES PROJECTS

With more than 300 projects planned to secure Copenhagen against heavy rainfall, it can get difficult to decide where to direct the adaptation efforts first.

Copenhagen therefore follows five simple principles to decide whether a project demands urgent attention or not.

- Big pipes: These pipes are the backbone of the climate adaptation infrastructure and will provide immediate relief to the sewer system. However, planning and construction can take up to eight years, so these projects need priority.
- Quick fixes: As the significant relief from the pipes won't come for years, it is important to initiate projects that are easy to execute and that will provide some relief.
- Delay roads or spaces: As the pipes providing relief are located downstream in the catchment areas, it becomes paramount to delay and store water upstream as long as possible so that water pressure from heavy downpours doesn't make the downstream system collapse. Therefore the plan prioritizes delay roads and spaces.
- Urban improvement potential: Finally projects that have the potential to improve the quality of an urban area are prioritized.

DKK 9.8 BILLION: THE TOTAL COST OF THE 300 CLIMATE-ADAPTATION PROJECTS IN COPENHAGEN.

FACTS ABOUT COPENHAGEN'S CLIMATE-ADAPTATION PLAN

- 300 different projects are needed to secure Copenhagen against the extreme weather of the future.
- Realizing all of the projects will take up to 20 years.
- The projects will cost DKK 9.8 billion.
- Copenhagen is divided into seven catchment areas that form their own hydrological unit.
- Prioritized project packages are made for each catchment area.

17. RESPONDING TO THE EXTREME WEATHER OF THE FUTURE

The summer of 2014 gave Copenhagen another stark reminder of what's to come in terms of extreme weather. Very heavy rain flooded parts of the city and created damage in the millions. But the city's response is clear: one of the most ambitious climate adaptation plans in the world.

Copenhagen has already experienced more than its fair share of the extreme weather that is expected as a result of climate change. Very heavy rains in 2011 and again in 2014 have created damage in the billions.

Even before the downpours in the summer of 2014, damage had been estimated at between DKK 6 to 9 billion. Compare that to conservative projections that estimate the total damage over 100 years at DKK 16 billion.

"The citizens of Copenhagen are already feeling the effects of climate change. And there is an eagerness to get started on our journey towards adaptation," says Jakob Hjortskov Jensen, chief consultant for climate affairs at the City of Copenhagen.

SOLUTION: 300 ADAPTATION PROJECTS GIVEN THE GREEN LIGHT

In truth, work to protect Copenhagen against heavy rainfall in the future has been going on for some time. Hydrological maps, projections and calculations pinpoint where the city needs to strengthen its defences against precipitation.

The detailed hydrological maps compared with projections from the UN's climate panel (IPCC) form the basis for more than 300 unique climate adaptation projects across the capital.

"It's fair to say that we have the solution to the extreme weather facing our capital in the future. However, it is not a quick fix, as all the projects will take about 20 years to implement. But we are focusing our efforts on the areas of the capital where the challenges are the greatest," says Jakob Hjortskov Jensen.

Three major pipes form the backbone of the system. The overall strategy of Copenhagen is to delay and store as much water upstream as possible, and to expand the capacity of pipes downstream to transport water to the strait of Øresund.

A key part of the climate adaptation plan is to build three large pipes to deal with the everyday rainfall as well as

stormwater. One in the neighbourhood of Vesterbro to transport the water to the harbour. Another in the eastern part of Copenhagen, Østerbro, and finally a large Y-shaped pipe in the north at Bispebjerg.

"These pipes are major infrastructural projects and will take up to eight years to complete, so the projects we launch in the meantime have to deliver immediate relief for our sewage system," says Jakob Hjortskov Jensen.

DKK 16 BILLION: THE ESTIMATED DAMAGE IN COPENHAGEN FROM STORMWATER AND FLOODS OVER THE NEXT 100 YEARS.



Visualization of the climate adaptation project in St. Kjeld's Square. Visualization by Tredje Natur.

FACTS ABOUT THE CLIMATE ADAPTATION PROJECT

The climate adaptation effort is an ongoing effort undertaken by the City of Copenhagen.

BUDGET: DKK 9.8 BILLION

Five types of climate adaptation solutions will be used:

- Roads for stormwater: These roads are specifically designed to lead rain towards lakes or the harbour.
- Pipes for stormwater: These pipes also lead rain towards lakes or the harbour.
- Roads for delaying rain: These roads are designed to store and delay the water resulting from heavy cloudbursts.
- Spaces for delaying the rain: These open spaces are meant to store large quantities of water.
- Green roads: These roads delay and store water locally. This solution is often used on minor roads.

18. THE FIRST CLIMATE-RESILIENT NEIGHBOURHOOD IN COPENHAGEN

Within just two years, the working-class district, St. Kjeld, has put itself on the world map. Today it is a leading example of a visionary approach to technical as well as citizen-led solutions to adapt to the changing climate.

The St. Kjeld's neighbourhood: Before 2012 no one would have recognized the area in Østerbro in Copenhagen as much more than an old working-class district with grey streets and big brick buildings. The area mostly consists of residential properties, but it also provides 10,000 workplaces. Visions to deal with the changing climate were virtually non-existent, as was any kind of urban life like cafes or urban green spaces.

SOLUTION: BOTH TECHNICAL AND CITIZEN-DRIVEN INITIATIVES

In 2012, the district was announced as the first climate-resilient neighbourhood in Copenhagen and it named itself "Klimakvarter". In November 2014 a central square in the neighbourhood, Tåsinge Plads, was launched as a symbol of the innovativeness of the climate adaptation of the entire St. Kjeld's neighbourhood.

More specifically, Tåsinge Plads has been sloped so that the lower part collects rainwater that then seeps into the ground. 2,000 sq m of concrete has been turned into a green oasis, where rainwater has become a resource for the lush flora.

Throughout the whole neighbourhood, solutions at street-level are being, and will continue to be, established to serve as attractive urban environments, which at the same time manage rainwater. Remodelled roads and pavements, water collection systems above and below ground, green roofs and green gardens will delay and reuse the rainwater in the neighbourhood before leading it away towards the harbour in the event of extreme downpours.

"The key to the success of St. Kjeld's neighbourhood is involvement of the public. When we started two years ago, more than 1,000 people met at Tåsinge Plads to contribute with their concerns, thoughts and ideas. By having dialogue with more than 10,000 people and letting them take part, 170 citizen-led projects have emerged," says Stefan Werner, project manager from the City of Copenhagen.

With financial support from the City of Copenhagen, the public-initiated projects have provided the best local solutions to absorb, recycle and lead away rainwater.

RESULTS: AN INNOVATIVE HOOD WITH RESILIENCE AGAINST FLOODING

Today St. Kjeld's neighbourhood is known as the first climate-resilient neighborhood in Copenhagen. Surface water from a total area of about 6,400 sq m can now be managed without being flushed directly into the drains, but instead it is reused or it is allowed to leach into the groundwater or evaporate. "Climate adaptation will be increasingly important in the future. This project has managed to involve people in creating something that benefits the public while dealing with large amounts of rain. Understanding climate adaptation processes as combinations of bottom-up change management and top-down technical solutions is one of the important lessons learned from this project," says Stefan Werner.



Illustration of the new Tåsinge Plads. By Malmo's landscape architects.

FACTS ABOUT ST. KJELD'S NEIGHBOURHOOD

St. Kjeld's neighbourhood has demonstrated how green areas and public involvement can tackle the problem of increased rainwater and create an attractive urban space.

- The project is a cooperative venture between the City Planning Office, the Integrated Urban Renewal in St. Kjeld's, Greater Copenhagen Utility (HOFOR) and the Environmental Centre Østerbro. Planning began in December 2011. The new square Tåsinge plads was inaugurated in November 2014 – but the total transformation of the district will continue until summer 2016.
- DKK 16 million: the cost of the new climate-adapted Tåsinge Plads.

6,400 sq m: surface water from a total area of about 6,400 sq m can now be managed without being flushed directly into the drains, but instead it is reused or it is allowed to leach into the groundwater or evaporate.

19. CURB EXTENSIONS COMBATING HEAVY RAIN

The sewers cannot handle the extreme weather resulting from climate change, and solutions must be developed to manage large amounts of water during heavy rainfall. One solution being tested in Copenhagen is the use of curb extensions next to roads.

During the summer of 2011, the citizens of Copenhagen saw a full-scale demonstration of what happens when the sewerage system is unable to cope with large amounts of rain. The huge pressure sent the water out of the sewers. Mostly into basements or flooding roads or low-lying areas. Moreover, simply directing the water towards lakes or the sea also poses problems.

“Rain washes particles off surfaces like roads, pavements and roofs. This means that the water can contain large amounts of heavy metals that we wouldn’t want ending up in our lakes or rivers,” says Jan Burgdorf Nielsen, project manager at the climate secretariat at the City of Copenhagen.

SOLUTION: CURB EXTENSION WITH CLEANING CAPABILITY

For these reasons, the City of Copenhagen began testing four curb extensions with a soil filter and soakaways underneath the curb extensions (or road beds). The curb extension consists of special filter soil designed to absorb heavy metals and organic components. From the filter soil, the water seeps into an underground soakaway where it will then gradually leach down into the ground water.

“The system is set with a regulator in such a way that when we have pretty mild downpours (2-year and 5-year rain events) the water is directed into the sewer. Bigger downpours are stored in the curb extension,” says Jan Burgdorf Nielsen. However, installing a curb extension is no easy task. The system requires digging large holes, and this can be risky in urban areas. Furthermore, residents and local traffic have to be able to access the road unhindered by the curb extension.

RESULTS: NO FLOODED BASEMENTS

The heavy showers in the summer of 2014 provided an excellent opportunity to test the effect of the recently installed curb extensions.

Residents in the area have previously been hit by flooding of basements during heavy rainfall. “We talked to a number of citizens in the area and none of them experienced flooding of their basements this time,” says Jan Burgdorf Nielsen.



One of four curb extensions in Husum, north of Copenhagen. Photo by City of Copenhagen.

FACTS ABOUT THE CURB EXTENSIONS

The City of Copenhagen has installed four curb extensions in the suburb of Husum.

PARTNERS BEHIND THE PROJECT

- Owner: City of Copenhagen
- Utilities company: HOFOR
- Universities: KU LIFE, DTU, Technological Institute
- Private companies: Orbicon, Wawin, Per Aarsleff A/S
- Each bed is eight meters long.
- The bed is covered with a layer of specially designed filter soil.
- The filter soil captures heavy metals from the water.
- The water then seeps into an underground soakaway and further into the groundwater.

A SIMILAR PROJECT: THE DOUBLE POROUS FILTER BEING TESTED IN COPENHAGEN

- The rain from two residential streets is directed into a 75-meter trench.
- In the trench water passes through a filter that captures particles.
- The other filter, containing lime, captures dissolved components.
- Finally the water is directed into a nearby stream.

20. HISTORIC SQUARE DELAYS 21 MILLION LITRES OF RAIN AFTER RENOVATION

St. Ann Square in the historic part of Copenhagen is being renovated. The renovation will create a green area that will have the capacity to hold 21 million litres of water. Together with new underground “rainpipes”, the area will be able to manage 2,100 litres of rain a second.

“The challenging part of the project was to combine the aesthetics of the historical area, with a new recreational area and climate adaptation for heavy rain,” explains Jan Rasmussen who is head of the climate adaptation project in Copenhagen.

The area has to function as a water channel. However, it also has to be a space in the city of “high quality”, as Jan Rasmussen puts it.

Therefore, the project had to incorporate the demands from the local people, respect for the historic area, and the requirements for a functional drain solution for heavy rain.

PIPES, TREES AND ONE GIANT BOWL SOLVE THE PROBLEM

To prevent flooding from heavy rain in Copenhagen, the old square is being turned into a giant bowl, with underground “rainpipes” and a green area.

The green area with trees and grass can hold up to 21 million litres of water. The complete area will be able to manage 2,100 litres of water every second. Jan Rasmussen explains how it works:

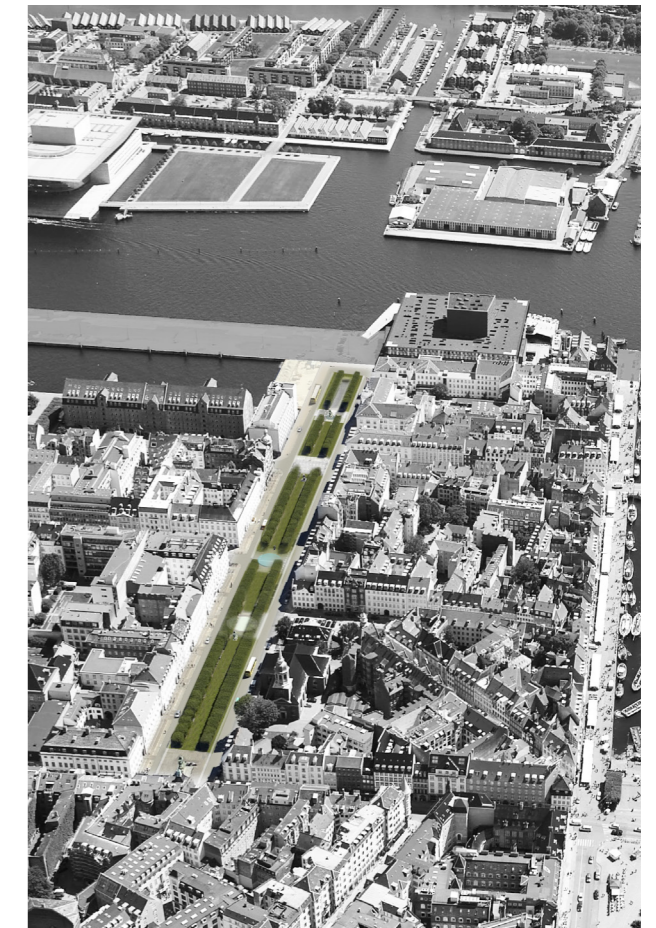
“The green area delays the water, the bowl guides it to the pipes, and the rainpipes guide the water into the harbour.”

DON'T BE AFRAID TO SHOW THE WATER

From the perspective of Jan Rasmussen, the successful combination of renovation, creation of a recreational space in the city, and climate adaptation, is the main positive from the project so far.

Nevertheless, Jan Rasmussen has one piece of advice for others with similar challenges: “Don’t be afraid to show the water. It can easily be a part of the attraction of the area”. For this to happen, it is very important to include climate solutions early in the process.

This will open up for many possibilities in combining climate solutions and recreational areas, according to Jan Rasmussen.



A view of the project from the sky (illustration). Illustration by Schönherr A/S.

FACTS ABOUT THE SANKT ANNÆ PROJECT

The project is a partnership between the City of Copenhagen, HOFOR A/S and Realdania.

- Budget: The total budget of St. Annæ is DKK 132 million. The budget for the climate adaptation part is DKK 63 million.
- Start and finish: Project development started in 2012. The project is expected to finish in 2016.
- To realize the project, 210 parking spaces will be removed from the area.

21. SHOPPING STREET PREPARES FOR CLOUD BURSTS

In the future, a major shopping street in Amager will be able to lead water from heavy cloudbursts away and then recycle it. This benefits both businesses, because it prevents shops from flooding, and also the citizens who want more green areas.

In 2012 it was decided that the most central shopping street in the Amager district of Copenhagen needed renovation. The objectives were better conditions for pedestrians, cyclists and busses, as well as for businesses and residents on the street.

Although a greener street with plants and trees was high on many people's list of priorities, it was not a part of the plan for the busy, congested street with only very little space for water to reach the trees. This was not until an additional objective to secure the whole of Amager against future cloudbursts came into the picture.

SOLUTION: A JOINT VENTURE

It was decided to combine the planned renovation and the cloudburst plans.

"Initially, the big challenge was to combine the vision of a major shopping street with the vision of excellent traffic flow for busses, pedestrians and bicyclists on a road which also sees 20,000 cars every day. Adapting the street to the future climate posed another challenge, but as things have turned out, many synergies have emerged from integrating the plans," says Jens Trædmark Jensen, project manager in the Department of Climate at the City of Copenhagen.

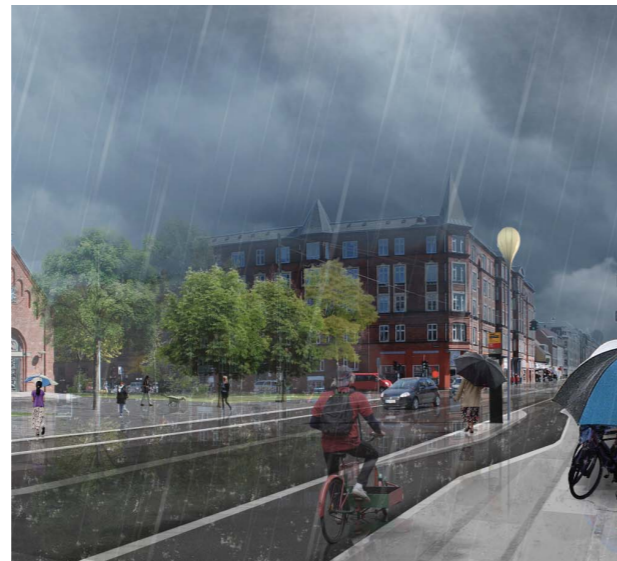
One of the ideas that has come out of the integration is to lower a part of the road to make it able to collect rainwater and lead it into the green area, 'Stadsgraven', nearby. This idea also enables a design where drains underneath the surface can be integrated to water the trees during normal rainfall. So ultimately everyone's wishes, including a greener street, could be met.

RESULTS: MANAGING HEAVY CLOUDBURSTS IN THE FUTURE

The street is dimensioned to handle a hundred-year rain event in 2100. That is the amount of rain that we typically only experience one every hundred years. But already today the planners as well as the stakeholders behind the rebuilding are experiencing the benefits of the solutions.

"By combining the projects we get more intelligent solutions, we save some of the project costs, and finally we

minimize the inconvenience for businesses and citizens of rebuilding twice," says Jens Trædmark Jensen.



An example that visualizes a climate-resilient Amagerbrogade with trees and permeable pavement. Photo by City of Copenhagen.

FACTS ABOUT THE PROJECT ON AMAGERBROGADE

The renovation of Amagerbrogade is an innovative demonstration of how a major shopping street can prepare for heavy cloudbursts.

- **CONTRACTOR:** The City of Copenhagen (Mobility & Urban Space and Climate) in co-operation with BF and CUA consulting and contractors.
- **DURATION:** The overall plans for managing cloudbursts on Amager started in early 2014. The reconstruction of Amagerbrogade is expected to begin in 2016.
- **THE SOLUTION** on Amagerbrogade primarily consists of collecting and leading away the rain to a place where it can gradually seep down into the groundwater, mainly the green area, 'Stadsgraven'.



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