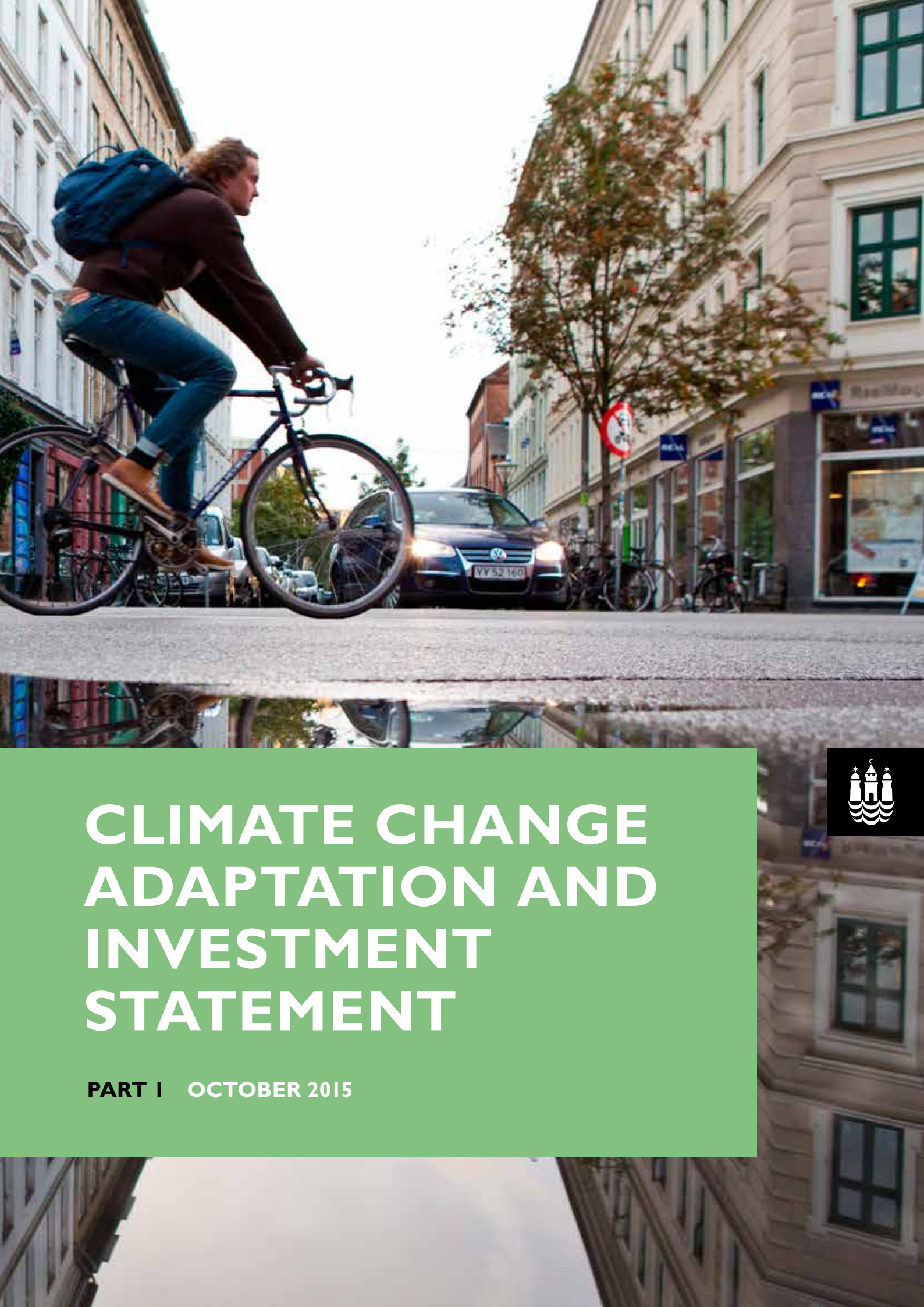

# CLIMATE CHANGE ADAPTATION AND INVESTMENT STATEMENT

**PART I** **OCTOBER 2015**

# CONTENTS

## PART 1



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## PART 2

CHAPTER 1

# THE CLIMATE CHANGE ADAPTATION STATEMENT

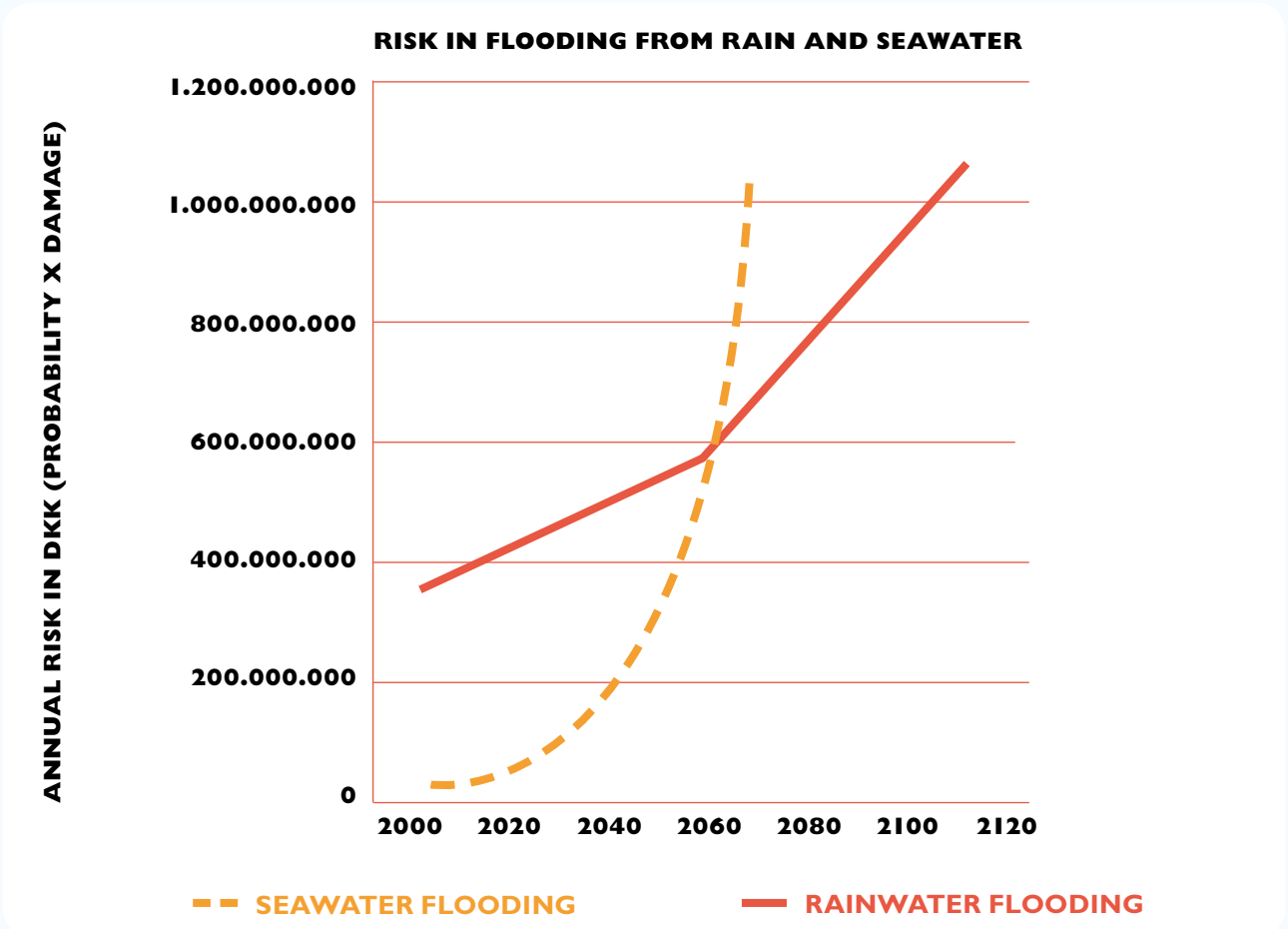
# CLOUDBURST MANAGEMENT OF COPENHAGEN

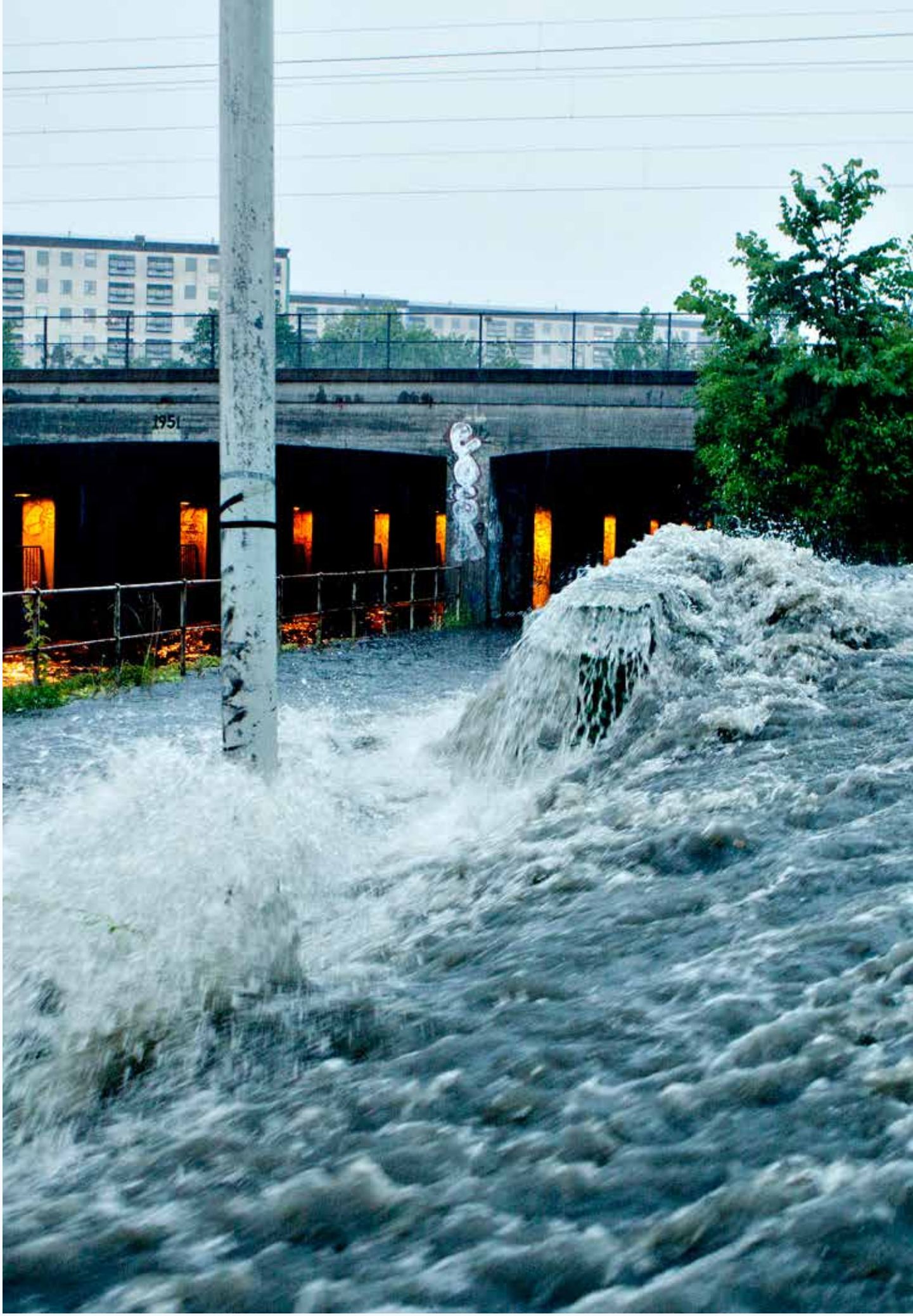
**Over the next few years, Copenhagen is to be protected against the extreme rainfall events of the future. Several projects have already been implemented, but the big construction projects are yet to come. The gains will be substantial. As well as avoiding the damage caused by the massive volumes of water and relieving the pressure on the sewer network from everyday rain, most of the projects will be capable of providing the people of Copenhagen with better urban spaces. This statement presents an overview, provides a status report on climate adaptation work and outlines the next possible steps.**

## MORE AND HEAVIER RAIN

There have already been examples of what the future will bring. In the summer of 2011, in 2014 and again this year, there have been torrential downpours. The same picture will increasingly occur in years to come. If the projections of the UN Intergovernmental Panel on Climate Change (IPCC) prove correct, there is a risk of the costs of damage in Copenhagen over the next 100 years totalling DKK 16 billion. This is a conservative estimate. Before the downpour in the summer of 2014, the cost of damage from extreme rainfall events already totalled DKK 6 – 9 billion over the past 6 years. If the Ministry of Finance's rate of increase is used for projection instead of the rate used in the Climate Adaptation Plan, future damage will total DKK 18 billion instead of DKK 16 billion.

There is much to suggest that the costs of damage will be higher than DKK 16 billion based on an assessment of rainfall events in recent years.

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# COPENHAGEN IS READY WITH A SOLUTION

**Copenhagen has come a long way in its efforts to protect itself against the heavier rains of the future. In fact, the solution for cloudburst management is ready now. Around 300 specific projects spread across the city will relieve the pressure on the sewer network and protect the cultural heritage and the homes of the people of Copenhagen and commercial properties against penetrating water.**

The solution means that instead of sending the water from torrential downpours and everyday rainfall down into the sewers, a completely new infrastructure is to be established for stormwater management. The alternative infrastructure combines cloudburst management solutions on the surface with cloudburst pipes below the ground, which retain the water and discharge it to lakes and the harbour. At the same time as the projects are being implemented over the next 20 to 30 years, there is an opportunity for further enhancements to be made to many urban spaces.

When the water is to be discharged to lakes and the harbour, there is a need to construct four extra-large cloudburst pipes. These are crucial in ensuring that the water is conveyed the last part of the way to the harbour. A pipeline is to be established in Vesterbro to carry everyday rain and stormwater from Vesterbro and Frederiksberg to the harbour basin. The lake of Sct. Jørgens Sø forms part of the project by acting as a retention basin. A cloudburst pipe is to be established in Østerbro to convey everyday water and stormwater from Østerbrogade to the Nordhavn Harbour basin. A third cloudburst pipe is to be established in Bispebjerg, from where everyday rain and stormwater will be discharged into Svanemøllen Bay. A fourth cloudburst pipe is to be established in Valby, from where the water is conveyed to Kalveboderne. The new alternative infrastructure thus consists of both surface solutions and cloudburst pipes below the ground.

It will take 7 to 9 years for the large cloudburst pipes to be completed. The first projects in water catchment areas selected will therefore be solutions that can stand alone and function without connection to the three large cloudburst pipes, for which the utility company HOFOR is responsible.

It will take at least 20 years for the projects to be fully implemented. So it is not a quick solution, and the people of Copenhagen will therefore have to be patient.

# FROM CLOUDBURST MANAGEMENT PLAN TO 300 PROJECTS

## LONG TIME FRAME IS A STRENGTH

There are a number of challenges that have not yet been overcome, and where the long time frame will prove to be a strength. For example, the principles for the treatment of everyday rain have been established, but the final treatment solutions are not yet known. Another challenge is salt on the roads in the winter, which normally ends up in the sewers, but which in future will have to be dealt with in the new cloudburst management infrastructure. It is common to both that they are challenges that can be converted into demand for new solutions to be found in cooperation with businesses and citizens.

The long time frame is thus a strength, because it means that the latest technology can be continuously brought into play, which will also mean that solutions that do not yet exist can be developed. The time frame also provides an opportunity to reduce the uncertainty that exists for construction projects in the phase the cloudburst management project is in now. This is to be done through continuous learning and exchange of experience, when the projects are implemented.

## THE FIRST STEPS HAVE BEEN TAKEN

The first steps along the way to the goal of equipping Copenhagen to cope with the extreme rainfall events of the future have been taken. The strategy has been to go for the low-hanging fruits first and direct efforts towards areas at highest risk.

In Indre By (Inner City), which has been one of the areas hardest hit by torrential downpours, new damage has been successfully averted by simple means in some areas by ensuring that rainwater can be discharged into the harbour, without seawater being able to penetrate in the opposite direction. In Østerbro, Tåsinge Plads is ready. The outcome is a new urban space combined with cloudburst management. The rains in the summer have shown that it works.

HOFOR makes continuous efforts to incorporate cloudburst management into its daily work, such as establishing cloudburst proofing in connection with the replacement of district heating pipes. Coordination with other construction projects will be crucial in the future. Success has also been achieved in substantially reducing the number of flooded basements, because the rainwater is not forced up from the overloaded sewers, as overflow from the sewer is created as an interim solution in connection with torrential downpours.

Finally, 16 new cloudburst management projects have been launched. They have been chosen because they can be implemented in synergy with other construction projects in the city. Vibevej in Fuglekvarteret is an example of this. Cloudburst management and urban renewal projects are conceived jointly here.

## THE MAJOR WORK IS ONLY STARTING NOW

Although we are well under way, the major challenges are yet to come. We now have a combined solution for the cloudburst management of Copenhagen, consisting of around 300 projects. The 300 projects are the combined framework that the City of Copenhagen can notify to the Secretariat for Water Supplies to allow for funding from charges.

Not all 300 projects are to be launched at the same time. The City of Copenhagen will make an annual selection of the projects that are to be started in the seven water catchment areas in Copenhagen. The Municipality can choose among the projects that are on municipal land. When a project is selected from the combined project framework, it can be developed in cooperation with the citizens, and a budget memorandum can be prepared for the task if the project if urban space improvements are to be added to the project. The selection of projects will be made on the basis of an annual climate change adaptation statement and proposals for project packages for the individual water catchment areas, see the Technical and Environmental Committee's choice of method of implementation from 16 June 2014.

The yearly cycle of regular development and execution of stormwater and rainwater management in Copenhagen will look as shown in the illustration. The following key political decisions will have to be taken:

- Annual climate change adaptation statement, which points the way for efforts to be made and the level of ambition
- Annual project package (see page 51) with selection of cloudburst management projects to be launched
- Budget memorandum and budget negotiation on possible investments in urban space improvements
- Decision on practical planning and execution of the individual projects as ordinary construction projects


*Årshjul klimatilpasning*

## OUTSIDE INVOLVEMENT

The climate adaptation of Copenhagen will require broad outside involvement, as the individual projects differ in character and always have to be designed in relation to local circumstances, other current projects and ambitions for the area. This involvement has to take place in the light of the climate adaptation projects typically containing complexity in the form of hydraulics, technological development, urban space improvements and requirements for coordination with a number of other construction projects, urban renewal projects, etc. As an aspect of outside involvement, the local committees are an important partner in cooperation, as their local knowledge may help enhance the resilience of the individual projects. Together with the local committees, the Technical and Environmental Administration sets the boundaries for outside involvement. This cooperation is part of the yearly cycle, which is described in the climate change adaptation statement. A new element is that the local committees are involved at an early stage in the preparation of the administration's proposals for project packages, typically in January. The Copenhagen politicians will thus have projects for the budget negotiations which the local committees have looked at, and where provision has been made at the same time for involvement to be planned in good time. Following the budget agreement for the year, citizens and local committees are involved in the specific construction projects. The intention is that the procedure will commence as early as January 2016, and will be reflected in the budget agreement for 2017.

## IN LINE WITH URBAN DEVELOPMENT

When the prioritised projects are to be selected, the artistry will be in interleaving cloudburst management with urban development in Copenhagen.

This interleaving is to ensure that cloudburst management actually does give the city a boost, and that the project becomes cheaper, because cloudburst management is done in places where Copenhagen has construction projects beforehand. In practice it means that cloudburst management in years to come will partly take place in conjunction with steam conversion and road restoration in Copenhagen. Finally there will be urban renewal projects, where it is natural to include cloudburst management in planning.

### HOW WE PRIORITISE PROJECTS

To be able to choose between the 300 projects, we will aim to:

1. Design the large pipes that will function from day one
2. Pick the low-hanging fruits and simple solutions
3. Establish retention spaces and retention roads, which will also be effective quickly
4. Find urban space improvements and present proposals for these
5. Systematically classify and repeat the same solution design and method in the 300 projects

# EXPORT POTENTIAL AND SKILLS BOOST

## EXPORT POTENTIAL

Water and environmental technology is an area in which Denmark has top-level skills to offer on the global market. Together, the area gives employment to around 100,000 people and comprises more than 700 businesses. Exports of water and environmental services are growing well and may be expected to account for a significant portion of future Danish exports.

Exports of water technology and environmental technology account for 10% of total exports, at around DKK 80 billion annually, but the sector is developing very rapidly, and is among the fastest-growing export sectors. More than 60% of Danish production of water and environmental technology is exported to foreign markets, which is an indication of good collective international competitiveness for Danish water and environmental technology products.

Implementation of the Copenhagen climate adaptation plan may provide a springboard for the development of innovative complete solutions that Danish companies can sell on a growing global market. Copenhagen is not the only city to face rising volumes of rain. The major cities of the world are increasingly demanding complex climate adaptation solutions that integrate the urgent need to manage extreme volumes of water and the development of modern major cities with high quality of life – an approach that is characteristic of the Copenhagen climate adaptation plan.

The City Administration and HOFOR will work to find solutions that can be repeated/copied, for example on cloudburst roads, retention roads and retention spaces. The aim here is to reduce costs by standardising the solution methodologies and creating a basis for reproducible solutions that businesses can refer to and, if appropriate, sell on.

## SKILLS BOOST

In conjunction with the forthcoming hospital construction projects, the Region of Southern Denmark and the Capital Region, in cooperation with local growth forums, have implemented projects aimed at small and medium-sized enterprises in the building and construction industry. The idea is to bring small and medium-sized enterprises together in partnerships and give them a skills boost, so that the small and medium-sized enterprises are capable of bidding for major construction projects. The Technical and Environmental Administration will take the initiative for similar activities in Copenhagen together with the Financial Administration and the Employment and Integration Administration.

# CHALLENGES AND COOPERATION

## CHALLENGES TO BE TACKLED

It is clear that a construction effort on this scale will face challenges. This also applies to Copenhagen cloudburst management.

## 158 KILOMETRES OF PRIVATE SHARED ROADS

Around a third of the projects are on private shared roads in the municipality, and the landowner associations have to raise loans to implement the projects. HOFOR has to negotiate with the landowners here to implement cloudburst management. At present there is a partnership between HOFOR and the City of Copenhagen which is to give the citizens a push and draw their attention to the opportunities to have their expenses for cloudburst management covered through charges. This necessitates landowners, as well as the municipality, applying to the Secretariat for Water Supplies for co-financing.

## CONSERVATION LISTING

Listing of areas for conservation may be significant for several projects. This is the case in particular in the water catchment area of Vesterbro Ladegårds Å, which in a densely built-up area has the lake of Skt. Jørgens Sø as a central element.

Initial screening of the problem of conservation listing has been done. The conclusion is that the Conservation Board can grant exemptions for from the conservation orders on Damhusengen, Damhussøen, Fredens Park, Hans Tavsens Park, Fælledparken, Enghaven and Sortedamssøen, because the projects do not alter the main purpose of the listing. Skt. Jørgens Sø can also be the subject of an exemption, but this is conditional on the present-day characteristics of the lake being preserved to a greater degree. The project will otherwise bring about a new conservation order.

## TREATMENT OF EVERYDAY RAIN

Trials are to be conducted with treatment methods for rainwater. At present there are trials with filtered topsoil and other solutions will be trialled later. The selection of the final treatment method is to be based on the targets the Technical and Environmental Committee has set for the treatment of everyday rain. The principles establish that stormwater can be conveyed to receiving bodies of water, but that everyday rainwater cannot be discharged without treatment. A sum of DKK 150 million is therefore earmarked in the application to the Secretariat for Water Supplies for the treatment of everyday rain.

## LARGE TASKS ARE BEST ACCOMPLISHED IN COOPERATION

Rainwater does not respect municipal boundaries or divisions between public and private land. Copenhagen cloudburst management therefore also has to take place in close cooperation with neighbouring municipalities, landowners' associations, citizens and local committees. In the spring of 2015 cooperation agreements were made with the surrounding municipalities of Gentofte, Gladsaxe and Frederiksberg and their utility companies, HOFOR, Nordvand and Frederiksberg Forsyning respectively.

## COOPERATION WITH LOCAL COMMITTEES

A strategy for the outside world has been developed in cooperation with the local committees. This is to ensure early involvement of the citizens in future cloudburst management projects. Among other things, it means that the local committees will be involved at the beginning of 2016 in selecting the projects for the project package for the 2017 budget.

## PARKING AND TORRENTIAL DOWNPOURS

The number of car parks may be affected by the cloudburst management projects, as the cloudburst proofing of Copenhagen take the form of surface projects. The final number of car parks affected is related to the individual projects. The final number will not be known until the specific construction projects have to be implemented. The assessment at present is that few car parking areas will be concerned. Instead of removing car parks, we will attempt to respond to the challenge by focusing on:

- Terrain regulation of cloudburst roads, retention roads, etc. taking account of car parking as far as possible
- Water-resistant functions being installed, for example containers in car parks, which are to be replaced by a cloudburst management solution, so that space is created for car parking elsewhere
- Further work being done on permeable surfacing or other technologies that preserve car parking and ensure that rain is managed at the same time
- Car parks being established in design

### HOW WE COOPERATE

Cooperation with surrounding municipalities
Copenhagen cooperates with

- Surrounding municipalities in relation to the Harrestrup Å
- Frederiksberg Municipality and Frederiksberg Forsyning in relation to Vesterbro/Ladegårds Å, and Copenhagen West and Frederiksberg West
- Gentofte and Gladsaxe municipalities and Nordvand in relation to Bispebjerg, Dyssegård and Ryparken
- Partnership with landowners' associations
- Cooperation is to be established with landowners' associations on cloudburst management solutions on private shared roads

# INITIATIVES IN 2016

**WE WILL BE IMPLEMENTING THE FOLLOWING INITIATIVES IN 2016:**

### # PROJECT PACKAGE FOR 2017

The next project package with proposals for cloudburst management projects will be prepared and presented to the Technical and Environmental Committee at the beginning of 2016, so that any urban space improvements can be included in the 2017 budget. The project plan for 2017 will focus, among other things, on projects that can be implemented in line with road renovation projects. Stand-alone projects that retain water can also be adopted. Finally a start will be made on maturing some of the larger projects, for example Skt. Jørgens Sø. Before the project package is submitted to the Technical and Environmental Committee, the administration has involved the local committees in selecting the projects in the project package.

### # GREEN THINK TANK

A green think tank will propose green solutions for cloudburst management projects over the next few years. The think tank will consider how the cloudburst management projects can contribute to boosting urban nature in Copenhagen. The work of the think tank will be incorporated into the cloudburst management project over the next few years.

### # HYDRAULIC MODEL

A new collective hydraulic model will be prepared for use in connection with implementation of the 300 cloudburst management projects. The model is to ensure combined hydraulic overview of the seven different water catchment areas.

### # STORMWATER AND RAINWATER MANAGEMENT IN A NEW URBAN COMMUNITY

A platform will be established for cooperation where citizens and businesses are involved as early as possible in the design of future cloudburst management projects. This means that citizens and businesses will be invited to take part in the cloudburst management projects and consequently in the cloudburst-proofing of Copenhagen. The aim is to create exports and growth by developing in close proximity to the citizens.

### # PUTTING INTO PRACTICE OF COOPERATION AGREEMENTS WITH SURROUNDING MUNICIPALITIES

Cooperation agreements have been entered into with the municipalities of Gentofte, Gladsaxe and Frederiksberg, as well as Nordvand, Frederiksberg Forsyning and HOFOR. The cooperation agreements are now to be activated, which means that a joint project package is to be drawn up with projects that are to be implemented in cooperation with the Municipality of Frederiksberg, where there are joint surface projects.

### # INTERNATIONAL COOPERATION

Cooperation has been established with New York City, among other things on transferring the ideas and results from the Climate Resilient Neighbourhood in Østerbro to a district of New York. This provides an opportunity for Danish companies to export knowledge and solutions.

In addition, a cooperation agreement has been entered into with the city of Beijing on exchange of experience of solutions for the management of everyday rain and torrential downpours.

### # PARTNERSHIP ON PRIVATE SHARED ROADS

Contact is being made with private shared roads to promote co-financing projects and implementation of these. The partnership has been launched and will continue in 2016.

### # WASTEWATER PLAN

Cloudburst-proofing is to be considered together with wastewater planning for Lynettefællesskabet (BIOFOS) and Harrestrup Å projects. Finally the wastewater plan is to give notice that orders will be issued for disconnection from the sewers. The wastewater plan is expected to be ready in 2016.

### # SKILLS BOOST FOR SMES

In cooperation with the Financial Administration and the Employment and Integration Administration, SMEs are being qualified to bid for large construction projects through a skills boost.

# WHAT HAS BEEN DECIDED BY TECHNICAL AND ENVIRONMENTAL COMMITTEE?

**The climate change adaptation statement, the project packages and the thematic discussions are merely the most recent steps along the way to cloudburst management of the city. There have previously been a number of key discussions and decisions, which can be summarised as follows:**

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| **CLIMATE ADAPTATION PLAN** | Decision that the cloudburst management of Copenhagen is to take place as a combination of surface solutions and pipes, which ensure that the water from cloudbursts is retained or discharged to the harbour and lakes. The investments in the solutions are to be recouped as a better city, growth and jobs. |
| **CLOUDBURST MANAGEMENT PLAN** | Decision on the level of service for cloudburst management, 100-year rainfall and a maximum depth of 10 cm on the road. Seven catchment areas are designated where cloudburst management efforts are to be made. A decision is finally made to prioritise cloudburst management efforts where the risk is greatest, and where there is an opportunity for synergies with urban development in general. |
| **DETAILING OF CLOUDBURST MANAGEMENT** | Contains proposals for surface solutions within each of the seven catchment areas in Copenhagen. There are five fundamental solutions: cloudburst management roads and cloudburst management solutions that transport the water in the event of torrential rain; retention roads, which retain the water; green roads, typically side-streets, that retain and store water; retention spaces, which store the water in the event of torrential downpours. All the solutions are significant for the part of the city where they are located. They are therefore to be thought of as the start of new urban spaces. |

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| **MODEL FOR IMPLEMENTATION** | The Technical and Environmental Committee on 16 June 2014 adopted a model for implementation that consists of a framework application to the Secretariat for Water Supplies that is implemented annually in project packages for each water catchment area and budget memoranda for the projects, where the committee wishes there to be urban space improvements on top of the hydraulic solution. The effort in itself and across water catchment areas is summarised in a timetable for cloudburst management. |
| **THEMATIC DISCUSSIONS ON THE TECHNICAL AND ENVIRONMENTAL COMMITTEEE ON 6 OCTOBER 2014** | Addressed the work on the timetable for the cloudburst management of Copenhagen. Drafts were prepared for project packages for each water catchment area, which were used as a basis for discussion of how efforts in the individual catchment areas are to be put together. Based on the thematic discussion, the Administration drew up the final project packages for the Technical and Environmental Committee in January 2015, together with the application to the Secretariat for Water Supplies. |

## FUTURE DECISIONS

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| **THE APPLICATION TO THE SECRETARIAT FOR WATER SUPPLIES** | The framework application will finally be considered in the autumn of 2015 on the Technical and Environmental Committee, the Finance Committee and the Municipal Council. The application is to be submitted by 1 January 2016 for approval by the Secretariat for Water Supplies. |
| **BUDGET 2017** | Based on the project packages, budget memoranda are prepared for the projects where there is a wish for urban space improvements, to be financed through the municipal budget, see the new yearly cycle. |

# CLIMATE ADAPTATION GLOSSARY

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| **CLIMATE ADAPTATION PLAN** | Describes the combined challenges facing Copenhagen which the climate of the future is expected to lead to. The plan sets the framework for the strategies that the city can choose to protect itself against climate change.<br><br>Adopted by the Municipal Council on 25 August 2011 |
| **CLOUDBURST MANAGEMENT PLAN** | Lays down the strategy for managing cloudbursts in Copenhagen. The plan establishes the level the city is to protect itself against and presents the first financial estimates of expenditure. The plan divides Copenhagen into catchment areas, which are based on how the water runs on the surface when rain falls. The catchment areas are prioritised according to a risk assessment in relation to where the water causes most damage.<br><br>Adopted by the Municipal Council on 13 December 2012 |
| **DETAILING OF CLOUDBURST MANAGEMENT** | Consists of seven plans, based on the division into catchment areas in the cloudburst management plan. These designate principles of solution and methods for each of the seven catchment areas in Copenhagen. The plans also contain examples of how cloudburst management solutions can be jointly conceived with urban space improvements.<br><br>Approved politically during the course of 2013 and 2014. |
| **HOFOR** | The role of the utility company HOFOR in climate adaptation is to manage wastewater, including rainwater. All the projects are developed in cooperation with HOFOR. |
| **TRADITIONAL SOLUTION** | The traditional solution will consist in ordinary sewers and stormwater pipes below the ground. |
| **ALTERNATIVE SOLUTION (THE PROPOSED SOLUTION)** | The solution means that instead of sending the water from torrential downpours and everyday rain down into the sewers, a completely new alternative infrastructure is to be built for rainwater management. The alternative infrastructure combines cloudburst management solutions on the surface with stormwater pipes below the ground, which together retain the water and divert it to lakes and the harbour. At the same time as the projects are being implemented over the next 20 or so years, the city is to be given a boost in the shape of urban space improvements. |

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| **THE CO-FINANCING SCHEME** | HOFOR can finance joint cloudburst management measures with the municipality and the private sector. The measures concern solutions for the management of rainwater on the surface.<br><br>HOFOR can finance joint cloudburst management measures to 100% up to and including 2015. In practice, HOFOR then finances the project over 25 years by refunding the municipality's instalments and interest on the loan taken out for the project.<br><br>Co-financing projects on private land are (in principle) basely solely on a contractual relationship between HOFOR and the landowners. The owners of the land are project owners, and themselves attend to and finance (through loans) the development, construction and subsequent management of the project, in return for 100% reimbursement by HOFOR. If HOFOR and the owners enter into an agreement after 2015, up to 75% reimbursement will be made. |
| **THE SECRETARIAT FOR WATER SUPPLIES** | The Secretariat for Water Supplies is a state secretariat under the Danish Competition and Consumer Authority. The task of the Secretariat for Water Supplies includes ensuring cheap and effective management of wastewater for consumers. Every year, in April, HOFOR submits an application to the Secretariat for Water Supplies for approval of a price ceiling for charges in the coming year.<br><br>In relating to climate adaptation, the Secretariat for Water Supplies has the role of ensuring that the municipality does not use the co-financing scheme to finance municipal tasks. It is therefore the task of the Secretariat for Water Supplies to ensure that the co-financing projects are cheaper for the municipality to carry out than traditional wastewater management.<br><br>HOFOR sends the combined approved plan for each catchment area to the Secretariat for Water Supplies. The municipality and HOFOR are not obliged to implement the plan. Large changes to the plan may, however, mean that financing changes from pure financing through charges to 75% charges and 25% through taxation, if the change requires new approval by the Secretariat for Water Supplies. |

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| **CATCHMENT AREA** | A demarcated area of the city where collective management of rainwater can be done. The individual catchment areas are said to make up a hydraulic unit, that is to say the projects in the catchment area are mutually dependent. A project therefore cannot be removed without replacing it with something else that serves the same function.<br><br>Catchment areas do not follow the normal boundaries between urban districts but are based on the local topography. In several cases, the catchment areas also transcend municipal boundaries. |
| **CLOUDBURST ROAD** | A cloudburst road is a road which in normal weather functions as a road in the city and when torrential downpours and large volumes of water occur transport the water to places from which they can either be collected or discharged (typically to the harbour or similar receiving body). |
| **RETENTION ROAD AND GREEN ROADS** | A retention road retains and stores water. This retention can be done with green elements. Green roads also retain and store water, but on a smaller scale and typically on small side-streets. |
| **RETENTION SPACE** | A retention space is a square or a park arranged to store water when cloudbursts occur, to avoid having too much water on cloudburst roads, etc. When the downpour is over, the facility is drained either to the sewers or to the cloudburst management system. An example of such a space is Enghaveplads. |
| **CLOUDBURST PIPES** | At certain places in the city there is insufficient space to manage the water on the surface, due to narrow roads or obstructions such as railway lines and large approach roads. A cloudburst pipe collects the water from the surface and carries it underground to the harbour, for example. An example of a cloudburst pipe is the tunnel to take stormwater from Skt. Jørgens Sø beneath the railway cutting to the harbour. |
| **LAR** | LAR stands for Local Removal of Rainwater (Lokal Afledning af Regnvand) and involves managing rainwater locally, so that less water is carried to the sewers. When LAR is used, the rainwater percolates and evaporates. If this cannot be done at the particular location, the water is retained before it is transported to a receiving body of water, an artificial water element or a road. There are various catalogues describing the different LAR methods. Percolation is not possible if the soil is polluted, percolating capacity is poor or the water table is high. However, percolation is possible in most of Copenhagen. |

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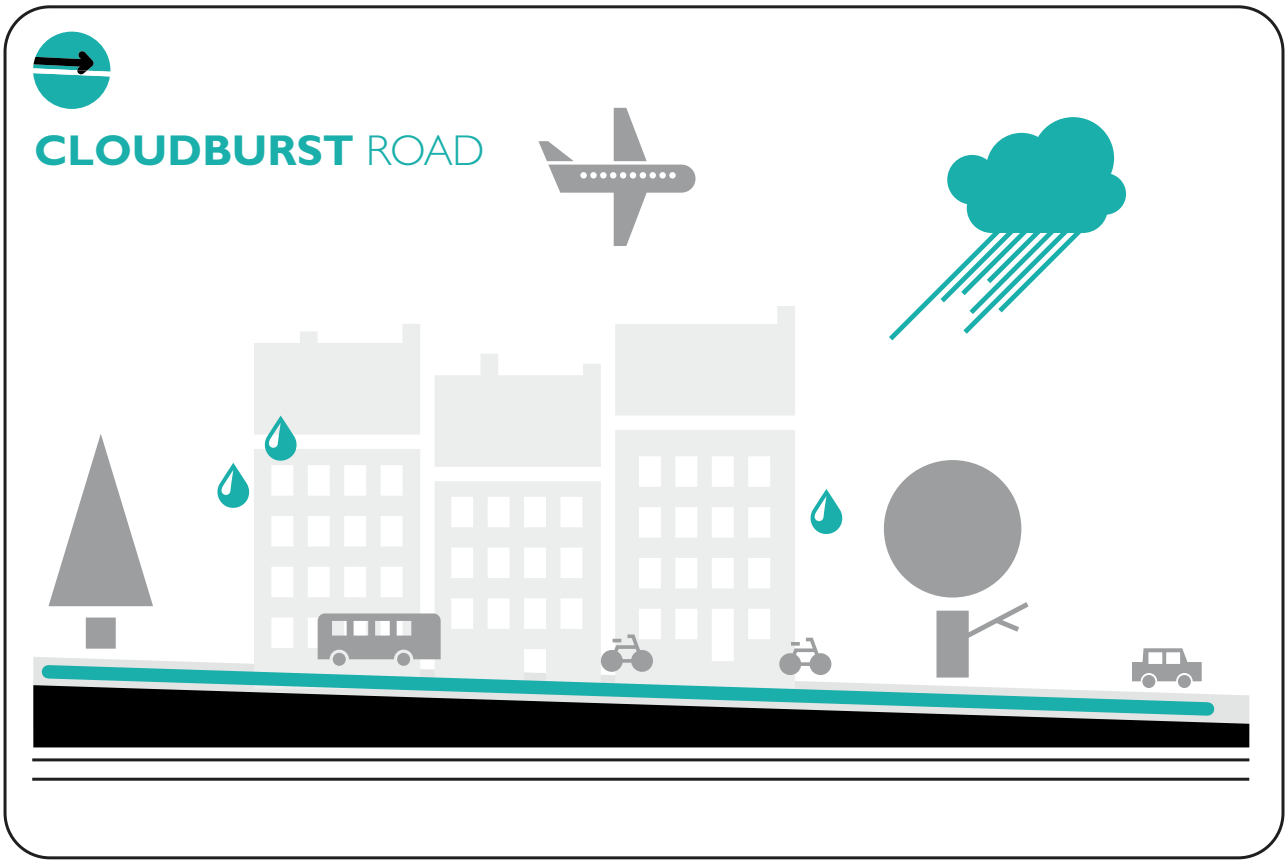
| **OVERFLOW TO THE HARBOUR** | When the sewer system is full in connection with a cloudburst, the pipe system cannot keep up, and it is therefore not possible for all the water to be carried to the treatment plants. In these situations an overflow to the harbour takes place, with sewage and rainwater flowing into the harbour untreated. This leads to bans on bathing. The aim of climate adaptation is also to ensure that no more overflows to the harbour take place, so that good bathing water quality can continue to be ensured.<br><br>When the sewer system fills up in connection with cloudbursts, there is more pressure than the system can handle. The water simply cannot be removed as quickly as it comes down. It therefore backs up in the systems and creates pressure down in the sewers. Among other things, this causes sewer covers to be dislodged, with the result that the water pours out onto the roadway, for example. Water also accumulates in people's basements, for example via toilets and floor drains. This is not due to the system failing to work but simply to it not being sufficiently large. |
| **DISCONNECTION FROM THE SEWERS** | In the future, around 30% more rain and more extreme rainfall events are expected. To ensure that the sewer system can cope, the climate adaptation plan proposes future-proofing the sewers so that some of the rainwater is managed outside the sewer system, for example through LARs or the systems established for cloudburst management. In that way a large proportion of the rainwater can be disconnected and expensive expansion of the sewerage system can be saved – and possibly also an expansion of the sewage treatment plants in the municipality in line with the growth in population in Copenhagen. |
| **PRIVATE INVESTMENTS IN CLIMATE ADAPTATION** | The citizens of Copenhagen are obliged to invest in climate adaptation. They generally have to safeguard their own homes and basements against penetrating water by securing basement steps, basement wells, etc. In addition, the citizens have to protect themselves against sewage by installing backwater valves for example in connection with floor drains in basements. Backwater valves ensure that flooding of basements cannot occur. Finally, citizens can contribute to the decoupling of rainwater for example by establishing LAR facilities in gardens and yards. |
| **WASTEWATER PLAN** | A large part of the climate adaptation work is regulated through the wastewater plan, which serves as the municipality's tool in setting targets and frameworks for HOFOR investments in the area. |

# SOLUTION TYPOLOGIES

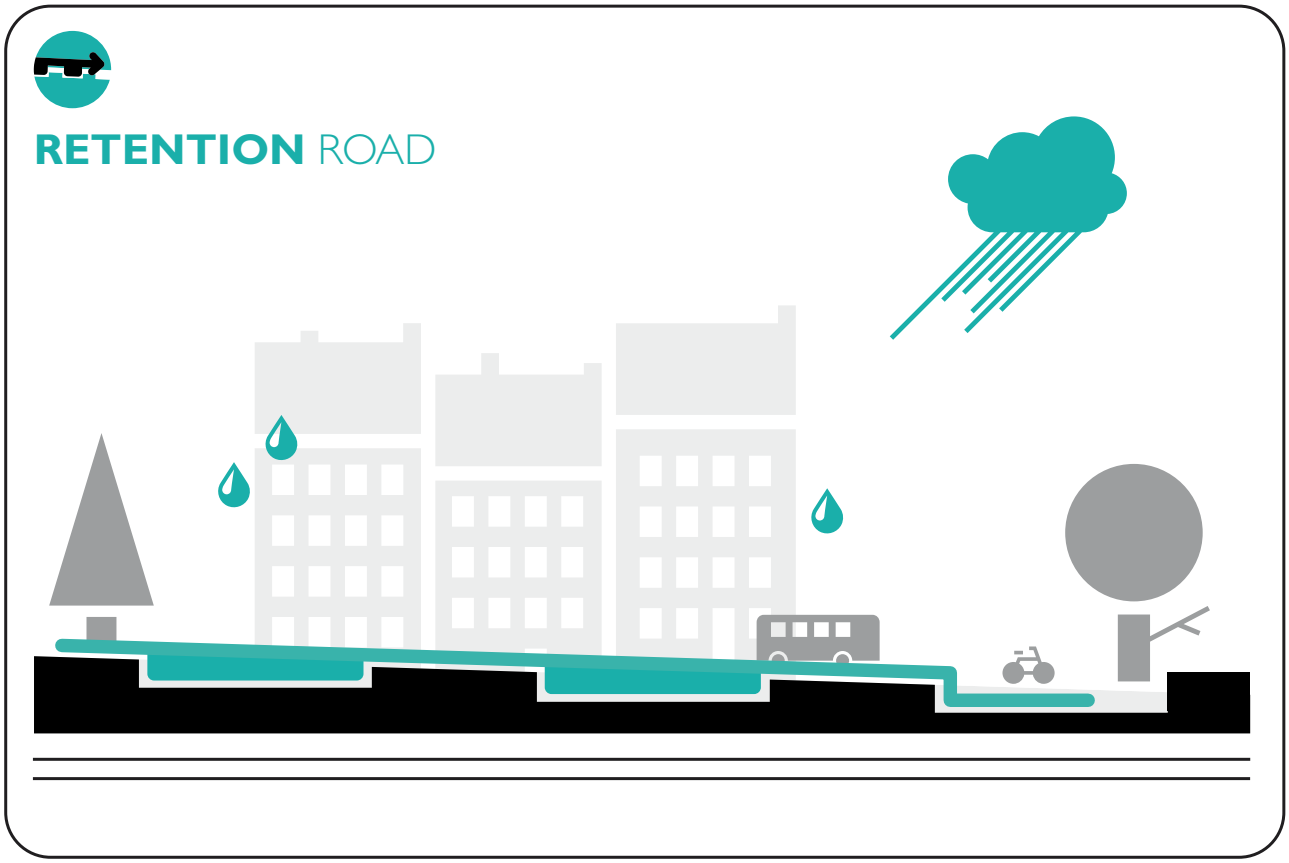
**The solutions on the surface are divided into four different typologies:**

**Cloudburst roads**
**Retention roads**
**Retention spaces**
**Green roads**

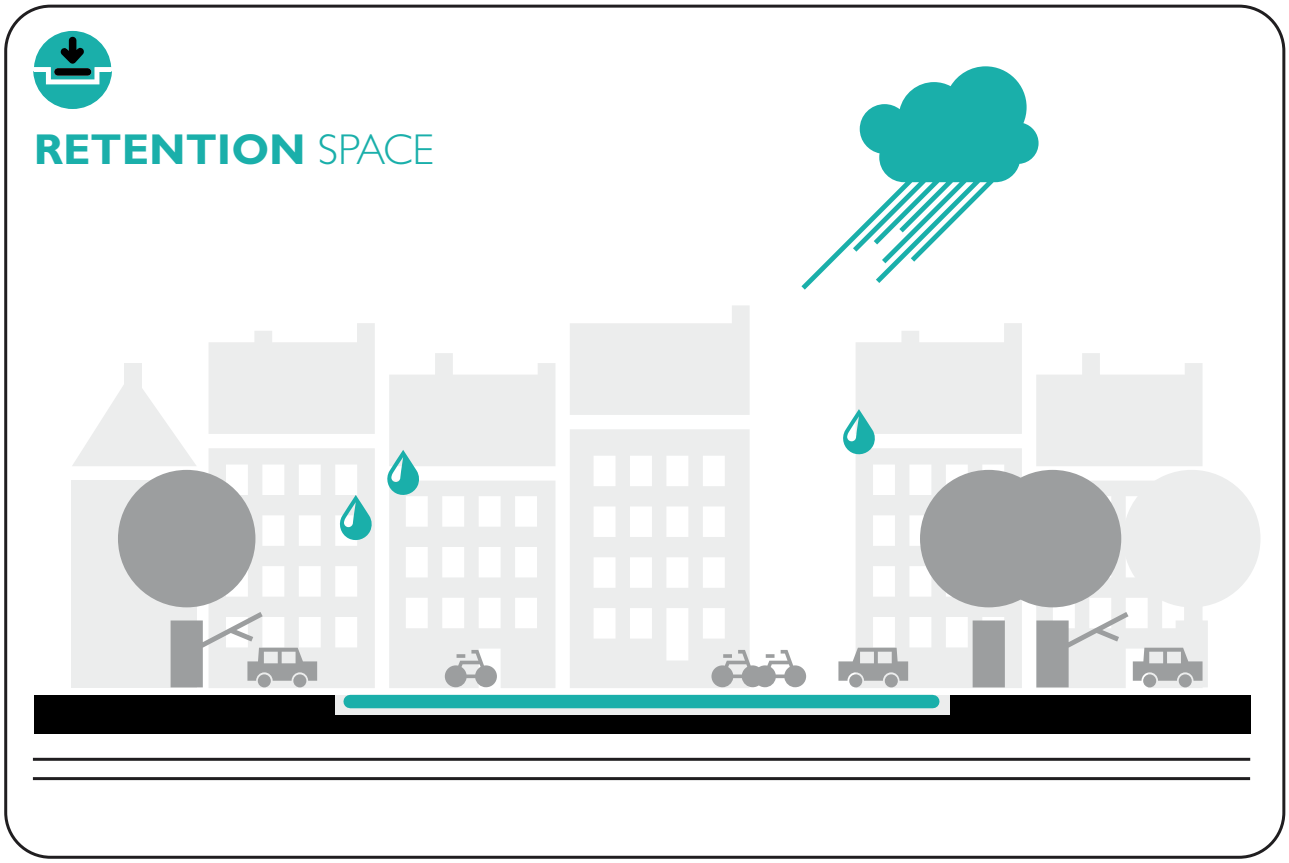
The solution typologies have different hydraulic characteristics, but it is common to them all that they can be designed according to local needs and can make improvements in urban spaces possible. The solution typologies can therefore be combined in the specific projects.



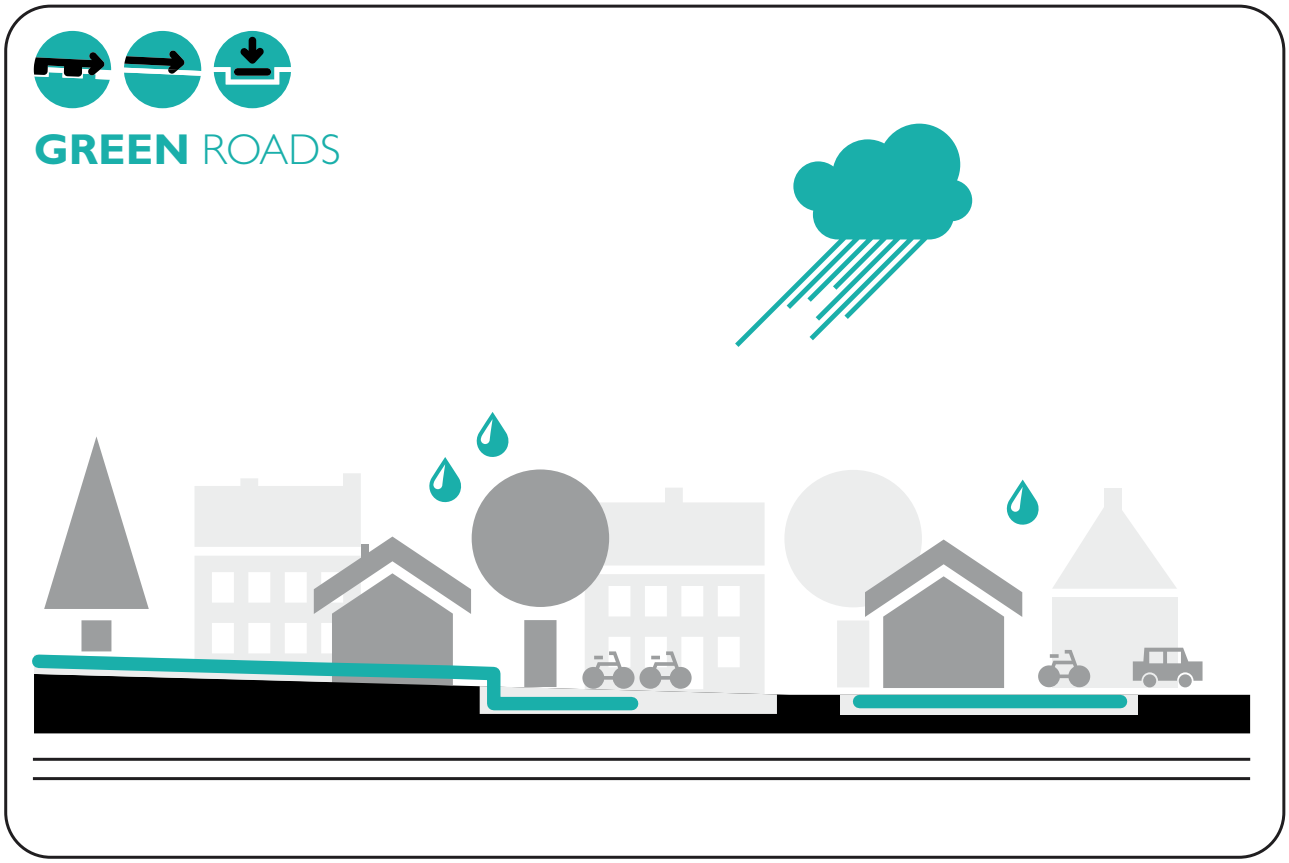

**The principal hydraulic function of cloudburst roads is to discharge water. Cloudburst roads are established by re-profiling the road, making changes to terrain or raising the kerb. In principle, no green elements are incorporated in a cloudburst road.**




**The principal hydraulic function of retention roads is to retain and store water. This is done by integrating various retention elements into the road – roadside beds, rain beds and similar features. There will often be good opportunities to incorporate urban space improvements, for example in the form of green and blue elements.**




**The principal hydraulic function of retention spaces is to retain and store water by creating basin volumes. The retention spaces can be advantageously designed as multifunctional urban space elements, which in everyday conditions function for example as sunk parking areas, squares, sports fields, or similar.**




**The hydraulic function of green roads is to remove and retain the water locally, typically on smaller roads, for example private shared roads.**


BO CH

CHAPTER 2

# THE INVESTMENT STATEMENT

**The Technical and Environmental Administration, together with the Finance Administration, has prepared a statement on the economics of the cloudburst management of Copenhagen.**

This statement answers the following questions:

1. Can cloudburst management for Copenhagen pay for itself?
2. What does it cost to build the new combined cloudburst and stormwater system in Copenhagen?
3. What does it cost to operate the cloudburst management facilities once they are ready?
4. How is expenditure on the cloudburst management system to be shared between the municipality, the utility company HOFOR and private landowners?
5. What will the financial impact of cloudburst management be in terms of loans, etc.?
6. How will the economics of the cloudburst management projects be controlled in the future?
7. What will the returns on the investments in cloudburst management be in the form of other gains?

# INTRODUCTION

**The entire economics of the solution is based on a level of service adopted in conjunction with the cloudburst management plan. It was decided that the city should be protected to a level so that Copenhagen at most experiences damaging floods in torrential rain of a magnitude which statistically occurs only once every 100 years.**

In the past 6 years, Copenhagen has experienced five major rainfall events, the most powerful of which, in 2011, led to damage in excess of DKK 6 billion. This figure does not include direct costs of improvements to municipal infrastructure and indirect effects, for example on the property market through rising insurance premiums, or businesses deciding to locate outside the City of Copenhagen.

The assessment of the overall economics is to be viewed in this light, as the risk in doing nothing is estimated at around DKK 16 billion in costs of damage over 100 years in the climate adaptation plan.

The IPCC's Fifth Assessment Report on the trend in the global climate was published in Copenhagen in October 2014. The risk of heavier and more frequent downpours will increase over the years in Copenhagen. This forecast for climate trend is in agreement with the observations made in Denmark in recent years with more and heavier cloudbursts, where the trend appears even to be ahead of the IPCC's forecasts.

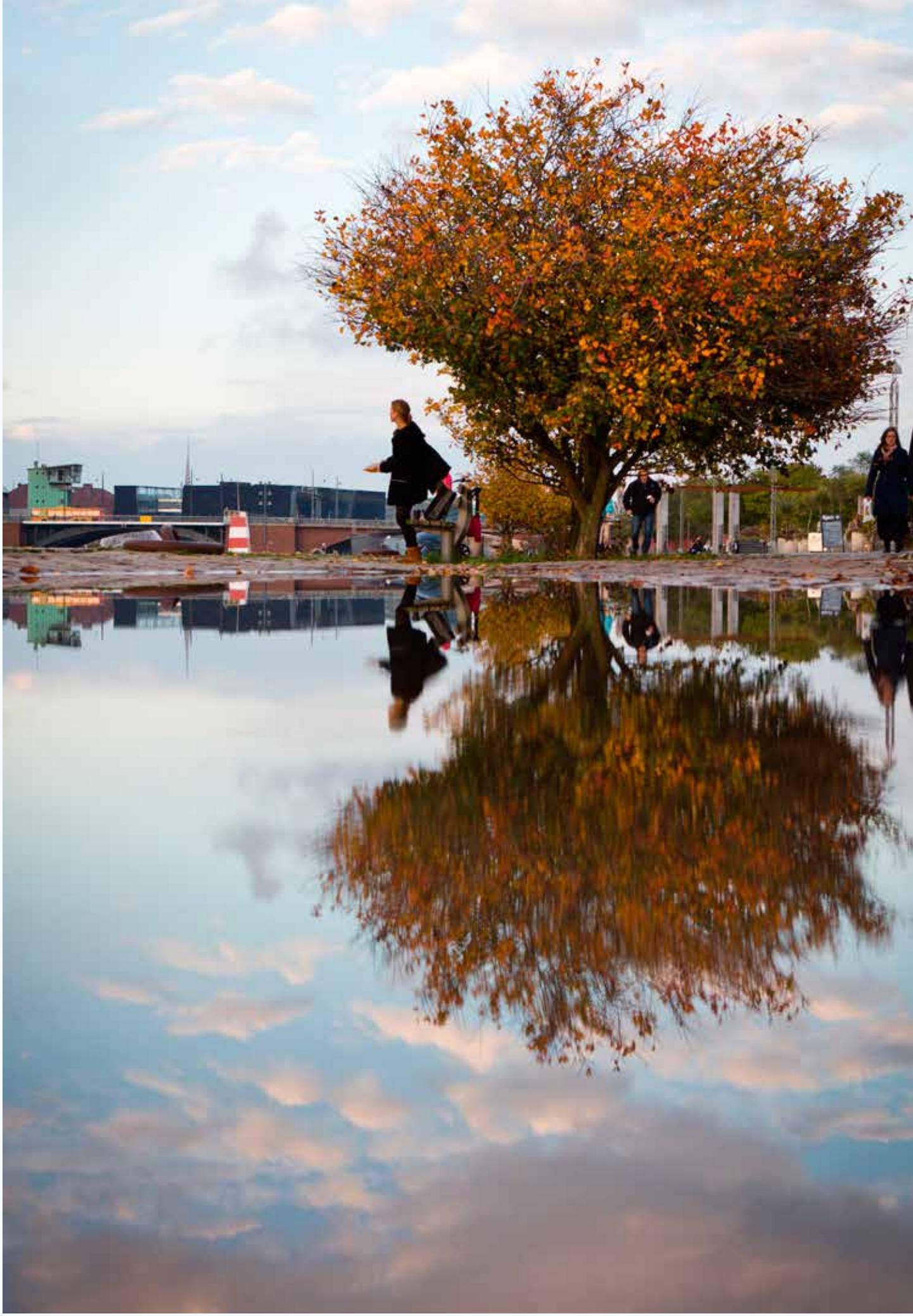
Based on the IPCC assessments and the extreme rainfall events in recent years, consideration should be given to whether the data and conclusions from the Copenhagen climate adaptation plan from 2011 need to be revised.
It thus appears unlikely that the total level of damage (without taking action) as a result of extreme rainfall events will end up at DKK 16 billion over the next 100 years, which is the estimate made in the 2011 climate adaptation plan. Up to DKK 9 billion of this sum has already been "used up" in the recent major rainfall events.

The Technical and Environmental Administration is undertaking a revision of the climate adaptation plan in 2016 based on the IPCC's Fifth Assessment Report and climate events in recent years. This revision will include a reassessment of the extent of damage and what significance the timeframe for implementation of the climate adaptation plan has for damage in the city.

Precisely because of the uncertainty over the size of future extreme rainfall events, combined pipe and surface solutions, which are far more flexible than pure pipe solutions, are adopted in the proposals for cloudburst management projects.

The established level of service means that private individuals in the worst-case scenario will have to tolerate 10 cm of standing water at the boundary between publicly accessible and private land.

Cloudburst roads are not covered by the general level of service. This means that private individuals on some sections of the road are at risk of there being more than 10 cm of standing water on land on average. On cloudburst roads the level of service is replaced by a principle that implementation of a cloudburst management element must not result in an increased risk of damage to private property.



# CAN IT PAY FOR ITSELF?

**A socio-economic assessment has been carried out to analyse whether cloudburst and stormwater management can pay off for society as a whole. The socio-economic analysis describes what the cloudburst management of Copenhagen costs society.**

The socio-economic assessment consists of:

- An assessment of the risk of flooding in the event of more rain and torrential downpours as well as the costs of damage it can cause over the next 100 years if we do nothing ("business as usual").
- A calculation of construction and operating costs in the traditional solution (sewers) and the combined alternative solution.
- A comparison of the costs in the two solutions and the gains in reducing damage in the city in relation to "business as usual" (cost-benefit analysis). This calculation provides an answer to the question as to whether the solutions are advantageous in relation to doing nothing ("business as usual").
- A comparison of the traditional solution and the alternative solution in relation to the specified service objectives (cost-effectiveness analysis), which provides an answer to the question as to what solution is most advantageous if there is a wish to meet the municipality's service objectives

Both the traditional sewer solution and the alternative solution meet the municipality's service objectives concerning stormwater and cloudbursts.

The result of the socio-economic assessment for the whole of Copenhagen is described in the table below. The Municipality of Frederiksberg and the surrounding municipalities are not included in the assessment.

### SOCIO-ECONOMIC ASSESSMENT OF COSTS AND GAINS IN CLIMATE ADAPTATION IN COPENHAGEN (DKK BILLION)

| STORMWATER | TRADITIONAL SEWER SOLUTION | ALTERNATIVE SOLUTION (CALCULATION METHOD OF CLIMATE ADAPTATION PLAN) | ALTERNATIVE SOLUTION (MINISTRY OF FINANCE METHOD OF CALCULATION) |
|---|---|---|---|
| **COSTS OF DAMAGE WITHOUT ACTION** | **16** | **16** | **18** |
| **COSTS IF ACTION IS TAKEN** | **20** | **13** | **12** |
| **REDUCTION IN COSTS OF DAMAGE** | **16** | **16** | **17** |
| **NET GAIN** | **-4** | **3** | **5** |


The table has been calculated at market prices. A net charge factor of 17% and a tax distortion loss of 20% have been added to the estimated construction costs, cf. previous analyses of the climate adaptation and cloudburst management plans. The solutions are implemented gradually over 20 years, and 1% is added per year in operating costs for the surface solutions and 0.5% per year for other solutions. Private disconnection and connection as far as the property boundary is, however, set for implementation over 70 years. Figures in the first two columns are discounted by 3%. The right-hand column indicates the results for the surface solution if, instead of 3%, the Finance Ministry's guidelines from 2013 are applied with regard to a falling discount rate. The economics in the table excludes costs and gains in the establishment of urban spaces.

The assessment shows that under current circumstances we can expect a total surplus of DKK 3 billion in the surface solution in Copenhagen in relation to a situation in which the municipality does nothing. In comparison with the alternative solution with the traditional sewer solution, the surplus is approximately DKK 7 billion.

The damage in climate change related to stormwater and torrential downpours is calculated at DKK 16 billion over a period of 100 years. This damage was first calculated in 2010 in connection with the climate adaptation plan, and is based on a cautious estimate of the IPCC's possible scenarios for future climate change.

To illustrate the uncertainties in the economic assessment, a supplementary calculation has been made of the alternative based on the Finance Ministry's guidelines from 2013 concerning socio-economic discounting. The calculation shows that the total damage rises from DKK 16 billion to DKK 18 billion over 100 years, and that the net gain also rises from DKK 3 billion to DKK 5 billion. This result is due in particular to the Ministry of Finance's discounting attributing greater weight to reductions in damage further into the future.

This means that it is also makes good socio-economic sense to establish the alternative solution with the Ministry of Finance's discount rate.

# CONSTRUCTION ESTIMATES

**The economic analysis of construction is calculated in relation to what it will cost to establish an installation for cloudburst and stormwater management in Copenhagen if it were to be built tomorrow. The overall economics of construction thus differs from the socio-economic analysis, which calculates the costs over a longer period.**

## CONTRUCTION ESTIMATES FOR ALTERNATIVE SOLUTION AT 2015 PRICES (DKK MILLION)

| CONSTRUCTION | CONSTRUCTION COSTS | FINANCING |
|---|---|---|
| **SURFACE SOLUTIONS** | **4,975** | Costs of municipal and private co-financing projects are reimbursed through water charges |
| **CLOUDBURST PIPES** | **2,600** | Water charges (HOFOR) |
| **DISCONNECTION AND CONNECTION OUTSIDE PROPERTY BOUNDARY** | **1,010** | Water charges (HOFOR) |
| **PROTECTION OF HOMES WITH ANTI-FLOOD BACKWATER VALVES AND DISCONNECTION WITHIN PROPERTY BOUNDARY** | **2,420** | Landowner |
| **TOTAL** | **11,005** | |
| **OPTION OF URBAN SPACE IMPROVEMENTS** | **1,000** | City of Copenhagen |


The construction estimate has been calculated at 2015 prices and contains 20% for project planning and 20% for unforeseen expenses. The estimate does not contain depreciation and operating costs. An example of this anti-flood backflow valves, which do not have the same service life as sewer pipes, for example, and therefore have to be replaced several times over a 100-year period. The total private investment under the item of "anti-flood backflow valves etc." will therefore be greater than stated over 100-year period. The service life of the units is, however, expected to increase and prices to fall in the near future. The Private column includes municipally owned properties.

The construction estimate of DKK 11 billion has been calculated at 2015 prices and comprises the combined costs to be paid by the City of Copenhagen, HOFOR and private individuals.

The utility companies Frederiksberg Forsyning and Nordvand are part of the solution in Copenhagen, because cloudburst management in the municipalities of Frederiksberg, Gladsaxe and Gentofte is dependent on the Copenhagen solution. If the utility contributions of Frederiksberg and Nordvand totalling DKK 0.9 billion are added to the solution, the construction estimate becomes DKK 12 billion.

The estimates are based on calculations performed in the climate adaptation plan, the detailing of cloudburst management plan and HOFOR's construction estimate.

In addition, there is expenditure on urban space improvements. The economics of this depends on the quality of urban space improvement chosen by the politicians.

# FINANCING AND DISTRIBUTION OF EXPENDITURE

**The combined alternative cloudburst and stormwater management solution in Copenhagen will cost a total of DKK 11 billion. The part of the solution concerned with management of water (hydraulic function) can be financed through the water charges, while the funds for urban space improvements have to found continuously through the municipal budget. The combined solution additionally necessitates private individuals investing in anti-flood backflow valves and local removal of rainwater.**

## GENERAL WASTEWATER MEASURES

HOFOR finances all the tunnel and sewer solutions, including the cost of conveying disconnected water from the property boundary to the cloudburst management system through the wastewater charges.

## THE CO-FINANCING MODEL

HOFOR can finance joint cloudburst management measures with the municipality and private individuals. The measures are concerned with solutions for the management of stormwater on the surface.

HOFOR can finance joint cloudburst management measures in full up to 2015. The municipality specifically finances the construction expenditure by taking a building loan, which at the end of the construction project is converted to an annuity loan. HOFOR then finances the project over 25 years to repay the municipality's instalments and interest on the loan set up for the project.

Co-financing projects on private land (in principle) are based solely on a contractual relationship between HOFOR and the owners of the land. The owners of the land are project owners and themselves attend to and finance (provide loans for) development, construction and subsequent maintenance of the project, with 100% reimbursement by HOFOR. If HOFOR and the owners enter into an agreement after 2015, up to 75% reimbursement will be made.

## INVESTMENTS ON PRIVATE LAND

As well as measures taken on private shared roads, the private initiatives encompass protection of properties against flooding from sewers in areas with joint sewerage during torrential rains. This can be done by installing anti-flood backflow valves on the private service pipe, protecting basements against penetration of water through basement wells, basement steps, etc.

In addition, the sewer has to be future-proofed by disconnecting roof water, as an integral part of the cloudburst management of the city. The Technical and Environmental Administration, in cooperation with HOFOR, has drawn up a strategy for this future-proofing of the sewers. The separation strategy will involve expenditure for a number of properties and is included under private investments, "disconnection and connection within property boundary (private)" under the construction estimate. To attain the target in the climate adaptation plan of disconnecting 30% of stormwater from the sewers and cloudburst-proofing the city, the areas in Indre By/Christianshavn and the Vesterbro, Nørrebro and Østerbro neighbourhoods are deemed to be the areas where disconnection will be most relevant and have the greatest effect.

The weather of the future will bring more and heavier rains. A greater volume of rain means that the sewer system will become too small as time passes. Other municipalities have

judged the best way of responding to the increased volume of rain to be installing new and larger pipes. This is seen typically in municipalities in which the sewers are in a poor state of repair and which were responsible for replacement. The situation in Copenhagen is different. The sewers are maintained and in good condition. Replacing the sewers would cost DKK 20 billion. In view of this, it is planned that the function of the sewers will be future-proofed by disconnecting stormwater from an area corresponding to the increase in the volume of water. In this way, the status quo is preserved for the sewers despite the volume of rain increasing.

In conjunction with the preparation of the climate adaptation plan, socio-economic analyses were made of whether cloudburst management of the city is a sound investment. They showed that if future-proofing of the sewers is carried out at the same time as cloudburst management, by disconnecting roof water to manage the greater volume of everyday rain, there is a positive business case. Disconnection from the sewers is therefore planned as an integral part of the cloudburst management of Copenhagen.

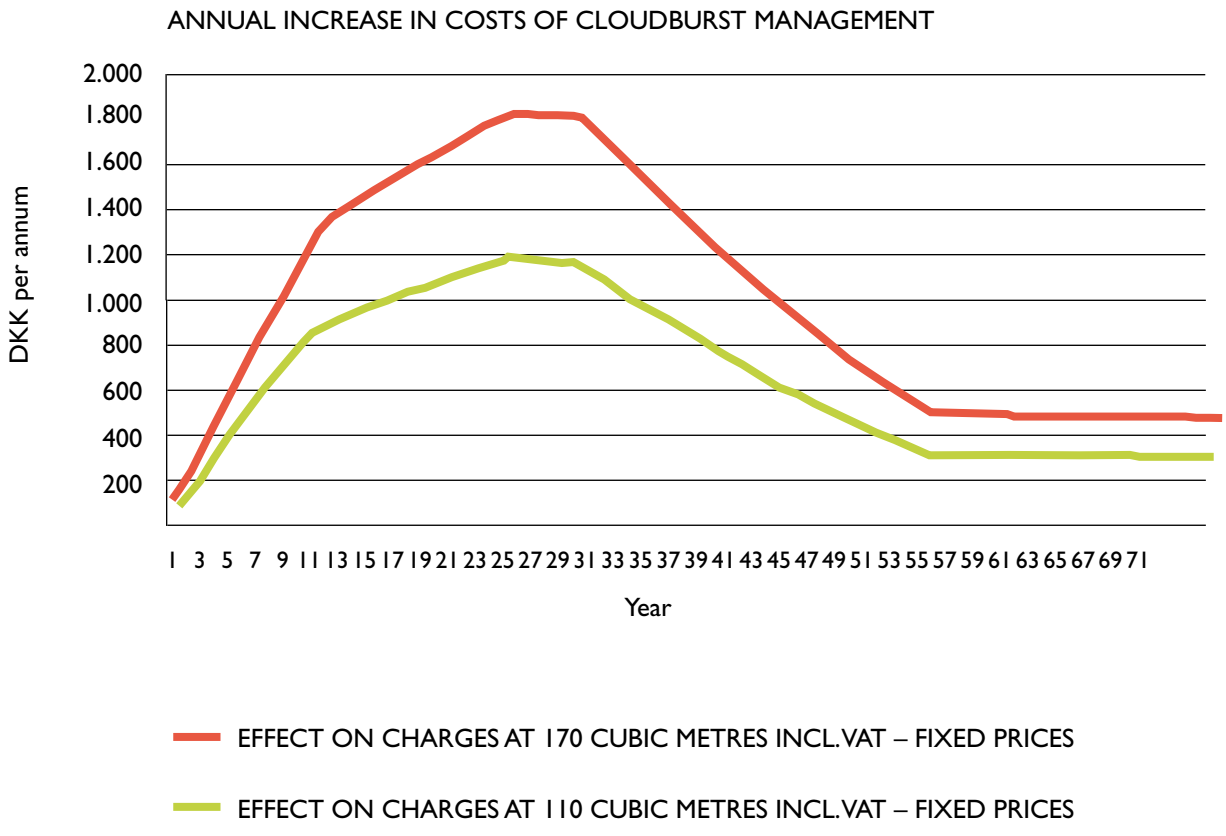
## URBAN SPACE IMPROVEMENTS

The costs of urban space improvements are paid by the municipality. Urban space improvements are set at around DKK 1 billion throughout the implementation period, depending on the level of ambition. This estimate is based on a lower price per square metre than is normally applied in calculating expenditure on urban spaces in Copenhagen. This is due to the fact that a large amount of construction expenditure, which is normally associated with the establishment of green facilities, is paid by HOFOR in connection with the construction of the fundamental hydraulic function of the areas.

# IMPACT ON WATER CHARGES

Annual water consumption of 110 m3 (apartment) means that the water charges will rise by an average of DKK 890 per annum. Consumption of 170 m3 (house) will mean an increase in charges averaging DKK 1375 per annum over a period of 75 years. The operating costs are included in the impact on charges.

It should be noted that this increase in charges varies depending on the rate of expansion with selection of projects and other possible savings under way in implementation. The impact on charges does not take account of the projected rise in population in the City of Copenhagen. An estimate of the trend in rates over time is presented below.



# OPERATION OF THE SOLUTIONS

The socio-economic assessment includes the operating costs associated with it being possible for the hydraulic functionality of the solutions to be maintained. Operation has to help ensure that rainwater is managed optimally.

To ensure the capacity of surfaces to convey the water, expenditure is required to keep the critical points clean. These are the places where it is vital, in a situation of torrential rain, that the water is able to run freely, without being obstructed by waste, fallen leaves, etc. In the season of cloudbursts, these places, as part of everyday operation, have to be inspected and if necessary cleaned up at intervals depending on the importance of the place in connection with drainage. Expenditure on this everyday operation is estimated at 0.30% per annum of the construction cost.

In addition, there will be operation of roadside beds, and after an extreme rainfall event it will be necessary to clean up surfaces and make them hygienic. Depending on the nature of the installation and the size of the event, this will be done by flushing, replacing topsoil, repairing and cleaning equipment, and so on. This expenditure is estimated at 0.60% per annum of the construction sum.

There is a special problem in the regular road maintenance work, where new asphalt is laid on top of old. This increases the height of the road and its capacity to drain in torrential downpours is reduced. A share of 0.1% of the construction cost is therefore to be set aside for cutting before laying new asphalt.

Operating costs are estimated to total 1% of the construction cost.

According to the co-financing scheme, it is possible to have the described operation and supervision of the projects billed to HOFOR based on actual consumption. The estimate relates to all surface projects, hence both municipal projects and on private roads. The assessment is necessary in consideration of the combined application to the Secretariat for Water Supplies, but the municipality solely deals with operation of the municipal roads.

Operation of the tunnel solutions and other solutions is set at 0.5% per annum.

The calculated operating expenditure in the socio-economic assessment does not include operation of the urban space improvements that might be chosen by political decision-making in the municipality.

There are associated operating costs for all the cloudburst management projects, but they vary among the different categories of construction. The operating costs of the tunnel solutions, for example, are among the lowest. Different costs of operation may be expected among surface solutions. Cloudburst roads do not have much green, which will be reflected in operation. The other types of surface solutions will have a higher level of operation. There is experience today with operating expenses relating to tunnels, whereas there is less experience in the operation of surface solutions. Experience with the extent of operation of surface solutions will thus have to be expanded over the course of time to provide a more precise picture of the task.

As well as the operation that can be billed to HOFOR, there is operation of the other solutions: anti-flood backflow valves, private disconnection and HOFOR's disconnection, which is set at 0.5% per annum of the construction cost. This operation is included in the socio-economic assessment, although the cost cannot be passed on.

## BUILD-UP OF EXPERIENCE IN THE OPERATION OF CLOUDBURST SOLUTIONS

The City of Copenhagen has already acquired its first cloudburst-managed spaces with the climate resilient neighbourhood Østerbro, Tåsinge Plads. Several projects are on the way, for example Sankt Annæ Plads in 2016, and a further 16 projects adopted in the spring of 2015. This means that within a few years the municipality will be able to build up

a bank of experience in the operation of cloudburst management projects.

There is cooperation among several municipalities, such as 'Water in Cities', tools have been developed to register the expenditure incurred in the construction and operation of facilities with local removal of rainwater (LAR). LAR facilities vary with conditions such as density of the built environment, soil types, topography, existing sewerage, municipal service requirements and requirements for protection of receiving bodies of water, but in comparison with others, it will be possible for the basis of operation for the hydraulic solutions to be strengthened. It will also be possible for there to be different operating needs within the municipality, because the use profile for a type of facility can vary depending on where the facility is located.

The cloudburst management solutions will, in some cases, require new responses for example to the selection of plants, treatment and storage of water, which are not currently included in the urban spaces of Copenhagen. When experience in operating the solutions has been gathered over a number of years, there will be better prospects of targeting efforts. This also means that there is uncertainty associated with the assessment of the operation that is undertaken.

Indirect operating expenses can be included in the calculation if they are a consequence of a project. An example of extra costs may be special needs for salting as a result of percolation facilities on roads. The level of this expenditure is not yet known, as no particular decision has been made on salting in the individual projects.

The Administration will work on the following measures to ensure the best possible management of operation for solutions owned by the municipality:

- Testing of specific models for operation and cleaning. End of 2015. Evaluation at the beginning of 2018
- Annual gathering of experience from operation for other relevant units in the administration, for example those responsible for project management and tendering
- Designation of projects that are closely followed with expanded monitoring, for example because operation of the project is suitable for setting a precedent

## SPECIAL COMMENTS ON ASPHALT AND OPERATION

In a normal operating situation of asphalt surfacing, several layers of asphalt on top of each other are permitted. In many places in Copenhagen there is up to ten centimetres of wearing course which means that it is only necessary to cut every fourth time new asphalt is laid.

Establishing a critical level, which is to ensure that the water can run along or on a road, influences the normal operating situation and consequently gives rise to increased operating costs due to the asphalt wearing courses having to be cut off more often.

The indirect operating costs depending on what considerations are made during project planning of a cloudburst road, for example. The cloudburst road may, for example, be constructed deeper than the critical level, resulting in an increase in operating costs. This means that if the cloudburst road is built ten centimetres below the critical level, it will be possible to maintain a normal operating situation for the asphalt surfacing and consequently not bring about increased operating costs. Caution must be exercised for example in relation to roadside beds, so that cutting does not impair the load-bearing capacity, etc. of the road.

# WHAT DOES THE CITY GET BACK?

**There are a number of potential gains from investments in the alternative solution for cloudburst and stormwater management.**

## MAINTENANCE OF INSURANCE

The citizens and the businesses pay to safeguard their property through a combination of climate adaptation measures and insurance. These are investments that can prevent damage to homes and belongings and businesses. But the measures taken may, at the same time, contribute to more stable frameworks being created for the Copenhagen property market, which comprises 300,000 homes and 355,000 jobs.

The property market may respond negatively to the uncertainty associated with changes to the climate and lack of timely, well-coordinated efforts to prevent damage. It is therefore not possible to rule out the possibility of the housing market in the city being adversely affected if cloudburst management measures are not implemented, resulting in a rise in insurance premiums.

The insurance industry emphasises that the insurance companies focus on the risk of damage and the actual history of risk (how many claims have been made for the individual property). This risk is affected, for example, by inadequate sewerage and climate change. The response of the insurance companies to an increased risk of claims will typically be to raise prices and/or make policy terms more stringent. For some properties, the risk of large claims will be so high that it is not possible to insure them. In addition, contact with sewage may be harmful to health, which for businesses may mean large operating losses.

The Municipality of Greve offers a good example of it paying to protect oneself against torrential downpours. After the torrential downpour in 2007, there were cases in which insurance premiums rose by 20%. Since the areas concerned have been the subject of cloudburst management measures, it has been possible to bring premiums back to their original level.

Insurance terms for municipal properties in the City of Copenhagen worsened substantially after the torrential rain on 2 July 2011. Before this event took place, there was an insurance excess for the municipal properties of DKK 25 million in claims per year and an excess per claim of DKK 100,000. It has not been possible to obtain the same insurance solution since the torrential downpour, and the level of premiums has risen substantially. The municipality consequently now has an excess of DKK 50 million for torrential downpours.

Similar changes are being seen for a number of private insurance policy holders in areas at risk.

Implementation of the measures in the climate change adaptation plan dramatically reduces the risk of damage to buildings etc. during heavy rain. As a result, the insurance industry also achieves a corresponding reduction in risk of claim payouts in connection with extreme rainfall events. However, it is also significant for the insurance companies whether actual claims expenditure falls.

There is therefore a link between climate adaptation of the city and the part of an insurance premium for properties which relates to insurance against damage caused by heavy rains. The logical conclusion is that citizens do not have to pay both through the measures taken by the municipality and HOFOR and through rising insurance premiums as a result of the rising risk of stormwater damage.

The insurance companies will study the trend in claims very closely in the future. On this basis, the public can look forward to widely differing insurance premiums. It will generally be the case that when the risk declines it will affect insurance premium prices and terms.

The City of Copenhagen together with HOFOR has formed a partnership to inform landowners about the opportunities for co-financing measures on private land and what specific solutions on private land can prevent damage from torrential downpours.

The City of Copenhagen and Forsikring & Pension will, in addition, continue to work on ensuring that the municipality's cloudburst management effort is continuously included in the risk scenario considered by the insurance industry.

## COOPERATION REDUCES EXPENDITURE

If the implementation of cloudburst and stormwater management is coordinated with other construction projects in the city, up to DKK 1 billion can be saved over the whole implementation period. The potential for coordinated thinking has been identified on the basis of an analysis of the opportunities for cooperation between HOFOR, DONG and the other construction projects of CPH City & Port Development and the City of Copenhagen. The estimate is, however, subject to uncertainty.

At the same time, well-executed coordination can reduce the risk of congestion on the roads, but no amount has been set for this item. There is a need for greater coordination of construction activities in the municipality of the City of Copenhagen and in the rest of the city. The gains from repetition projects can also contribute to reducing the risk and costs when the 300 projects have to be detailed.

## LESS NEED FOR INVESTMENTS IN TREATMENT PLANTS

It is expected that disconnection will reduce the need for investment in expanding treatment capacity, and consequently deliver a gain for the combined business case.

## RISES IN PROPERTY VALUES

The detailed descriptions of the cloudburst management plan mention the possibility of making urban space improvements, to be paid for by the municipality. They may help in reducing the heat-island effect, strengthening biodiversity, future-proofing planting schemes, and creating create space for physical activity and well-being. But urban space improvements can also add to the value of properties nearby.

It is currently estimated that, depending on the level of ambition, it may cost DKK 1 billion over 20 years to establish urban space improvements with recreational value. A rise in property prices in Copenhagen of just under DKK 1.4 billion is expected as a result of the establishment of the new urban spaces. The upgrading of urban spaces can also increase revenue from property tax due to a significant increase in the value of those properties that are adjacent to the parks. Over 100 years, this extra revenue will amount to a value in present-day prices of DKK 1 billion. However, the equalisation system at present is structured in such a way that 66% of property tax revenue in Copenhagen is included in the equalisation, and consequently goes to other municipalities.

## INCREASED EMPLOYMENT

The construction works relating to cloudburst and stormwater management for Copenhagen will result in jobs and tax revenue being created in the construction phase.
Combined employment of more than 13,000 full-time equivalents and DKK 1.6 billion in tax revenue are created in the construction period. It must be said, however, that the tax revenue from increased employment in the building and construction industry at all times accrues to the municipality in which the employee is resident. For that reason it has not been possible to calculate the effect in the City of Copenhagen alone. If the construction of urban spaces is included in the calculation, the number of full-time equivalents will rise to more than 15,000, and tax revenue to around DKK 2 billion.

## DEMAND FOR NEW SOLUTIONS

It can generally be expected that innovation will take place within climate change adaptation technologies and the frameworks for climate change adaptation. This innovation will lead to more effective technologies and more effective implementation, which will lead to savings in costs.

Technological innovation may, for example, be warning technologies with better radar, monitoring of more conditions around the city and integrated solutions. The gain in product development is expected to become apparent within a few years, for example with anti-flood backflow valves, which are becoming substantially cheaper and last longer.
Innovation can also be created by changing the framework conditions in the area of climate adaptation. This happens, for example, when authority requirements for the treatment of water or architectural considerations for urban spaces challenge the solutions from the outset.

Finally, as the Productivity Commission points out in its working report from 2014, it is possible to obtain innovative gains by changing tendering procedures to focus to a greater extent on the function desired for the facility concerned. Too many requirements can lower the number of tenders submitted and the degree of innovation. A focus on repeating projects is considered to meet some of the criticism expressed by the Productivity Commission on the effectiveness of construction projects.

The Danish clean-tech cluster 'Clean' has pointed out that the enterprises specifically involved in the processes and solution of the tasks for which tenders are invited achieve

great competitive benefits. Specific opportunities are created for partnerships in connection with task solution, for example between larger enterprises, knowledge institutions and small and medium-sized enterprises. These partnerships may lead to the partners picking up similar assignments in other cities, including cities abroad. The experience form Copenhagen may thus led to increased export shares for Danish enterprises.

The climate change adaptation statement which the Technical and Environmental Administration has to deliver annually to the Technical and Environmental Committee will present innovation which is significant for the solutions, and the specific significance of this for the roll-out of the investments among both private and public-sector operators.

# CONSEQUENCES FOR MUNICIPAL ECONOMICS

**The investments in the alternative solution have the following indirect consequences in terms of municipal economics.**

The cloudburst and climate adaptation solutions have a number of effects on municipal economics, in addition to the direct impact of cloudburst and climate adaptations in the form of increased wastewater charges, which the municipality as well as enterprises and citizens have to pay.

## ROAD DRAINAGE CONTRIBUTION

The road drainage contribution is a percentage of the annual investments of HOFOR Spildevand København, which the municipality has to pay to HOFOR. The municipality has set the rate at 4%, but the Secretariat for Water Supplies sets the rate every year at 8%. Following a ruling by the Eastern Division of the High Court, the Secretariat for Water Supplies has withdrawn its old rulings, but the case has been appealed to the Supreme Court and has therefore not yet been finally settled. In the assessment of the significance of the road drainage contribution for municipal economics below, the effect on municipal economics is calculated with a road drainage contribution rate of both 4% and 8%.

The annual investments in sewers and cloudburst and climate change mitigation are not fixed, and nothing precise can therefore be said at present regarding the annual carriageway drainage contribution.

The investments in canals and tunnels in the construction cost estimate, DKK 2,600 million, and in connections DKK 1,010 million, will result in carriageway drainage contributions of the order of DKK 144 million at 4% and DKK 289 million at 8% (2015 P/L). The carriageway drainage contribution is included in the budget of the Technical and Environmental Committee. The carriageway drainage contribution is included in the operating/service budget of the Technical and Environmental Committee, and target figures therefore have to be set for the increased expenditure in the municipality's budgets.

As HOFOR is regulated by price caps, the increased expenditure from the carriageway drainage contribution will have the effect that the charges have to be set lower.

## INCREASED BORROWING LIMIT FOR HOFOR

HOFOR has to carry out, and pay the costs of, canals, tunnels and connections for an estimated sum of DKK 3,610 million (DKK 2,600 million + DKK 1,010 million, see table of construction cost estimate page 36)). It is expected that the City of Copenhagen will guarantee HOFOR's loans for cloudburst and climate adaptation solutions. This will have the effect that the municipality's guarantees for HOFOR Spildevand København A/S have to be increased by DKK 3,610 million as a result of investments in cloudburst management and climate adaptation.

HOFOR Spildevand København A/S pays a guarantee commission of 0.3% for the loans guaranteed by the City of Copenhagen. The revenue from the guarantee commission depends on when and to what extent HOFOR makes use of the guarantee limit. The revenue is included in the municipality's budget.

## COPENHAGEN AS LANDOWNER

Properties in the City of Copenhagen are included in the private investments in the diagram relating to the construction cost estimate. This means that the City of Copenhagen, primarily the property unit Københavns Ejendomme, has to pay the costs of anti-flood backflow valves, climate-proofing of basement steps and basement wells and forced disconnection of municipal buildings.

## CO-FINANCING PROJECTS

The surface solutions in cloudburst and climate change adaptation to more everyday rain are expected to cost DKK 4,975 million in construction costs. It is expected that surface solutions will have to be funded as co-financing projects. The City of Copenhagen is expected to have to construct and own around two-thirds of the co-financing projects, equivalent to around DKK 3,284 million. HOFOR reimburses the municipality's costs in interest and instalments on the municipality's loans for the co-financing projects. The remaining approximately DKK 1,642 million relates to co-financing projects between HOFOR and private operators. HOFOR can only reimburse the costs of private operators in part by mutual agreement, and the maximum reimbursement after 2015 will be 75% of the co-financing project.

The City of Copenhagen may, in certain cases, be obliged to take over private roads in order to ensure that essential climate change management measures are implemented. Taking over private roads will have the effect that the municipality has to set aside a budget for future maintenance of the road.

The municipality's borrowing will therefore be increased by DKK 3,284 million. As there is an automatic borrowing limit for the co-financing projects, the total borrowing limit of the municipality will not be adversely affected.

The City of Copenhagen as owner of the surface facilities will also have to attend to operation and maintenance of these. The portion of operating and maintenance costs attributable to the cloudburst and climate adaptation function can be reimbursed by HOFOR.

The municipality's operating/maintenance framework is a net framework. HOFOR reimburses relevant and verifiable operating and maintenance costs of cloudburst and climate adaptation measures. This means that the municipality's operating/service framework is not affected.

# FINANCIAL CONTROL

**With a construction project in this phase, uncertainty is to be added and future financial control is established.**

With its application to the Secretariat for Water Supplies, the City of Copenhagen has a large number of cloudburst management projects to be rolled out over two decades. No similar number of projects of that calibre has previously been carried out in Copenhagen. After a few years there is a need to evaluate the cloudburst management projects and the financial control of the projects, including deviations that will arise from the amounts applied for to the Secretariat for Water Supplies. It must be emphasised that the combined level of expenditure continues to be subject to substantial uncertainty, primarily due to there being very limited experience of construction in this area. The annex to this statement describes the economics of the application to the Secretariat for Water Supplies and uncertainties in the combined level of expenditure and points to an evaluation after 2 – 3 years and after 5 years. There are also uncertainties associated with the operating expenditure, which are discussed in the section on the socio-economic assessment on page 21. There is provision for adjusting economics in water catchment areas and sub-projects. The application to the Secretariat for Water Supplies describes the cloudburst management solutions in the catchment area as a combined project with its own independent economics. The cloudburst management projects in the catchment area are sub-projects each with their own budget. As the catchment area is regarded in the application as a combined project, a levelling-out of prices in the sub-projects can occur. If the combined catchment area becomes more expensive, the application has to be adjusted, and the adjustment in principle has to be approved by the Secretariat for Water Supplies. It will continue to take place at 100% co-financing, as there is an adjustment of the application based on hydraulics and the same solutions.

The economics may thus change between sub-projects within the catchment area and for the combined catchment area. All the sub-projects are drawn up on a rule-of-thumb basis, such that the surface solutions including reinvestments and operating costs may only account for around 70% of the price of the traditional solution. There are therefore deemed to be good prospects of broadening the framework, if it can be demonstrated that this broadening serves a hydraulic function. As sub-projects are planned and designed, more precise budgeting of the expenditure will take place. When the projects have been carried out and completed, the sub-projects are deducted according to the actual costs incurred, the expenditure being broken down according to which solution typology (cloudburst road, retention basin or retention road) is concerned.

When the actual costs are known and deducted, an annex to the application is prepared which documents the expenditure and a precise budget for the subsequent operation of the cloudburst management project.


| YEARLY FINANCIAL POOL FOR CLOUDBURST MANAGEMENT PROJECTS IN THE CITY OF COPENHAGEN | | | | | | | | | | | | | | Total amount DKK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water catchment areas | | | | | | | | | | | | | |
| | København Vest og Frederiksberg Vest | | Ladegårdsåen | | Nørrebro | | Østerbro | | Bispebjerg, Ryparken og Dyssegård | | Indre By | | Amager og Christianshavn | |
| | Project pool | Remaining amount | Project pool | Remaining amount | Project pool | Remaining amount | Project pool | Remaining amount | Project pool | Remaining amount | Project pool | Remaining amount | Project pool | Remaining amount |
| 2016 | | | | PROJECT PACKAGE 2016 | | | | | | | | | | |
| 2017 | | | | PROJECT PACKAGE 2017 | | | | | | | | | | |
| 2018 | | | | PROJECT PACKAGE 2018 | | | | | | | | | | |
| 2019 | | | | PROJECT PACKAGE 2019 | | | | | | | | | | |
| 2020 | | | | PROJECT PACKAGE 2020 | | | | | | | | | | |

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