Climate change adaptation in Copenhagen
Background on Copenhagen

- 550,000 inhabitants
- 1.5 mio in Greater Copenhagen
- We expect a 20% increase in the next 10-15 years
Climate Change Adaptation in Denmark – how does it work?

- Private landowners – responsible for their own property
- Storm water management – responsibility of local governments
- Storm water management – handling is carried out by the utilities (publicly owned private companies)
- Storm water management paid through water taxes
Copenhagen sewerage system
Harbour and harbour baths

- Industrial harbour abandoned in 70’s and 80’s
- Combined sewer overflows
- Bad water quality
- In 1992 the city decided on a plan to improve water quality
- Trigger – we want to be able to swim in the harbour
Measures in the harbour

- Disposal of waste water from six municipalities according to EU Urban WW Directive
- Protect bathing water according to EU Bathing Water Directive
- Construction of 12 large retention basins, in total 220,000 m³
- Closing of sewer outlets
- Water quality warning system based on modelling of indicator bacteria concentrations
The harbour today

- An urban harbour park
- The center for urban life in the summer
- Increased economic activity
- Soaring house prices
Ørestad

- New city district
- Born adapted
- Separated sewer system (3 string system)
The adaptation plan

• Inspired by cities like New York, London and Rotterdam
• Work started in 2009
• Plan finally approved by City Council in August 2011
Adaptation Plan - contents

- Impact of future weather in Copenhagen
- Risk assessment
- Strategies for action
- Suggestion of first actions
- An estimated implementation period of 30-50 years
- Focus on opportunities of climate change
Climate change impacts

Risk map for flooding caused by rain in 2110

Risk map for storm surges from the sea in 2110
Estimated costs and the probability of damage show that rain water is the most immediate threat.

But in 30 years time the risk of flooding due to rising sea levels will be greater (and the damage higher).

- Long decision making process - complicated financing
- Consequences for urban development
- Therefore we must start planning now
The weather is changing

• The most immediate threat is from rain
• But rising sea levels will increase the risk of storm surges
Cloudburst

Large distribution in rain intensity
Cloudburst over Copenhagen
Cloudburst over Copenhagen

19-03-2015
Cloudburst over Copenhagen
Cloudburst over Copenhagen
July 2011 – the city is vulnerable

- 150 mm rain in 2 hours
- Damages close to 1 billion euro
- Damages to critical infrastructure
The game changer

- High political attention (nationally and local)
- More speed - and to hell with uncertainties
- Change in legislation - new finance mechanisms to enable surface solutions
Emergency outlets

- Water accumulating behind harbor quays and flooding basements
Cloudburst Management Plan

- New service level
- Protection against a 100 year event
- Cost benefit analysis
- Principles of solutions
The cloudburst management plan

- The utility takes care of the water management on public land – and runoff from private that is connected to sewer system
- The city takes care of urban space improvement in connection with adaptation measures – and its own buildings
- Private landowners have to protect their own building and finance measures on private land
Modelling
Data from events

Løvstræde 6

Oversvømmelse i kelder. Vand kom ind via gulvaflejr og eller toilet.
Der er siden opsat høvandsslukke i keldere/floret/toilet.

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ib@sumut.dk

Rutevejledning: Hertil - Hetta
A new infrastructure
Following the natural flow of water
7 water catchments in the city
Different options for each catchment
Types of solutions

- Cloudburst boulevards – transporting water
- Retention boulevards – delaying water
- Central delays – for storing water
Examples of solutions

- Cloudburst boulevard at HC Andersens Boulevard
- Traffic important
- Leads the water to the harbour
Examples of solutions

- Vesterbro – a district with high flood risks
- A low point in the city
- No natural run off for the water
Examples of solutions

- Istedgade as retention boulevard
- Transporting and delaying the water moving to the lower areas of Vesterbro
Example of solutions

- Skt Jørgens sø
- Lowering the water level in the lake
- A new park on the wider banks
- Park can store up to 40,000 m³ of water in case of cloudburst
- A pipe empties the lake – and also collects water from Vesterbro
Implementing the plan

- 300 projects
- Project descriptions
- Political process
- Estimated 20 years of construction
- Annual project packages
Financing adaptation in Denmark

• Sewers and storm water management – traditionally financed through water taxes

• Surface solutions also financed through water taxes – as long as they can be distinguished clearly as storm water management (canals, open basins etc)

• Mixed solutions – with new legislation are owned, constructed and maintained by the city – but paid through water taxes

• Urban space improvement – paid by the city
A good business case

- Robust socio economic figures
- Cheaper than traditional solutions
- Less flooding – less damage
- Lower insurance costs
- Higher house prices
- Total costs 1.3 billion euro
The opportunities of adaptation

- Focus on urban spaces
- Green and blue urban spaces
- We are developing a concept for the integration of water in the urban space
- Green adaptation – using the synergies to create green corridors and hopefully increase biodiversity
- Synergies – saves times and money
Cooperation and co-creation

• HOFOR – Greater Copenhagen Utility
  Close partnership in all aspects

• Citizens
  Will be involved in all the projects.
  Partnerships on private land
  Organisations

• Other municipalities
  Key as water does not respect administrative boundaries

• Local committees and neighbourhood regeneration
  Local anchoring – and local cooperation with local knowledge
The next steps

- Adaptation is the top priority for our Administration
- Political process – right now!
- Prioritizing projects – the first projects
- Setting up the organisation
- Application for financial advancement with the government
Organising the work in the city

- Joint steering group with Greater Copenhagen Utility
- No project organisation – we need to handle this within our current organisational structure
- The Climate unit responsible for the program
  - Selects annual project packages
  - In charge of overall urban space improvement in connection with adaptation
  - In charge of hydraulic coordination in cooperation with our utility
- After political approvalment projects will be handled by our Department for City Construction
  - Programming
  - Construction
- Environmental regulations and construction coordination will be handled by the Department for City in Use
The first water park
And hopefully in a few years time this will be the past.

- But we need to communicate that citizens need to invest in protecting buildings.
- And we need to communicate that it will take time.
Thank you for your attention
Flooding in 2110 – a 100 year event
## Estimated damages

<table>
<thead>
<tr>
<th>Water level</th>
<th>Frequency</th>
<th>Year</th>
<th>Estimated damages in dollars</th>
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<tbody>
<tr>
<td>137 cm</td>
<td>16 years</td>
<td>2010</td>
<td>0</td>
</tr>
<tr>
<td>158 cm</td>
<td>85 years</td>
<td>2010</td>
<td>90 mill</td>
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<td>200 cm</td>
<td>73 years</td>
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<td>300 mill</td>
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<td>226 cm</td>
<td>11 years</td>
<td>2110</td>
<td>900 mill</td>
</tr>
<tr>
<td>255 cm</td>
<td>75 years</td>
<td>2110</td>
<td>1.5 billion</td>
</tr>
<tr>
<td>285 cm</td>
<td>300 years</td>
<td>2110</td>
<td>2.5 billion</td>
</tr>
</tbody>
</table>
Close calls in 2011, 2014, and 2015:

- 2011 – 1.4 meters
- 2014 – 1.68 meters (metro’s floodgates close at 1.7 meters)
- 2015 – 1.3 meters
Estimated damages

- gggg
Possible solutions
Decentral protection
Decentral protection

- **Pros:**
  - Flexible
  - Step by step protection – as the need progresses

- **Cons:**
  - Very expensive
  - Damage to historical and cultural centre of city
  - Can limit the access to water
Central protection

- Establishing central dikes and flood gates at north and south end of the harbour
- Flood gates can close in case of a storm surge
- East coast will need extra protection
Central protection – using the existing features

- Raising the level of the new beach on the east coast
- New harbour areas will be developed with coastal protection as a key feature
Central protection
Central protection

**Pros:**
- Expensive – but cheaper than decentral protection
- Possibility for urban development – recreational features – added benefits

**Cons:**
- Less flexible – unless it is integrated into the design
Coastal protection - challenges

• Water quality – we need to make sure that it is still a high quality in the harbour

• The need to coordinate with surrounding municipalities

• Financing – national legislation is not in place