

COPENHAGEN CLIMATE PROJECTS

ANNUAL REPORT 2016



**CITY MAP OF COPENHAGEN
CLIMATE PROJECTS**



CITY WIDE PROJECTS

ENERGY EFFICIENCY AND SAVINGS: ENERGY PRODUCTION: MOBILITY: CLIMATE ADAPTATION:

2016

PREFACE BY MORTEN KABELL	4
INTRODUCTION: COPENHAGEN DECIDING N EXT STEPS TOWARDS CARBON NEUTRALITY	6
SMART CITY: CASE: STREET LAB – HIGH TECH TESTING RIGHT IN THE CITY	10
ENERGY CONSUMPTION:	
STRONG ALLIANCE PLEDGES ENERGY SAVINGS	12
CASE: A GIANT LEAP FOR ENERGY RETROFITTING	14
CASE: BUILDING THE SUSTAINABLE CITY	16
CASE: THE RIGHT RECIPE FOR SAVING ENERGY	18
CASE: THE MOST CLIMATE FRIENDLY BLOCK IN TOWN	20
ENERGY PRODUCTION:	
COPENHAGEN TAKES BIG STEP FORWARD ON BIOMASS	22
CASE: BIOGAS - FROM THE TOILET TO THE STOVE	24
CASE: OUTSOURCE THE MANAGEMENT OF OUR ENERGY CONSUMPTION	26
MOBILITY:	
CREATING AN IRRESISTIBLE OFFER FOR MOTORIST	28
CASE: SMOOTH CRUISING THROUGH COPENHAGEN'S TRAFFIC	30
CASE: CAN A BICYCLE USE ANOTHER BICYCLE? (HINT: YES)	32
CASE: GOOD ADVICE AND GOOD PRICES ON ELECTRIC CARS	34
CASE: RAPID GHARGING KEEPS ELECTRIC BUSES ON SCHEDULE	36
CLIMATE ADAPTION:	
CLIMATE ADAPTATION EFFORT GETS UNDER WAY	38
CASE: SKT. ANNÆ SQUARE – A BLUEPRINT FOR CLIMATE ADAPTION	40
CASE: CLIMATE ADAPTATION BUILDS COMMUNITY SPIRIT	42
INTERNATIONAL COOPERATION:	
MULTIPLYING THE POSITIVE CLIMATE IMPACT	44
CASE: NEW YORK – USING DATA TO REDUCE EMISSIONS	46
CASE: WASHINGTON – MAKING THE CITY RESILIENT	48
CASE: AMSTERDAM – GETTING SERIOUS ABOUT CIRCULAR	50
CASE: HAMBURG – A “CLIMATE SMART CITY”	52
CASE: STOCKHOLM – THE WALKABLE CAPITAL	54

WE ARE ALL IN IT TOGETHER

Just under nine years. That's all we have left. Nine years to make Copenhagen the first carbon neutral capital in the world. There are of course challenges ahead, but Copenhagen is well on its way – as you can read from this report. And as long as we remember that we are all in this together, the cities of the world are making leaps forward in creating a better and more sustainable future for all of us.

Since we first set our minds on becoming carbon neutral, many cities have joined us in the effort to reduce the impact of cities on our global climate. Not through fancy calculations or quota systems – as there was a tendency to earlier – but by reducing our actual impact. In October 2016 we presented the results of our efforts so far at a two-day conference in Copenhagen. I want to take this opportunity to thank the participants and indeed to thank everyone that has helped us on our way – without your ideas, experiences and sometimes annoyingly obvious questions Copenhagen would not be where it is today.

While conferences may seem secondary to more tangible efforts like converting the energy system to run on renewables, I believe that an emphasis on international cooperation, partnerships and knowledgesharing is crucial. When we want to tackle a global and complex challenge like climate change, going at it alone will just not work.

2016 marked the end of the first planning period for Copenhagen's climate initiatives, and the next set of initiatives to reduce the City's emissions are now well under way. We have reduced carbon emissions with 38 % from our 2005 baseline – and created an 11 % drop between 2014 and 2015. It is what has allowed us to maintain the same amount of heating and reduce energy consumption with 7 % with a city that has grown with 9 % since 2010 – just to name a few examples.

We still have a lot of work to do, but what we have experienced so far is that urban planning with sustainability in mind yields results beyond simply carbon reductions.

It gives us the opportunity to think across different areas and combine efforts in mobility, water resilience and energy consumption. It gives us the opportunity

to increase biodiversity, create recreational value in urban space and quite simply create a better and more liveable city – a city more in balance with itself, with its surroundings and citizens. And to achieve that we need to engage with our city in a higher degree.

In the absence of the necessary national regulation, we are continuously pursuing a strategy of close involvement and collaboration with businesses, industry and knowledge institutions, investors, building owners and of course Copenhageners to develop the best tools to tackle the climate challenge. Ideally this creates a win-win situation for all parties as innovation and new climate solutions create business models and solutions adapted to our city's needs.

We are quite proud of what we have achieved. There is no doubt about that. But we are also fully aware that we wouldn't have gotten far without help – and that we still need all the help we can get. My hope is that you will read the report and that it will stimulate your thoughts. If that happens, if you have an idea, a question or experiences to share, please do share.

We are all in this together and with our efforts combined we will find the best ways to create better solutions for better cities for a better world.

Morten Kabell,
Mayor of Technical and Environmental Affairs





INTRODUCTION

COPENHAGEN PAVING THE WAY FOR CARBON NEUTRALITY

2016 marked the end of the first planning period for Copenhagen's climate initiatives. And the next set of initiatives to reduce Copenhagen's emissions is ready. The results of the previous efforts and the plan for the next four-year period were presented at a two-day fully booked international climate conference in October 2016.

How is Copenhagen doing in its efforts to become the world's first carbonneutral capital by 2025? 350 climate experts from all over the world were gathered in Copenhagen in October 2016, to hear an answer to this question and many more. More importantly, the conference - CPH 2016 Climate Solutions – offered an opportunity for climate experts to inspire each other and debate solutions on how to turn major cities carbon neutral.

While conferences may seem secondary to more tangible efforts like converting the energy system to running on renewables, Copenhagen places a great deal of emphasis on international cooperation, partnerships and knowledge-sharing. The importance of sharing solutions was echoed by the participants. To tackle a global and complex challenge like climate change, doing it alone will just not work.

INTERDISCIPLINARY COOPERATION CRUCIAL

The need for climate cooperation holds true, globally and nationally. In the absence of national regulation, Copenhagen is continuously pursuing a strategy of close involvement and collaboration with businesses, industry and knowledge institutions, investors, building owners and citizens to develop the best tools to tackle the climate challenge. Ideally, this creates a win-win situation for all parties as innovation of new climate solutions creates new business models and thereby growth.

Therefore, Copenhagen's climate efforts actively support the city's business and growth strategy as well as its citizen engagement strategy, Sharing Copenhagen. Therefore, it was only natural that the climate conference was organized in cooperation with the Confederation of Danish Industries. At the conference, the City of Copenhagen presented the results of its climate efforts after the first planning period.

The participants learned that Copenhagen has come a long way towards its goal of carbon neutrality by 2025.

COPENHAGEN MAKING PROGRESS

Most encouraging is the fact that Copenhagen's overall CO₂ emissions have dropped by 38 percent compared with the baseline year of 2005. And a lot of the progress has been made recently as emissions dropped by 11 percent from 2014 to 2015. That means that Copenhagen last year emitted 1.45 million tonnes CO₂, corresponding to 2.5 tonnes CO₂ per capita – one of the lowest per capita emissions for any European capital.

The reduction is also remarkable as this was achieved during a period when Copenhagen experienced a population growth of 16 percent (2005-2015). The impressive results can mainly be attributed to an increased use of biomass in Copenhagen's Combined Heat and Power plants (CHP) and a larger share of energy from wind in the energy system.

But wind and biomass alone will not bring Copenhagen to carbon neutrality.

A ROADMAP TO CARBON NEUTRALITY

The recent evaluation of the progress of Copenhagen's climate initiatives shows that Copenhagen will still emit 286.000 tonnes of CO₂ by 2025, with the currently planned initiatives. Therefore, Copenhagen needs further initiatives in the next implementation period (2017-2020) to achieve carbon neutrality by 2025.

These initiatives are laid out in Copenhagen's Roadmap 2017-2020. The Roadmap proposes new initiatives within the four areas of focus in Copenhagen's 2025 Climate Plan: Energy Production, Energy consumption, Mobility and the City Administration initiatives.



THE CLIMATE CONFERENCE CPH CLIMATE SOLUTIONS IN NUMBERS

A two-day conference including workshops, tours and on-site presentations in the City

- 12 sessions focusing on Climate and Climate adaptation
- 477 persons from 19 different countries
- Participation by sectors:
 - 8 % NGO's
 - 31 % businesses
 - 48 % public institutions
 - 13 % students, experts, universities and citizens.

Copenhagen places a great deal of emphasis on international cooperation, and 350 climate experts from all over the world were gathered in Copenhagen for a two-day conference in October. Photo by Troels Heien, City of Copenhagen.

As you can read in the chapter on energy consumption, Copenhagen will work systematically in the coming implementation period with optimizing operation of heating installations in all buildings in the city. The goal is to have optimized at least half of the installations by 2020.

Furthermore, Copenhagen has high hopes for the unique new partnership called Energy Leap, which you can read about in the same chapter. The partnership consists of major building owners, administrators and housing associations committed to improving energy performance.

80 PERCENT CARBON NEUTRALITY IN DISTRICT HEATING

When it comes to the way Copenhagen gets its energy, the shift to sustainable biomass and energy from wind will still account for a large share of the CO₂ reductions. Construction has already begun on the new biomass unit at the city's major CHP plant, Amagerværket. When the new unit is operational in 2020, 80 percent of Copenhagen's district heating system will be carbon neutral. Copenhagen will also continue to invest in wind power – whether it be large off-shore wind farms or smaller projects on land.

After coal has been completely phased out of Copenhagen's power plants in 2020, the plastic in the city's waste will be

the biggest source of CO₂ emissions in the heat production when the city's waste is incinerated. Copenhagen has already established a sorting system for rigid plastic in apartment buildings and will soon start to establish source separation of the soft plastic components as well. Furthermore, Copenhagen plans to start from 2017 separating organic waste from households and use it for biogas production.

MOBILITY AS A SERVICE

To make more Copenhageners shift from cars to public transportation, the City of Copenhagen intends to make it as easy as possible to move freely across the city. One way of doing this is by offering citizens and visitors alike an easy digital subscription service that allows users to travel freely whether by bus, metro, train, bike-sharing system, car share or taxi. Copenhagen will initially test the concept in a pilot project with 200 participating families and if successful, the initiative will be rolled out across Copenhagen.

Furthermore, Copenhagen intends to accelerate the shift from busses running on fossil fuels to busses running on gas or electricity. Together with the capital region's traffic company, Movia, Copenhagen will add award criteria for alternative fuels in future public tenders for busses.

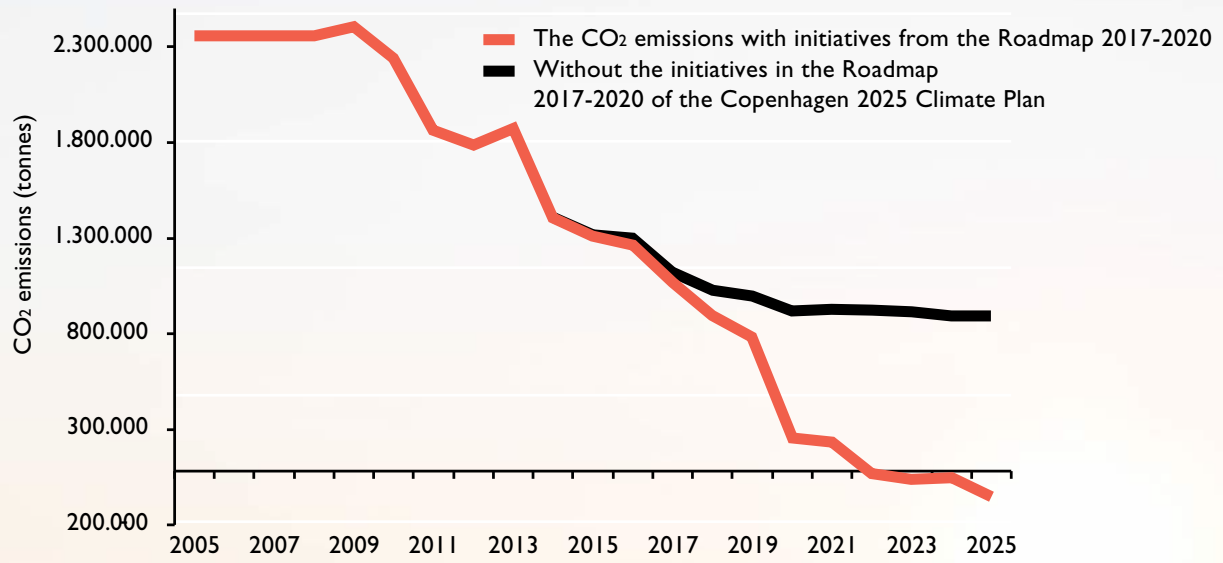
COPENHAGEN'S 2015 CLIMATE PERFORMANCE IN FIGURES

- Copenhagen's carbon emissions in 2015 were 38 percent below the emissions in 2005
- Carbon emissions dropped by 11 percent between 2014 and 2015
- Copenhagen uses approximately the same amount of district heating as in 2010 though the city had 9 percent more citizens in 2015 than in 2010
- Copenhagen's electricity consumption has dropped by 7 percent which is mainly attributed to more energy efficient appliances in the City's households
- In the commercial and services sector, electricity consumption remained stable between 2010 and 2015 even though businesses had longer opening hours
- Since 2010 emissions from the transport sector has been reduced by 9 percent
- At the same time the number of kilometers driven by cars has dropped by 3 percent.

COPENHAGEN'S MAJOR ACHIEVEMENTS IN 2015

- Flagship partnership, Energy Leap, launched with major building owners
- Remote reading of heat meters in the City of Copenhagen's own properties
- Ambitious requirements for new buildings and renovations in Environmental and Civil Engineering (MBA 2016)
- Agreement between Copenhagen and the National Association of Public Housing including the vision of reducing heat consumption in public housing by 30 per cent by 2025
 - Bicycle Bridges in the harbor (Circle Bridge, Tran Grave Bridge, Chandlers Bridge, Belvedere Bridge and Inner Harbor Bridge)
 - Super Bike Trails (third route, "Ishøj", opened in 2016)
- Electric buses (tests) and about 300 buses in 2016 upgraded to the latest environmental standards
- Bike sharing system
- Establishment of the Traffic Tower in cooperation with the Danish Road Directorate. Ensuring priority to buses and bicycles and smooth road traffic
- Final investment decision to build BIO4
- Political adoption of separation of organic waste throughout the city
- The city's street lights have been changed to LED
- The majority of the municipality's garbage trucks run on gas.

CO₂ EMISSIONS IN COPENHAGEN



The figure shows CO₂ emissions since 2005, plus projections with and without the initiatives outlined in the Roadmap



STREET LAB – HIGH TECH TESTING RIGHT IN THE CITY

An area in the middle of Copenhagen city center has been fitted with the newest technology: From powerful networks to sensors and cameras. The object of this is to test and develop new solutions for monitoring and managing everything from air pollution to traffic to use of waste bins.

Close to Copenhagen's iconic town hall, there stands what looks like a camouflaged green shipping container. The container's roof is covered by a forest of instruments used to measure air quality. Needless to say, the container isn't pretty but Copenhageners have gotten used to its clunky presence as they pass by on the busy H.C. Andersen's Boulevard.

"We've been measuring the city's air quality this way for years, but technology has made huge leaps since then. We are looking to test new and smarter ways to monitor air quality," says Marius Sylvestersen, manager of Copenhagen Solutions Lab, an incubator for smart city solutions set up by the City of Copenhagen.

To test new solutions, Copenhagen Solutions Lab initiated a project called Street Lab. Street Lab is much more than just testing new ways to monitor air quality.

THE CONNECTED TOWN SQUARE

Instead of merely partnering with researchers and testing solutions in a closed lab, Copenhagen opted to turn several streets around the city's town square into a high tech test lab. The City choosing to partner with experienced private technology companies.

"We approached the Danish telephone company, TDC, the international technology company Cisco and the French company, Citelum, which is currently working to change thousands of Copenhagen's street lights to low energy LED lights. They all saw potential in the Street Lab project," says Marius Sylvestersen.

Street Lab consists of three different levels of technology. Firstly, an advanced infrastructure of fiber connections and wireless connectivity has been installed in the area.

"We are taking this opportunity to test both smart city networks as well as next generation cellular networks designed for a future of the internet of things, in which everyday objects continuously send data throughout the day," explains Søren Nørgaard Madsen, IoT & Smart City Strategist with TDC.

Secondly, once the infrastructure in the area is in place, the team can install all sorts of different technology on it: anything from cameras and sensors tracking the movement of bicycles to registering data about temperature and air quality.

"At the third level, Copenhagen will implement a data infrastructure to process the large amounts of data that sensors and cameras will generate. Ideally, the infrastructure should use machine learning in which software and computers are able to process and interpret data on their own and make appropriate adjustments," says Søren Nørgaard Madsen.

THE LEARNING CITY

The lab has numerous applications: From monitoring waste bins in order to discover excess capacity or adding capacity during major events in the city to testing smart parking measures by using sensors to determine whether a parking space is empty or vacant. And not least of all, monitoring air quality.



Street Lab is Copenhagen's test-area for Smart City solutions in real urban space. Photo by Troels Heien, City of Copenhagen.

“Accurate readings on air quality are notoriously hard to obtain. Particles from traffic are heavy and will quickly drop to the ground. For that reason, it’s immensely important where you perform readings, as you will get completely different readings from a busy intersection compared to a quiet street. We will start collecting data on air quality from Street Lab in September 2016. After which we will have to compare our data readings to the data from traditional measuring stations in order to determine the quality of our data,” says Marius Sylvestersen from Copenhagen Solutions Lab.

In another case, researchers will use sensors to allow the city gardeners to remotely measure soil humidity and temperature around the trees in the Street Lab in order to improve plant care. Copenhagen has an ambition to plant 100,000 more trees before 2025.

“We are taking this opportunity to test both smart city networks as well as next generation cellular networks designed for a future of the internet of things”

Søren Nørgaard Madsen, TDC

COPENHAGEN SOLUTIONS LAB (CSL)

- CSL is an initiative by the City of Copenhagen, an incubator for smart city solutions
- Street Lab is a three-year project under CSL
- The commercial partners in Street Lab are TDC, Cisco and Citelum.

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STRONG ALLIANCE PLEDGES ENERGY SAVINGS

Copenhagen is making progress on energy savings. One simple approach has been to focus on how consumers of district heating operate their installations. Another promising development has been the establishment of a partnership with the City's major building owners, committing them to energy savings.

Most of us only receive a brief introduction to the basic installations when we buy an apartment or a house. These instructions are easily forgotten and unless the system fails few of us check if our heating or electrical installations, for instance the ventilation systems or district heating unit are configured optimally.

Even though professional building operators are expected to have an excellent understanding of the installations in their buildings, studies show that if the district heating installations in the properties in Copenhagen were run efficiently, heating consumption would be reduced by 10 percent. That is why Copenhagen is determined to optimize at least half of the City's district heating installations by 2020.

Another potential energy saving lies within newly constructed buildings. Copenhagen's utility company, HOFOR, has documented that even newly constructed buildings often do not perform according to prior calculations. This may be due to new owners receiving inadequate introductions about the building or perhaps new owners simply fail to ensure that the new building performs as intended. Therefore, Copenhagen is seeking to develop new methods to create greater consistency between the calculated performance of new building and their actual performance. A solution may be performance contracting and tests, where documentation for actual energy performance is part of the tendering material.

In another initiative, HOFOR, has developed a business model for apartment buildings with district heating units in their basements. Building owners are offered access to data on the building's heat consumption and this data can be remotely accessed. Currently data on the individual apartments' energy consumption can only be manually read by a technician, but HOFOR is working to develop ways around this.

ENERGY LEAP – A PROMISING PARTNERSHIP

Later in this chapter you will be introduced to the newly

launched initiative, Energy Leap (Energispring), which aims to stimulate energy-optimization of Copenhagen's buildings. Like in many other cities, investment in the energy efficiency of Copenhagen's buildings has been sluggish for years. The reasons are many; from the building owners lack of knowledge to a lack of real incentives to invest in energy efficiency.

Enter Energy Leap, a partnership between the City of Copenhagen and major building owners, landlords, housing associations and administrators with a shared commitment to optimize the operation of buildings. Energy Leap has commitments from partners covering more than 8 percent of Copenhagen's building stock – the aim is to have commitments corresponding to 17 percent of the City's buildings before 2020.

SYSTEMATICALLY IMPROVING BUILDING ENVELOPES

Each year numerous urban renewal projects are carried out in Copenhagen. Each project is a unique opportunity to improve outdated building envelopes (e.g. roofs, gables and house fronts) which is why Copenhagen is aiming to ensure that each project delivers an energy reduction of between 20 and 30 percent, depending on how worthy of preservation the building is.

If the number of urban renewal projects continues unchanged, approximately 1.500 apartments in Copenhagen will be energy retrofitted each year.

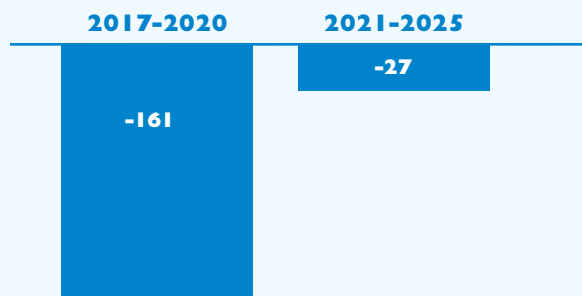
With Copenhagen's Roadmap for 2017 to 2020 the city will also work to systematically improve energy efficiency in the apartment buildings with the lowest energy labels (buildings are awarded an energy label ranging from A to G according to their energy performance). Copenhagen currently has 6.000 buildings with an E energy label or lower. These buildings account for 23 percent of the energy consumption of residential housing and 32 percent of the consumption of commercial buildings.

Finances

During the period covered by the Roadmap, the City of Copenhagen has budgeted with expenditure on energy efficiency in the building stock of DKK 161 million, rising to a total of DKK 188 million by 2025. Investments in cutting energy consumption will reduce the need for investments in greater heating capacity in the long term. In addition to CO₂ reductions, these investments can improve the indoor climate and reduce traffic noise in apartments in Copenhagen

In addition to CO₂ reductions, these investments will improve the indoor climate and reduce traffic noise in flats in Copenhagen.

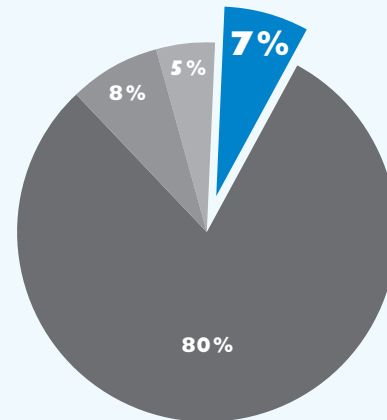
The City Administration budget: Energy consumption (DKK million)



CO₂ reductions in 2025 for Energy consumption

Percentage of the total CO₂ reduction for the City of Copenhagen

CO₂ reductions from Energy Consumption in 2025



Furthermore, the City of Copenhagen has a joint vision with the Danish Social Housing Sector to reduce heat consumption in the public housing sector by 30 percent per square meter. Social housing makes up 20 percent of the total housing area in Copenhagen, and the partners are aiming to reach a 20 percent reduction by as early as 2020, through optimization of heating installations as well as through energy retrofiting.

MAKING ENERGY CONSUMPTION FLEXIBLE

Even though the Danish energy system already has one of the highest shares of wind energy in the world, that share is going to increase in the future. Incorporating this wind energy into the energy system requires both storage capacity and flexible consumption so that electricity is used when energy from wind is abundant. This issue could be solved by businesses postponing their demand for cooling, air conditioning and ventilation.

Another way to add flexibility to the energy system is to make use of the fact that older buildings are better at storing heat, and thereby they can reduce their reliance on power generating plants designed for peak load scenarios.

Copenhagen is continuously monitoring and testing new technology most noticeably in the numerous ground-breaking research projects in the City's new neighbourhood of Nordhavn.

THE MAJOR GOALS FOR ENERGY CONSUMPTION BY 2025 IN COPENHAGEN

- 20 percent reduction in heat consumption
- 20 percent reduction in electricity consumption in commercial and service companies
- 10 percent reduction in electricity consumption in households
- 40 percent reduction in energy consumption in municipal buildings
- Installation of solar cells corresponding to 1 percent of electricity consumption in 2025.

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A GIANT LEAP FOR ENERGY RETROFITTING

By approaching key players within the building sector individually, Copenhagen has managed to assemble a powerful list of partners committed to improving energy efficiency in buildings. The first step will be to optimize the operation of heat installations in buildings.

There is no shortage of explanations to why it is so difficult to stimulate private-sector energy retrofitting of buildings.

For instance, many companies renovating buildings aren't always aware of all the potential of energy efficiency improvements, or have the necessary know-how to carry them out. There is also often an issue regarding financing energy retrofitting projects, as creditors are sceptical of the potential energy savings and the long payback periods. Last, but certainly not least, building owners are understandably reluctant to invest in energy retrofitting as the profits from energy savings often end up with the tenants and not the owner.

However, Copenhagen decided to relegate these facts to the "True but useless" (TBU) category and instead opted to go knocking on doors.

"We went to major building owners, administrators and housing associations, presented our thoughts and ideas, and asked directly what it would take for them to commit. We got great input and the result was Energy Leap," explains Annette Egetoft, Senior Advisor at the City of Copenhagen

GETTING BUILDINGS INTO SHAPE

Energy Leap is a growing partnership of major building owners, administrators and housing associations committed to improving the energy efficiency in buildings. It has resulted in a commitment with the partners, whereby they agree to seven principles and pledge as many buildings to the project as they would like.

"It is like a bootcamp at which we are getting their buildings into shape. The first step will be to offer technical personnel training courses on optimizing the operation of the heating installations in buildings. We can save up to 10 percent on the energy bill by just optimizing heating instal-

lations," says Gorm Elikofer, Corporate Account Manager at HOFOR, Copenhagen's utility company.

Furthermore, HOFOR offers Energy Leap partners two meters to monitor energy and water consumption in their buildings.

"Our team of experts then monitors and interpret the building's consumption data and offer advice on improving performance. Based on our data, we also offer suggestions for saving energy in the building. For instance, we can compare data on heat consumption with weather data and make educated guesses as to where the biggest potentials lie for energy savings in buildings," says Gorm Elikofer.

Simultaneously, the administrator of the municipal building mass, Copenhagen Properties, will offer their experience and know-how from their own energy retrofitting projects.

"This partnership is all about sharing know-how and experience with the other partners to better tackle this challenge. Several of our partners have already offered to share their knowledge as well," says Annette Egetoft. The partners of Energy Leap will also be asked to participate in regular workshops.

ALREADY EXCEEDING EXPECTATIONS

The City of Copenhagen initially aimed for 20 partners to join the partnership, that goal has already been achieved: at present, the number of members stands at 22. Among them, the current partners own more than 3 million square meters of property or what represents 8 percent of Copenhagen's total building mass. So, it is safe to say that Energy Leap is well on its way to representing 17 percent of Copenhagen's total building mass.



*The Mayor of Technical and Environmental Affairs with the 22 partners at the launch of Energy Leap in June 2016.
Photo by Troels Heien, City of Copenhagen*

FACTS ABOUT ENERGY LEAP

- Background: Copenhagen aims to cut its heat consumption by 20 percent by 2025. At the same time, Copenhagen will reduce electricity consumption by 20 percent in commercial and service companies and by 10 percent in households
- The partnership currently consists of 22 partners from major building owners and administrators, to housing associations
- The goal is to have commitments from partners corresponding to 17 percent of the building mass in Copenhagen. Currently, partners own more than 8 percent of the building mass in Copenhagen
- Commitments from 17 percent of the building mass would result in a 6,000 tonnes CO2 reduction by 2025
- Partners have committed to cutting energy consumption by 3 percent in the buildings that they have volunteered for Energy Leap during the first year.

“We are very pleased with the response to Energy Leap. Not least because of the diversity in our partners with everything from housing associations to administrators of office buildings to major shopping malls being represented”

Annette Egetoft

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BUILDING THE SUSTAINABLE CITY

Usually only a few buildings in an area are built to the highest standards. However, this will not be true for Copenhagen's new neighbourhood in Nordhavn. For the first time, an entire neighbourhood has received a sustainability certification. And all future buildings in the area will have to be certified as well.

When Danish construction and property development group, CASA, won the bid to build the first apartment building in the new area in Nordhavn, it was met with joy even though they would have to do something that had never been tried before. The new building – called Sundmolehusene - had to meet strict criteria set out by the DGNB certification system. The system originated in Germany and is a sustainability certification system for the construction industry. In Denmark, the first version of this certification was launched in 2012.

“We have years of experience in building quality housing but we have never had one of our buildings DGNB certified. We therefore enlisted the assistance of a DGNB certification consultant to guide us through the process,” explains Claus Møller, Section Chief from CASA.

With the help of the consultant, CASA soon discovered that managing the building process of a sustainable building was, indeed, manageable.

“To get the certification, you have to account for your decisions throughout the building process. From your choice of construction materials to the way you heat your buildings on the construction site. It has been a challenge to justify our decisions at every step of the building process, but it quickly gets easier,” says Claus Møller.

SOCIAL AND ECONOMIC SUSTAINABILITY

The DGNB sustainability certification is not only awarded

to individual buildings but also to entire urban areas. What sets Nordhavn apart is the fact that an entire neighborhood has been awarded the certification at an area level in which the individual buildings must also be certified.

The DGNB certification system is a holistic approach to urban development. Areas and buildings have to balance five different sustainability parameters. Environmental sustainability is merely one of the parameters. The area or building must, for instance, also be economically sustainable in the sense that buildings costs cannot spiral out of control. The other parameters are technical quality, quality of process and the building or area's social sustainability.

“By getting an entire area like Nordhavn certified, we get a tool to measure sustainability in urban development. As it turned out, we were already well on our way with Nordhavn just by having optimized the neighborhood in order to support climate friendly transport behavior: Walking distances to daycare and shopping and prioritizing public transportation and bicycle routes,” says Rikke Faaborg Jarmer, Director of Sustainability & Urban Development, CPH City & Port Development, Copenhagen's urban development company.

As the area of Nordhavn is still under development, the area has only been precertified. However, Nordhavn can expect to receive a platinum certification once the area is ready, meaning it lives up to highest standards of sustainability.



The area of Nordhavn that has been DGNB certified. Photo by Ole Malling, CPH City & Port Development.

RESIDENTS WILL FEEL A DIFFERENCE

Rikke Faaborg Jarmer stresses that the DGNB sustainability system is primarily a tool to manage building and development processes, but the future residents of Sundmolehusene and Nordhavn will most certainly also feel a difference.

“With DGNB we are creating great urban areas with a diverse composition of residents, plenty of spaces for recreation as well as pleasant energy efficient buildings,” she explains. As an example of the environmental sustainability of the buildings, the district heating is delivered at lower temperatures (supply temperature of 65-70 degrees Celsius instead of 65-95) and the residential buildings are orientated towards sunlight in order to maximize heat gain.

“With DGNB we are creating great urban areas with a diverse composition of residents, plenty of spaces for recreation as well as pleasant energy efficient buildings”

Rikke Faaborg Jarmer

NORDHAVN – THE FIVE-MINUTE CITY

- In the new development in Nordhavn, urban planning strives to create the “five-minute city”
- The five-minute city seeks to minimize car traffic by making everything from shopping and daycare to parking and public transportation readily available
- A part of the development, Nordhavn has been awarded a DGNB precertification
- The DGNB system is administered by Green Building Council Denmark – a non-profit member organisation working to promote sustainability in the construction industry
- CPH City & Port Development is looking to have future developments in Copenhagen DGNB certified
- Sundmolehusene is limited to 72 apartments and 11 townhouses.

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THE RIGHT RECIPE FOR SAVING ENERGY

Getting restaurants and other service businesses to reduce their energy consumption is a key part of Copenhagen's climate efforts. A newly developed concept uses mobile data logging to help businesses discover their hidden energy drains – and gives them the tools to fix it.

When it comes to cutting meat and vegetables, most restaurants are full of experts. When it comes to cutting down on energy consumption – not so much. In the daily hustle to get food onto the plates of their hungry guests, most restaurant owners struggle to find the time and motivation to take a closer look at how they might improve the energy efficiency of their business.

This is bad news for both the City of Copenhagen and the restaurants themselves. In order to reach its climate goals, Copenhagen needs its restaurants and other service businesses to reduce their energy consumption by 20 percent. Many restaurants are missing out on thousands of Danish kroner in potential energy savings.

“Our mapping of the city's energy consumption showed that restaurants and industrial kitchens consume a significant portion of total energy. The challenge was to identify and effectuate potential savings. Traditional energy surveys based on questionnaires and estimates are both costly, time consuming and often inaccurate. This made the business owners reluctant to commit to them. We needed a cheap and easy method that gave the restaurants a clear picture of what to do,” says Lotte Kjærgaard, project leader from the City of Copenhagen.

SOLUTION: AUTOMATIC MONITORING AND ON-LINE REPORTS

The City of Copenhagen put the assignment up for tender, inviting electrical contractors and other relevant companies to submit solutions, which were to be tested in a trial

project with 10 local restaurants. The winning proposal came from R&M-EL, a local contractor. They developed a concept that used mobile data logging directly from the restaurants' electrical panels to get an accurate picture of the energy consumption. The data was transmitted to R&M-EL's servers, where it was processed and could be displayed online, on iPads or on monitors in the restaurant kitchens. That way, the restaurant staff got a direct look at how much energy they were using.

“Our method allowed us to accurately measure the energy used in the restaurants around the clock. Since most of the major appliances, such as ovens, freezers and ventilation units, each run on their own circuit, we could see their individual energy consumption in detail, and output that information live. We were also able to generate energy reports automatically,” says Lars Elmvang, head of strategy and business development at R&M-EL.

RESULTS: CHANGES IN BOTH BEHAVIOR AND EQUIPMENT

Once the data started coming in, the next step was to get the restaurant owners and staff to act on the information. The logging soon revealed a number of potential areas where a change in behavior would result in a significantly lower energy consumption.

“Once we had the data, it was fairly easy to identify patterns in energy consumption. We used this information to suggest changes in behavior. In one restaurant, the staff started each day by turning on the large professional coffee



Cap Horn Restaurant in Copenhagen participated in the project. 7 out of 10 restaurants reduced their energy use by between 8 and 23 percent by adjusting procedures and workflows. Photo by Cap Horn

machine, even though the first guests didn't turn up until the evening. In another case, the staff used a heating cabinet to heat warm towels for the guests. They discovered that using the surplus heat from the oven instead was both faster and more energy efficient," says Lars Elmvang.

Besides changes in behavior, many restaurants were also able to cut back on energy consumption by adjusting their equipment or, in some cases, replacing it. In several restaurants, the ventilation system was running around the clock, even when the kitchen was closed. For one restaurant on Kongens Nytorv, the investment in a new timer controlled ventilation system was able to pay for itself in less than a year.

“We needed a cheap and easy method that gave the restaurants a clear picture of what to do...”

Lotte Kjærgaard

SAVING ENERGY IN LOCAL RESTAURANTS

Most of the participating restaurants were able to reduce their energy consumption through:

- Changes in behavior: 7 out of 10 restaurants reduced their energy use by between 8 and 23 percent by adjusting procedures and workflows
- Technical adjustments: By using timers and turning off stand-by functions, energy consumption from technical appliances and installations was reduced by up to 16 percent
- Technical replacements: The restaurants were able to identify equipment in need of replacement, including dishwashers, stoves, ventilation systems, lighting and heating.

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THE MOST CLIMATE FRIENDLY BLOCK IN TOWN

An entire block of older buildings in Copenhagen is about to undergo extensive renovation in order to reduce energy consumption and manage rainwater. The solutions applied in the project are easily scalable and cost-effective, so they can be applied to other buildings in Denmark and abroad.

Like many other major cities, a large portion of Copenhagen's residential areas consist of city blocks of older apartment buildings surrounding outdated courtyards. More often than not, these buildings are poorly insulated, have insufficient ventilation and obsolete windows that do not let in enough sunlight. Add to this the increasing volume of rainwater that needs to be managed and it is easy to see why sustainable urban renewal on a large scale is essential if Copenhagen is to fulfil its climate goals.

However, achieving this goal is no easy task. Renovation is costly and complex, and presents a major barrier to property owners and residents. To overcome this obstacle, the City of Copenhagen launched the Climate Resilient Block project in 2013.

“The goal was to take a holistic approach to renovating older buildings and courtyards. We wanted a flagship project that could both develop cost-effective and resilient solutions with high architectural and technical quality as well as serve as an inspiration to others. It was a clear objective of the participating advisors that the solutions should be both scalable and transferable to other urban areas,” says Hanne Arildsen, the City of Copenhagen.

SOLUTION: INSULATION WALLS AND RECYCLED RAINWATER

One of the first challenges was to find the right city block for the project, since resident involvement and motivation was vital to its success. After more than 100 Copenhagen residents submitted their block for consideration, a block in the eastern part of Copenhagen was selected and a preliminary project was launched.

“We had two consulting agencies investigate the needs of the residents and establish contact to industry suppliers. In

the next phase, a team of consultants led by Henning Larsen Architects was selected to suggest specific solutions for the buildings and the courtyard. They looked at the larger picture, and were able to develop robust solutions that could achieve our vision of a significant reduction in energy consumption and rainwater retention while maintaining high architectural quality,” says Hanne Arildsen.

The solution focused on insulating the rear of the buildings with an outside insulation wall of glass wool. When constructing the outside insulation wall new shafts were added for ventilation and other technical installations permitted the replacement of existing windows with French balconies or bay windows, thereby increasing the amount daylight let in and quality of life. This method retains the original architecture of the outward façade. In addition, the courtyard will be renovated and fitted with more plants. Drainpipes and gutters in the courtyard will be modified to guide the rainwater to underground collection tanks, from where it can be recycled.

RESULTS: ENERGY CONSUMPTION CUT IN HALF

The chosen solutions highlight the importance of focusing on an entire city block, especially when it comes to managing rainwater.

“The water really ties the entire project together, because we have been able to collect 100 percent of the rainwater for reuse. Additionally, the improved insulation and ventilation will provide a 50 percent reduction in energy consumption. More importantly, we have conducted a workshop where the solutions were presented to selected suppliers. They confirmed that the solutions can be industrialized, which is essential to developing standard, cost-effective products that can be applied to similar projects,” says Hanne Arildsen.



The solution focused on insulating the rear of the buildings with an outside insulation wall of glass wool. The improved insulation and ventilation will provide a 50 percent reduction in energy consumption. Photo by the City of Copenhagen

“We wanted a flagship project that could both develop cost-effective and resilient solutions with high architectural and technical quality as well as serve as an inspiration for others...”

Hanne Arildsen

THE CLIMATE RESILIENT BLOCK

- The Climate Resilient Block is located on the streets of Helsingborggade, Kildevældsgade, Thomas Laubs Gade og Landskronagade in Eastern Copenhagen
- Residents from the block have been closely involved throughout the project period, through interviews, planting events, meetings and other activities
- In the next phase of the project, the residents will decide on new windows and balconies. Construction is scheduled to begin in 2017.

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COPENHAGEN TAKES BIG STEP FORWARD ON BIOMASS

Construction of a new biomass powered block at one of Copenhagen's major CHP plants has begun. BIO4 is a key component in the city's ambition to become carbon neutral. In the coming years Copenhagen will work towards establishing large wind farms and support a flexible energy system.

Keeping Copenhageners warm and powering everything from their washing machines to toasters requires lots of heat and electricity. No wonder then, that the heat and electricity production is Copenhagen's biggest carbon emitters. Making both carbon neutral, combined with initiatives in the other utility sectors, will contribute 80 percent of the overall reduction needed to become carbon neutral by 2025.

The City of Copenhagen is using a two-pronged approach to cut the dependence on coal and natural gas. Investments in wind power and biomass are the key pillars in the transformation.

Needless to say transforming the way, a major city is powered, is a challenge. Copenhagen intends to install 360 MW wind power by 2025 and incorporating a larger share of fluctuating wind energy will require greater flexibility from and integration of the electricity, gas and district heating systems.

A lot of the solutions to secure a flexible energy system will be tested in the coming years and implemented in Copenhagen's EnergyLab Nordhavn and around the city.

BIO4 GETS GREEN LIGHT

After years of careful planning and analysis, a new biomass-powered unit at the Amagerværket combined heat and power plant (CHP) was adopted in early 2016. The new unit, called BIO4, will replace the last coal-fired unit in the City of Copenhagen and will run on wood chips from sustainable sources.

Construction began in September 2016 and the new unit is expected to start producing carbon neutral heat and electricity to Copenhageners in 2020.

The CHP plants delivering heat to the district heating system in the Copenhagen area is simultaneously switching from coal to biomass. By 2016 half of the city's district heating, was produced by carbon neutral sources.

In the absence of a common European agreement on sustainability criteria for biomass, Copenhagen through its utility

company, HOFOR, has joined a national industry agreement setting out rigorous principles for sourcing of biomass. The principles are similar to FSC and means that Copenhagen only use wood chips from logging residues or trees felled as part of forest thinning in order not to deplete the forests.

Currently Copenhagen has a number of heating plants in reserve for when demand peaks (during winter) or for when one of the major plants are out for maintenance. These plants currently run on fossil fuels but Copenhagen is developing a strategy to secure that also the peak and reserve load runs on fossil free fuel in 2025.

PREPARING MAJOR WIND BID

The shift to biomass at the CHP plant, Amagerværket, as well as the effort to replace fossil fuels with sustainable biomass at Copenhagen's district heating plants is expected to deliver a total reduction in carbon emissions of 249.000 tonnes CO₂. A third of what's needed to make the city's energy production carbon neutral.

Another 40 percent is planned to come from investments in wind power.

Copenhagen has already successfully installed 23 wind turbines on land with a total output of 64 MW. However, the biggest potential for Copenhagen to cover a large part of its electricity demand with wind power still comes from offshore wind farm projects.

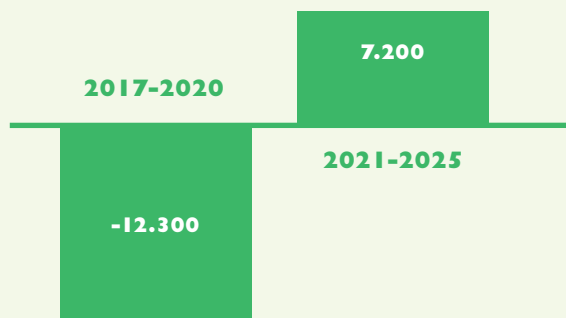
In September 2016, Copenhagen through its utility company, HOFOR, submitted a bid to The Danish Energy Agency for a tender for 350 MW of offshore wind power. The tender was the result of a broad political agreement in 2012 for so-called "near shore" projects in which turbines can be erected as close as 4 kilometers from the shore. Unfortunately, HOFOR didn't win the tender, why they together with the City of Copenhagen are searching for new offshore areas and possibilities to erect wind farm parks.

One of the areas the City of Copenhagen is looking into now is the nearby straight of Øresund, where HOFOR has sub-

Finances

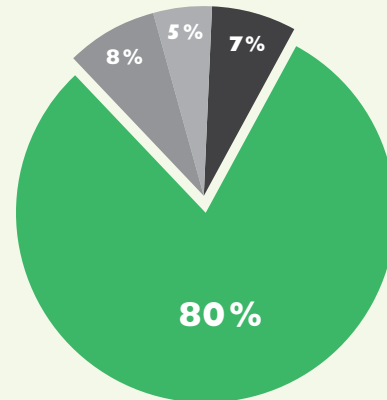
The initiatives under Energy Production are financed by City of Copenhagen utility companies and by waste tariffs. The commercial investments during period covered by the roadmap amount to DKK 12,3 billion, partly due to major investments in a new unit at Amagerværket and in wind turbines. During the third implementation phase (2021-2025), the remaining working life of the units and ongoing operating revenue will provide a profitable return on invested capital.

Commercial investments: Energy Production (DKK million)



CO₂ reductions from Energy Production in 2025

Percentage of the total CO₂ reductions from Energy Production



mitted an application to erect wind turbines through a so-called Open-door-procedure that allows any project developer to take the initiative to establish an offshore wind farm.

Simultaneously, the City of Copenhagen is looking for potential locations to erect wind turbines on land – across Denmark or within the municipality itself.

SOLAR POWER AND A FLEXIBLE ENERGY SYSTEM

Until now, both the price and the technology of solar cell have hindered any large-scale application of solar cells as a way to cut Copenhagen's carbon emissions. However, prices have dropped significantly in recent years and the technology has taken a leap forward, which is why Copenhagen is continuously monitoring the market looking to establish a large-scale solar plant when the time is right.

Obviously, integration of large amounts of renewable energy especially wind power increases the need for flexible energy systems, where energy is stored and used when it is abundant.

GRADUALLY FINDING SOLUTIONS FOR PLASTIC WASTE AND BIOGAS PRODUCTION

The waste from Copenhagen's households is being used to generate heat for the city. However, in order to reduce carbon emissions Copenhagen is looking for solutions to recover plastic from the waste. In 2016 Copenhagen introduced a sorting system for rigid plastic in apartment buildings. It will in 2017 include plastic ... as well.

In September 2016, the Technical and Environmental Committee in Copenhagen decided to make it possible for Copenhageners to source separate the organic fraction of their waste. The plan is to establish a new biogas plant near Copenhagen, where the organic fraction will be treated and used to produce biogas. The biogas can subsequently be used in the city's gas system or in the transportation sector to further reduce CO₂ emissions.

THE MAJOR GOALS FOR ENERGY PRODUCTION BY 2025 IN COPENHAGEN

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

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BIOGAS – FROM THE TOILET TO THE STOVE

Every time Copenhageners use the toilet, they are helping to reduce carbon emissions. The wastewater from more than 1 million citizens is transformed into biogas and used as a substitute for natural gas in Copenhagen's households.

Professional chefs have long preferred cooking on gas, and gas is also highly popular among regular consumers in the City of Copenhagen. The Greater Copenhagen Utility Company, HOFOR, delivers gas (so-called town gas) to more than 300,000 consumers. In fact, demand for town gas doubled from 2009 to 2015, which has also increased demand for biogas.

“If we are to realize our ambition, our gas supply has to become carbon neutral as well. Furthermore, we have to continue reducing the energy used to treat Copenhagen's wastewater,” explains Morten Stanley, HOFOR's Gas Manager.

A city the size of Copenhagen produces large amounts of wastewater. The wastewater treatment company, BIOFOS, runs all three treatment plants, which service greater Copenhagen, and the treatment plants receive about 351 million liters of wastewater each day.

SOLUTION: CREATING A COMPLETELY NATURAL CYCLE

The solution sounds incredibly simple: Convert Copenhagen's own wastewater to biogas. However, the underlying process is much more complex:

“The untreated wastewater from the City's thousands of households first passes through a number of tanks to filter grit and debris, before the sludge passes to a digester. Here, natural bacteria start decomposing the sludge, releasing raw biogas in the process,” says Carsten Thirsing, Process Engineer at BIOFOS.

The raw biogas has several purposes. As much as possible is mixed with natural gas and air and is used by both business

and private consumers in Copenhagen's town gas network. Before the biogas is ready to be used in the City's households, it is cleaned with carbon filters to remove the unpleasant odours of ammonia and hydrogen sulphide.

“When biogas production at Lynetten (one of the treatment plants) exceeds the demand for gas in the City's households and businesses, we've got boilers that use biogas for district heating as well. The wastewater treatment plant, Damhusåen, has biogas generators that can produce green electricity for the grid and district heating,” says Anders Faber, Environmental Manager at BIOFOS.

RESULTS: 40 PERCENT CARBON NEUTRALITY IN 2017

Biogas already makes up 25 percent of the gas Copenhageners use in their kitchens and by the end of 2016, that figure is expected to increase to 30.

“BIOFOS is installing new and efficient digesters at the treatment plant, Lynetten, that will allow HOFOR to achieve 40 percent carbon neutrality by 2017 and 50 percent by 2018, because we also receive biogas from BIOFOS' other wastewater treatment plant in greater Copenhagen, the wastewater treatment plant Avedøre,” says Morten Stanley from HOFOR.

“BIOFOS and national and international partners are looking into technologies that would allow electricity from wind to create hydrogen that is then mixed with biogas and special bacteria to create methane. This would allow us to link gas and electricity production and thereby create a much more efficient use of our renewable energy resources,” says Morten Stanley.



Biogas production in digesters at BIOFOS. Photo by BIOFOS

CREATING BIOGAS FROM COPENHAGEN'S WASTEWATER

- Biogas production at the wastewater treatment plant Lynetten has been in operation for more than 20 years
- In 2014, Lynetten delivered 2.5 million cubic metres biogas to the City gas system. The following year, it was 4.4 million cubic metres and in 2016, BIOFOS will produce 8.5 million cubic metres of biogas and deliver 6 million cubic metres to the town gas system
- The Greater Copenhagen Utility Company, HOFOR, expects its gas supply to be more than 50 percent carbon-neutral by 2020
- The remaining reductions (50 percent) are expected to come from investing in other national biogas projects or possibly by developing solutions to create biogas from organic waste from households
- BIOFOS, which runs Copenhagen's three wastewater treatment plants, managed to make its operations 80 percent carbon neutral in 2015 (compared to the baseline year of 2005)
- BIOFOS reduced emissions by producing much of its own electricity on biogas-powered generators and solar panels. BIOFOS also produce district heating used in greater Copenhagen
- Emissions from BIOFOS have also been reduced by implementing new energy efficient technology at the treatment plants
- BIOFOS has a positive energy balance and in 2015, the sale of energy was 50,1 percent greater than the energy required to operate the three wastewater treatment plants.

“This would allow us to link gas and electricity production and thereby create a much more efficient use of our renewable energy resources”

Morten Stanley

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OUTSOURCE THE MANAGEMENT OF OUR ENERGY CONSUMPTION

In Copenhagen's new neighbourhood, Nordhavn, researchers are looking to test new and flexible ways to control the energy consumption in private apartments. This way, the homes will become part of a flexible energy system that can run on high levels of fluctuating wind and solar energy.

You may have a friend or two who have installed smart meters in their homes to monitor and control electricity and heat consumption. However, the majority of consumers still get their desired temperature by manually adjusting the thermostat on their radiator and expect appliances to start when they push the button.

This way of consuming energy puts a strain on the energy systems, as most people will use energy when they get up in the morning or return from work in the afternoon. This often requires an extra plant to kick in to cover the peak load. Plants that today use fossil fuels.

“As consumers we are used to control when to turn on the washer or adjust the heat. However, in the future we will have to integrate more fluctuating energy from wind into our energy system. One way of dealing with this unsteady production of energy is to change the way that we use energy – so that energy consumption is able to follow the patterns of production. That will take new solutions and that is what we are testing in EnergyLab Nordhavn,” explains project manager of EnergyLab Nordhavn, Christoffer Greisen. EnergyLab Nordhavn is a research and demo project in Copenhagen's new urban development, Nordhavn.

SOLUTION: THE INTELLIGENT APARTMENT

To demonstrate the new solutions, the project asks the future residents in some of the apartments in Nordhavn to hand over control of electricity and heat consumption to the project – of course with the guarantee that it doesn't compromise general comfort.

“We intend to install building automation systems in 50 new apartments. The systems will be able to automatically adjust temperature as well as turn on lights when the need is there.

The idea is that the building is doing the thinking and constantly monitor and controlling heat, electricity and water consumption,” says Morten Herget Christensen from Balslev Consulting Engineers.

The system also allows the building to use predictions on weather conditions and energy prices to use energy at the best possible time. The idea is to find energy consumption that is flexible – meaning that they can shift in time or intensity - and offer this flexibility to the energy systems.

RESULTS: MAKING ENERGY CONSUMPTION VISIBLE AND SMART

The participants in the experiment will also have easy digital access to information on their energy consumption. The aim is to raise awareness among the consumers about the new ways of consuming energy.

“The residents will be able to follow their energy consumption and the decisions made by the automatic system. If for instance the washing machine is delayed until more wind power is available in the grid, or floor heating is cooler than expected, the user will be able to understand what services the building is providing to the energy system and how they are helping towards cleaner energy. The increase in information will help compensate for the loss of control.

In this way we hope to show the residents that if it they do experience small changes to the comfort in the apartment, for instance when heating is temporarily shut off, it is for a good reason,” says Morten Herget Christensen.

The project has made agreement with developers and is now recruiting residents. However, the aim is to develop concrete recommendations to guide future building regulations.



EnergyLab Nordhavn is a large-scale integrated research and demonstration project that contributes to the grand challenge of transforming the energy system to efficiently integrate a large share of renewable energy. Photo by, CPH City & Port Development

ENERGYLAB NORDHAVN – LIVING LAB DEMONSTRATING THE FUTURE ENERGY SOLUTIONS

- The EnergyLab Nordhavn project will run from 2015 to 2019
- The project has an overall budget of DKK 143 million
- The project is supported by two grants from the Danish Energy Technology Development and Demonstration Programme (EUDP), contributing DKK 84 million to the total budget
- Behind the project is a consortium composed of the Technical University of Denmark (DTU), the City of Copenhagen, the capital area's utility company HOFOR, Radius, CPH City & Port Development as well as the private companies, ABB, Balslev, Danfoss, CleanCharge, METRO THERM, Glen Dimplex and PowerLab.

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CREATING AN IRRESISTIBLE OFFER FOR MOTORISTS

It may seem greedy for a city to ask for more when more than 40 percent of all commuters ride their bicycles to work or study in Copenhagen. But Copenhagen wants to convince even more people to walk or take the bicycle or public transport to get around the City. And, the past year gave Copenhageners even more alternatives to taking the car.

Copenhagen is a popular city and projections estimate that by 2026 the number of inhabitants will have risen by almost 100,000. And the growing population poses challenges to the City's climate efforts.

Projections also estimate that car ownership will increase in the future and the number of cars in Copenhagen may rise by as much as 20 percent. That obviously creates a challenge for a city that wants 75 percent of all trips in Copenhagen to be on foot, by bike or public transportation in 2025.

So far however, Copenhagen seems to be doing something right. In the period 2005 to 2015, traffic by car fell by 3 percent, while bicycle traffic showed a 12 percent increase in the same period. However, progress is slower than expected and 33 percent of the trips in Copenhagen are still taken by car.

As a consequence, carbon emissions from transportation in Copenhagen are only slowly dropping, which paradoxically means that the transport sector's share of overall carbon emissions has increased from 24 percent to 34 percent in 2015 as other sectors have reduced their emissions more.

Copenhagen's strategy to reduce emissions from transportation remains unchanged – create the best possible conditions for bicyclists and pedestrians while improving public transportation. This approach has the added benefit of solving other urban challenges such as freeing up the urban space and improving public health by reducing pollution.

GREENING THE CITY'S CARS AND BUSES

Another component of Copenhagen's strategy to reduce emissions from transportation is a push to make the necessary trips by car, vans or trucks happen in the cleanest vehicles possible – preferably running on alternative fuels.

As you will be able to read in another article in this chapter, Copenhagen took a small but significant step in 2016 with the introduction of two electric buses. The initiative, which is a joint project between Copenhagen, the traffic operator Movia and the energy company E.ON, will provide valuable

experience in the possibilities and challenges in converting to public transportation that runs on alternative fuels.

In the coming year, Copenhagen will take an even greater step when the busiest bus line in Denmark – the 5A route – will start running on biogas. The new buses are also Copenhagen's first successful tender for carbon neutral buses and more are expected to follow.

By changing a number of its own vehicles to hydrogen cars, Copenhagen has become the leading city in the world in terms of hydrogen cars. The push has led to the establishment of a national infrastructure of fuelling stations for hydrogen cars – a global first. Copenhagen also has a good citywide network of charging stations for electric vehicles, but the Danish market and consumer demand for electric and hydrogen cars is still limited.

Copenhagen is hoping that new car-sharing services offering an easily accessible citywide network of electric cars will convince existing and potential car owners to opt for an electric model or forego car-ownership altogether.

FUELLING THE LOVE FOR THE BICYCLE

It is an understatement to say that Copenhagen is a bicycle city. Fifty-six percent of the City's inhabitants take the bicycle to work or study in Copenhagen.

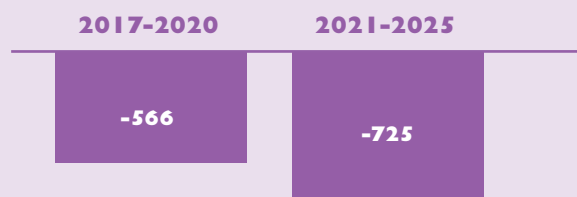
The success of the bicycle in Copenhagen is so great that congestion on the City's bike lanes may become a real concern, and it can be hard to find parking for bicycles. Therefore, Copenhagen is continuously working to expand the capacity of the City's bike lanes as well as to provide parking at busy train, metro and bus stations. The goal is to make it easier for citizens changing between bicycles and public transportation.

Another initiative is the work to close gaps in the City's network of bike lanes. One major and very literal gap was closed in 2016 with the opening of the Inner Harbour Bridge that ties the old city centre together with the neighbourhood of Christianshavn.

Finances

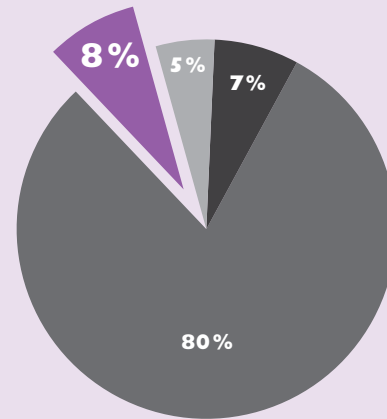
During the period covered by the roadmap, the City of Copenhagen has budgeted with expenditure of DKK 566 million on green mobility rising to DKK 1,3 billion by 2025, mainly to improve conditions for cyclists. As well as CO₂ reductions the mobility initiatives will have a number of positive sideeffects in the form of better health, smoother traffic in the city and development opportunities for urban spaces.

The City of Copenhagen budget: Mobility (DKK million)



CO₂-reduction in 2025 for Mobility

Percentage of the total CO₂ reductions from Mobility



To achieve carbon neutrality by 2025, Copenhagen must also succeed in creating incentives for commuters from other municipalities to leave their cars before entering Copenhagen. This is where Copenhagen's new city and commuter bike system is looking to offer an attractive alternative. The new bike sharing city bike system is intended specifically for commuters, with more than 1.800 electric bikes accessible at major metro and train stations.

Some commuters prefer to use bicycles for even longer distances. To make this attractive to more commuters, Copenhagen is collaborating with 22 other municipalities and the Capital Region to develop a coherent network of Super Cycle Highways.

INTELLIGENTLY SMOOTHING TRAFFIC FLOWS

New technology offers possibilities to improve the flow of traffic in cities like Copenhagen. For instance, trucks have different driving patterns than cars, which in urban traffic often results in unnecessary stops and starts. These interruptions to the smooth flow result in increased fuel consumption as well as increased noise and air pollution.

Therefore, Copenhagen is working systematically with Intelligent Transportation System (ITS), developing solutions to ensure that the necessary traffic into the City can reach its destination as efficiently as possible.

As you can read in an article in this chapter, Copenhagen has tested ECO-driving solutions at 12 intersections in the City. At those locations, traffic signals and trucks can communicate allowing the driver to know when the light will turn green.

The ECO-driving project is just one of Copenhagen's ITS projects. The City has also tested "green wave" riding for cyclists travelling at a certain speed. In the coming years, the City will further test ITS solutions to improve the traffic flow of cyclists, cars and pedestrians as well.

THE MAJOR GOALS FOR MOBILITY BY 2025 IN COPENHAGEN

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

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SMOOTH CRUISING THROUGH COPENHAGEN'S TRAFFIC

New electronic guidance systems help commercial drivers adjust their driving patterns, thereby allowing them to catch more green lights and have fewer stops while driving through Copenhagen. In some cases, the traffic light will even stay green for a bit longer. This could potentially reduce CO₂ emissions and travel time.

Each day, thousands of trucks, lorries and busses travel the roads and streets of Copenhagen, hauling freight and delivering passengers. Every time one of these busses or heavy vehicles stops at a red light, it uses over half a litre of fuel. In addition, driving patterns with many frequent stops increase noise and particle pollution as well as traffic congestion.

“If we want a more effective and environmentally friendly flow of heavy traffic through Copenhagen, we need to use new technology to help guide the drivers. If we can communicate to the drivers how much time they have left before the green light changes, they can adjust their speed and driving patterns to match the timing of the traffic signals,” says Mads Gaml, ITS program manager from the City of Copenhagen.

Recently, two City of Copenhagen projects, titled Compass4D and ECO-Driving respectively, have examined the effects of using on-board displays to provide drivers with traffic light information. This information gives them a better chance of catching the green waves through some of the city's busiest roads.

SOLUTION: SPEED ADVICE AND GREEN PRIORITY

During the project, the screens communicated with selected traffic signals and informed the driver of the optimal speed needed for catching green lights ahead.

In Compass4D, an EU-backed project implemented in 2015, heavy goods vehicles, busses and hydrogen cars were fitted with the system. The test area covered several routes in central Copenhagen, and the system could negotiate with traffic signals in order to allow busses 15 extra seconds of green light in order to pass through intersection if needed.

Prior to the Compass4D project, the City of Copenhagen had the ECO-Driving project, in which around 15 commercial trucks tested the technology while driving along the Folehaven route, which leads from one of the main highways, Holbækmotorvejen, to the centre of Copenhagen, cutting across 12 intersections.

“With Compass4D, we built on the experiences we had gained from ECO-Driving. In Compass4D we used an EU standardized communication protocol, and implemented a Road Hazard Warning system. Our goal was to expand the system to include the entire expanse of Ring 2, selected intersections and routes in Copenhagen,” says Mads Gaml.

RESULTS: LESS CO₂ AND FASTER BUS ROUTES

In Compass4D, the busses were able to achieve a more fluent travel pattern, reducing travel time by over 10 percent and the number of stops by 5 percent. This is estimated to provide an approximately two percent reduction in CO₂ emissions.

As for the ECO-Driving project, 40 percent of drivers estimated that they had fewer stops along the road, after the ECO-driving system was set up.

“International projects have shown that ECO-Driving can reduce CO₂ and NO_x emissions by as much as 13 percent. Compass4D showed positive results, and we will now upgrade the ECO-Driving system to the EU standardized communication protocol and implement the solution on a larger area. It will also be available to private motorists and cyclists via a smartphone app. Covering a larger area and including more vehicles is essential if we are to make a significant impact on driver behaviour,” says Mads Gaml.



*Screens communicate with selected traffic signals and inform the driver of the optimal speed needed for catching green lights ahead.
Photo by Ursula Bach, City of Copenhagen*

“If we want a more effective and environmentally friendly flow of heavy traffic through Copenhagen, we need to help guide the drivers...”

Mads Gaml

ECO-DRIVING AND COMPASS4D

- Compass4D was implemented on 21 intersections on key bus routes. Time-to-green and time-to-red information, green priority and Road Hazard Warning were provided
- A total of 87 busses, 17 heavy goods vehicles and 2 hydrogen cars and a total of 330 drivers participated in Compass4D
- ECO-Driving covered 12 intersections along the Folehaven route in the southwest part of Copenhagen. During this project, drivers received on-board information about time-to-green and time-to-red and the driver received green priority in four intersections outside of rush hour.

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CAN A BICYCLE CITY USE ANOTHER BICYCLE?

(HINT: YES!)

Copenhagen's new generation bike sharing system is now up and running. The aim is for the bike to become equally popular among Copenhageners and commuters as the thousands of people who visit the City every year.

Aiming to encourage even more people to use a bicycle seems like hubris for a city where more than half of the citizens already take their bike to work. However, Copenhagen's new public bicycle system aims to do just that.

Discussions about finding a substitute for Copenhagen's old public bicycle system began years ago, back in 2008. The predecessor was the first generation of a bike sharing system, and both the bicycles themselves and business model to run them had become outdated.

"The old bicycles were typically located around the City to maximize visibility for advertisers, but rarely according to traffic patterns. In other cities like London for instance, we saw the emergence of a new generation of bike sharing systems that aimed to close the gaps in the public transport system. We wanted our new system to be a fourth leg in a public transport system in addition to the metro, trains, and busses," says Pia Preibisch Behrens, Project Manager from the City of Copenhagen.

Copenhagen partnered with the national train operator, DSB, the company behind the Copenhagen metro as well as the neighbouring municipality of Frederiksberg.

"DSB saw a clear business case in the new bike sharing system. For years they had for years felt the flipside of the success of the bicycle in Copenhagen, with more and more passengers bringing their bikes onto the trains. Similarly, the parking situation was deteriorating at train and metro stations as commuters often had two bicycles to make the morning commute," says Pia Preibisch Behrens.

SOLUTION: A COMMUTER BIKE

To manage and develop the new bike sharing system, Co-

penhagen and its partners set up the City and Commuter Bike Foundation (CCBF). The foundation's purpose is to improve the public transportation system and make it an attractive alternative to driving a car.

After a tendering procedure, the partners settled on Gobike as the provider of the more than 1.860 new bikes. The bike is unlocked via a tablet and also has an electric motor. The tablet can be used to navigate around town but can potentially run many different applications. Copenhagen will also use the bikes' technology to collect traffic data.

Users can either use the bike sharing system via a monthly subscription or by paying an hourly rate. As a special perk to encourage commuters to subscribe, short trips (30 minutes or less) are free to subscribers.

"The bikes are distributed over a network of 105 bike stations across Copenhagen and the neighbouring municipality of Frederiksberg. The locations specifically target busy traffic hubs like metro, bus or train stations," explains Tina Füssel, CEO of City and Commuter Bike Foundation (CCBF).

RESULTS: TRIPS HAVE QUADRUPLED

After a quiet start in 2015, the new bike sharing system has made a breakthrough in 2016. In August 2015, the 1.000 bikes in operation were used for a total of 36.000 trips. A year later, in August 2016, a total of 1.600 bikes were used for more than 130.000 trips.

"Copenhageners are starting to incorporate the bike sharing system into their transport habits. We estimate that 40 percent are by foreign visitors, while the other 60 percent are from Denmark. We can also see from the huge number



The bike is unlocked via a tablet and also has an electrical engine to assist the user. Photo by Ursula Bach, City of Copenhagen.

of short trips in the mornings that commuters are using them a lot, and since April the number of subscriptions has risen from 1.300 to 4.000,” says Tina Füssel.

The next step will be to make special offers to companies wanting to offer their employees an easy and healthy alternative to taking a taxi. Moreover, the CCBF will look into expanding the network of bike sharing stations to residential areas with large numbers of potential users. Neighbouring municipalities are also interested in joining the system.

“Copenhagenerers are starting to incorporate the bike sharing system into their transport habits”

Tina Füssel

FACTS ABOUT THE BIKE SHARING SYSTEM

- The City and Commuter Bike Foundation (CCBF) runs the bike sharing system
- The foundation was established by the City of Copenhagen and neighbouring Frederiksberg
- There is a total of 1.860 bikes in Copenhagen and Frederiksberg with around 1.600 in operation.

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GOOD ADVICE AND GOOD PRICES ON ELECTRIC CARS

Copenhagen is playing a leading role in a joint procurement collaboration with several municipalities, ministries and other public organisations. The collaboration helps secure better prices and allows the participating partners to benefit from Copenhagen's extensive experience with electric cars.

A growing number of Danish municipalities and other public organisations are looking to acquire electric cars for their vehicle fleets and for a good reason: Electric cars have lower operating costs than conventional cars, are easier to drive, make less noise, and emit no CO₂ or NO_x particles.

But the constantly shifting market makes purchasing electric cars on public contracts a complicated affair. Additionally, it can be difficult for a single organisation to negotiate competitive prices with the suppliers. For this reason, the Capital Region of Denmark reached out to the City of Copenhagen in 2013, looking to establish a joint procurement collaboration for electric cars.

“Electric car technology evolves so rapidly that requirement specifications quickly become obsolete and keeping track of available models, options and operating costs demands a significant investment of time. We wanted to establish a framework for a joint procurement strategy that was open to public organisations, and we knew that the City of Copenhagen already had significant expertise in this area,” says Kathrine Fjendbo Jørgensen from the Capital Region of Denmark.

SOLUTION: A NEW DEAL AT LEAST ONCE PER YEAR

The proposal was received positively by the City of Copenhagen, and the framework for the joint procurement strategy was put into place. The City of Copenhagen handles the details and requirement specifications of the public tenders and maintains a dialogue with the various suppliers. The

participating partners are then able to order the cars they need through the City of Copenhagen. In the process, they can also request sparring and advice on their choice of car models and infrastructure.

“The collaboration saves the participating partners from a lot of administrative hassle and the need to keep up with the technological development. We put together a new tender at least once a year, due to the frequent shifts in the market. This is essential, both in terms of getting the right prices and ensuring that the latest models are included in the deal,” says David Marc Gurewitsch from the City of Copenhagen.

RESULTS: LEARNING FROM PAST EXPERIENCES

The joint procurement helps ensure that the participating partners get the right cars at the right prices. Being able to lean on the City of Copenhagen's knowledge plays a big part in that regard.

“We can advise the partners on how suitable the cars they have requested are for the tasks they are to be used for. For instance, if a car is to be used for multiple shifts, it needs to be able to recharge quickly. The placement of charging stations can also have a big impact on how much it costs to install them. We take care to maintain a close dialogue with the suppliers, so we know what new models are on the way and ensure that the terms we set are realistic and allow for sufficient competition, so we can get the optimal prices,” says David Marc Gurewitsch.



Photo: Electric vehicles are used for a variety of roles in public organisations, and selecting the right car for the task can be difficult. Photo: Capital Region of Denmark.

BUYING ELECTRIC CARS IN BULK

- A total of 13 public organizations participate in the joint procurement collaboration, which covers electric cars, plug-in hybrids and hydrogen cars
- The City of Copenhagen is responsible for administering the joint purchases. In exchange, partners pay a fee of 3.000 DKK per vehicle
- Since 2014, a total of 162 vehicles have been purchased through the collaboration.

“The collaboration saves the participating partners from a lot of administrative hassle and the need to keep up with the technological development...”

David Marc Gurewitsch

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RAPID CHARGING KEEPS ELECTRIC BUSES ON SCHEDULE

Copenhagen's two new electric buses have zero emissions of CO₂ and particles, run almost silently, and are powered exclusively by renewable energy. City officials aim to have all buses in Copenhagen run on electricity within the next 10-15 years.

When one of Copenhagen's new electric buses pulls silently into its final stop at the terminus, a long arm on the roof of the bus rises up to connect with a charging station mounted above the bus lane. In less than three minutes, the batteries on the bus are fully recharged, and the bus is ready for another trip.

Electric buses are vital elements in Copenhagen's efforts to make the entire public transit system in the city carbon neutral. Today, buses emit about 25,000 tonnes of CO₂ every year, so achieving this will have a significant impact in regards to fulfilling the City's climate goals. Electric buses are an obvious solution, but there are several technological challenges that need to be overcome.

"Electric buses have a number of advantages. They emit no CO₂ or harmful particles, produce very little sound while driving and run on renewable energy produced by Danish offshore wind turbines. We just needed to crack the technological obstacles for making electric buses viable on a city-wide scale. In particular, we have found that charging technology and battery capacity play a key role," says Mikkel Krogsgaard Niss from the City of Copenhagen.

SOLUTION: LIGHTNING-FAST BATTERY RECHARGE

After some test projects with different types of electric buses, the City of Copenhagen recently put two new electric buses into operation.

"In the past seven years, we have gained valuable insights through our trials with different types of electric buses. Previously, the buses had to be recharged at the bus depots, which made it difficult to keep enough buses running on the routes at all times. Our new opportunity charge system at the terminus recharges the buses very rapidly, and the new light-weight batteries have enough capacity for the bus to complete its route without problems," says Mikkel Krogsgaard Niss.

RESULTS: ZERO EMISSIONS AND HAPPY PASSENGERS

The first preliminary reports from the bus operator indicate that the two buses use significantly less energy than anticipated, although this may be due to fair weather. In addition, both drivers and passengers seem happy with their new noise and odourless transportation.

"Support for the project has been overwhelming. Drivers report that the buses are nice and smooth to drive and some local residents have already recognizing the low noise from the new electric buses. With the new charging technology, we appear to have found a viable way to switch from diesel to electricity. The producers of electric buses say, that the electric buses function very well on routes of less than 20 kilometres, and can be supplemented by biogas fuelled buses on longer routes. At this moment, the largest obstacle is the very high tax the Danish parliament has imposed on electricity for buses, which is 200-times higher than on trains and trams," says Mikkel Krogsgaard Niss.



*The pole-mounted charging stations are especially designed for city use, and can recharge the bus in 1-3 minutes.
Photo by City of Copenhagen*

ELECTRIC BUSES IN COPENHAGEN

- The two electric buses will run for a two-year trial period from September 2016 to September 2018 on the 3A route between Nordhavn and Valbyparken
- The electric busses are three to four times more energy efficient than diesel fuelled busses. They use 1.05 kWh/km on average, while a new model diesel bus uses the equivalent of 3-4 kWh/km (2.5-3.4 km/litre diesel)
- The pole-mounted charging stations are especially designed for city use, and can recharge the bus in 1-3 minutes. A bus can run for 3-4 hours between recharges, but then it needs more charging time
- The City of Copenhagen is working to have the first bus line operated solely by electric busses in service by 2019.

“With the new charging technology, we appear to have found a viable way to switch from diesel to electricity...”

Mikkel Krogsgaard Niss

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CLIMATE ADAPTATION WILL RESHAPE COPENHAGEN

Copenhagen's climate adaptation plan is so unique and massive in scale that it will take decades to complete. More than 300 projects will not only protect the City of Copenhagen from increased precipitation, but will also give its inhabitants a unique opportunity to reshape their neighbourhoods and urban communities.

To make Copenhagen climate resilient, as the first capital in the world, the City has developed a grand plan for securing the city against increased precipitation and major cloud bursts. The plan involves rebuilding almost every park and square in the city as well as almost half of the streets, so that they form a vast web of 300 interconnected climate adaptation projects that maintain rainwater in the parks and squares, and utilise the roads to divert surplus rainwater out of the city and into the harbour. This means that climate adaptation efforts will form the backbone of Copenhagen's physical development for years to come.

Connecting the 300 climate adaptation projects in a citywide grid are 50 cloudburst pipes as well as four major cloudburst tunnels like the Østerbro Tunnel described below. The plan is still in its early stages and the current priority is to secure major rainfall recipients like parks, lakes and the harbour. The City will harvest the full benefits of its efforts when all the projects are connected to the grid in 2035.

CREATING SYNERGY WITH URBAN RENEWAL

While all climate adaptation projects add value to urban communities by protecting them from flooding and providing better rain water management, some hold the potential for even greater benefits. For instance, by establishing more urban nature, creating new urban spaces or increasing the quality of existing ones. This is especially true if the local residents and businesses are involved throughout the process, strengthening their commitment and sense of ownership.

In this chapter, you can read about the successful restoration of Skt. Annæ Square, which demonstrates the process for the type of climate adaptation project mentioned above. The square has been completely transformed from a crowded parking area for cars into a new breathing space for Copenhageners, while also being able to delay and transport large amounts of precipitation during cloudbursts.

Ideally, climate adaptation projects should aim to strike exactly this balance between improving urban spaces and quality of life while also fulfilling their hydraulic purpose of making the City resilient to a future with increased precipitation. To facilitate this, it is possible to apply for co-financing of climate adaptation projects that have dual purposes – such as remodelling a road to manage precipitation during cloudbursts. Private foundations and donors also play a big part in making these opportunities reality.

CLOUDBURST TUNNEL PROTECTS ØSTERBRO

Not all climate adaptation projects are suitable for urban improvements, but they still play a vital role in the grand plan to protect the city from flooding. Copenhagen's neighbourhood of Østerbro is a good example of how urban development can create barriers to the natural flow of water from precipitation. The neighbourhood sits on a hill with a natural slope towards the harbour, but a massive cloudburst in the summer of 2011 showed that a railway embankment stops the water from flowing to the sea.

A part of the grand plan therefore includes four major cloudburst tunnels. One of these ensures that water from cloudbursts can be safely directed from Østerbro towards the harbour. Construction of the tunnel, which is expected to cost more than DKK 100 million (approx. USD 15 million), began in 2015 and will be finished by early 2017.

The Østerbro tunnel has a considerable hydraulic effect and will greatly reduce the risk of floods. As such, it will be the backbone in protecting an area with 22,000 citizens from cloudbursts. Without it, Copenhagen would have to manage precipitation in the regular sewerage system, which would have meant pumping water across town to the City's wastewater treatment facility, Lynetten.



Preparation of the tunnel boring machine for the Østerbro tunnel. The tunnel has considerable hydraulic effect as it will ensure that water from cloudbursts can be safely directed from Østerbro towards the harbour. Photo by HOFOR

COORDINATING THE COMPLEX PROJECTS

The climate adaptation projects in Copenhagen are being developed, constructed and maintained in a close collaboration between the City of Copenhagen and a wide range of partners, including HOFOR, the Utilities Secretariat, other municipalities, public and private foundations, residents and business owners. For example, the climate adaptation plan includes a joint initiative between Copenhagen and its three neighbouring municipalities, Frederiksberg, Gentofte and Gladsaxe to drill a massive Y-shaped tunnel to relieve an overburdened catchment area north of the City.

The City of Copenhagen is managing overall coordination and is responsible for 2/3 of the 300 projects, while the remaining 1/3 are on private property. This is a demanding task, but there are immense benefits to be gained by careful coordination. Financially, there is a significant potential for planning several projects at once, for instance renovating a road while at the same time converting it to a cloudburst road. Good coordination will also prevent traffic congestion, as it minimizes the need to block roads during construction.

COPENHAGEN'S CLOUDBURST PLAN

The Cloudburst Plan in short:

- The plan consists of 300 projects distributed across seven different water catchment areas
- Realizing the plan will take up to 20 years and will cost an estimated DKK 11 billion
- Yearly project packages are designed to prioritize the gradual implementation of the Cloudburst Plan.

The overall goal of the Cloudburst Plan and the 300 climate adaptation projects is:

- By 2035 to protect the city against a statistical 100-year cloudburst event.

The City of Copenhagen is tracking progress towards the goal of a full implementation in 2035 by measuring the following indicator:

- Reduced risk of flooding by 30 percent, while protecting 160.000 Copenhageners from floods in 2025.

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For further reading visit www.kk.dk

SKT. ANNÆ SQUARE – A BLUEPRINT FOR CLIMATE ADAPTATION

The urban renewal of the historic Skt. Annæ Square is an example of how an integrated approach to climate adaptation projects can have numerous benefits to the city.

The residents in the area around Skt. Annæ Square in the center of Copenhagen didn't realize they were living in a bowl. Until 2 July 2011.

The square was previously mainly used for parking. It is situated lower than its surrounding areas and the square sloped towards the buildings on the edge of the square. Furthermore, the edge of the nearby harbor formed a natural barrier for water. The consequences of this were felt on 2 July 2011 when one of the worst cloudbursts hit Copenhagen in years.

The enormous amounts of water quickly flooded the square and flowed towards the buildings on the edge of the square, flooding basements and stores. The cloudburst shut down businesses for days and the damage costs were considerable.

Therefore, when local politicians decided to build an underground parking facility, they jumped on the opportunity to shoot two birds with one stone.

“The vision was to improve Copenhageners' quality of life through well-designed and appealing urban spaces, while simultaneously improving conditions for cyclists and pedestrians. Finally, the project would provide protection from cloudbursts to the square's inhabitants,” explains Ole Bach, CEO of the Skt. Annæ Company, a company established to carry out this major urban renewal project.

SOLUTION: CITIZEN INVOLVEMENT CREATES BETTER SOLUTIONS

A key ingredient of the Skt. Annæ Square project and its success undoubtedly lies in its systematic involvement of citizens and stakeholders. Usually, the public is involved once or twice during a project of this size. During the Skt. Annæ Square project, neighbors, residents and local busi-

nesses were invited to 12 public meetings and more than 100 participants showed up at each meeting.

“We started the project by asking what the citizens liked about the area and what was worth preserving in the area. This approach revealed that there was broad agreement on preserving the avenue of trees and the grass area in the middle. Those ingredients became fixtures for the project,” says Ole Bach.

In the end, the avenue of trees was extended all the way to the pier, and the grass area in the middle and the sidewalks were widened. That left 3 meters of road on each side for car and bicycle traffic. However, what happened underground was just as significant.

“We began by separating local rainwater from the sewer system by leading it through underground pipes directly into the harbor. We designed the square to handle large amounts of precipitation during cloudbursts by lowering the square so it slants towards the middle instead of towards the edges,” explains Carsten Cronqvist, Project Manager at HOFOR, Copenhagen's utility company.

RESULTS: MONITORING BENEFITS FROM URBAN RENEWAL

The transformed square was reopened in the summer of 2016 and Copenhageners instantly started using it for recreation and the emergence of several new restaurants in the area proves that the square is quickly becoming a popular venue for the public.

“We intend to monitor development in the area in the coming years to document the effects of the urban renewal project. This will provide us with great insight into the potential benefits of integrating climate adaptation projects with urban renewal projects,” says Carsten Cronqvist.



Skt. Annæ Square was designed to handle large amounts of precipitation during cloudbursts by lowering the square so it slants towards the middle instead of towards the edges. Photo by Søren Svendsen/Kvæsthusprojektet.dk

“We intend to monitor development in the area in the coming years to document the effects of the urban renewal project. This will provide us with great insight into the potential benefits of integrating climate adaptation projects with urban renewal projects”

Carsten Cronqvist

FACTS ABOUT THE SKT. ANNÆ SQUARE PROJECT

- Two thirds of the Sct. Annæ Square project is financed by the City of Copenhagen and its utility company, HOFOR
- The last third of the total financing is from private funds
- The overall costs of the project were DKK 110 million.

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CLIMATE ADAPTATION BUILDS COMMUNITY SPIRIT

An entire neighbourhood in Østerbro is becoming climate resilient. Not only by large projects managed by the City of Copenhagen, but also through dozens of green projects initiated by the residents themselves.

In the St. Kjelds neighbourhood in Eastern Copenhagen, the local urban landscape is being transformed in response to climate change. The transformation is necessary in order for the neighbourhood to handle the increasing volumes of water from heavy rainfall. However, the transformation is not just a physical one, it is a social one as well.

With the Climate-Resilient Neighbourhood project, the City of Copenhagen seeks to gain control of rainwater and minimize the damage caused by downpours in the future, while at the same time transforming the area in order to provide greater recreational value for the residents.

“The overall goal is to create a narrative of an entire neighbourhood moving in a greener direction. On the one hand, we need to implement innovative technical solutions to handle the massive amount of rainwater. On the other hand, we also want to encourage green initiatives from the residents themselves and ensure that the end result not only makes financial sense, but also creates more urban quality and a stronger sense of community,” says René Sommer Lindsay from the City of Copenhagen.

SOLUTION: FINDING THE LOCAL HEROES

Efforts to transform the neighbourhood are happening on different levels. The City of Copenhagen is overseeing the renovation of several public squares and streets, which are being altered in order to handle the heavier flow of rainwater. On one of the streets, Bryggervangen, drains are to be modified in order to separate polluted water from clean rainwater. The first flush of rainwater, which is often polluted by surface chemicals and petrol, will be led into the sewer drains, while the cleaner second flush flows onto nearby green areas of St. Kjelds Plads where it can percolate into the soil.

Along with projects managed by the City, local residents and associations are also able to seek funds for their own initiatives. The City does what it can to support these efforts, and to facilitate more cooperation within the community.

“These local projects are a great way of finding local heroes, and to get resourceful individuals and associations in the neighbourhood talking to each other, and to us in the City. So even though they require more administration and effort, they have other benefits than the purely financial,” says René Lindsay Sommer.



Cleaner rainwater flows onto the green areas of St. Kjelds Plads where it can percolate into the soil. Before it reaches the area the first flush which is often polluted by surface chemicals and petrol, will be led into the sewer drains. Illustration by SLA

“Besides successfully handling the rainwater, we have also boosted social life in the neighbourhood...”

René Sommer Lindsay

RESULTS: GREEN SHEDS AND ROOFTOP FARMS

Supporting the initiative of local residents has paid off for the neighbourhood. A multitude of different private projects have emerged to augment the public projects. They range in scale from establishing rooftop farms and roadside gardens, to planting roses and putting up a rainwater barrel. In total, they all strengthen the sense of community and serve to inspire others to come up with projects of their own.

“Besides successfully handling the rainwater, we have also boosted social life in the neighbourhood. A group of residents have formed a committee to organize activities on Tåsinge Plads, one of the first squares renovated. A local man covered the roof of his shed in green plants, inspiring others to do the same, and several homeowner-associations have invested millions of their own funds into various projects, such as stormproofing basements and planting trees along the streets,” says René Sommer Lindsay.

THE CLIMATE-RESILIENT NEIGHBOURHOOD

- The Climate-Resilient Neighbourhood is a demonstration project, which tries to inspire the rest of the city to think green about climate adaptation
- The project covers St. Kjelds neighbourhood in the eastern part of Copenhagen
- The City of Copenhagen is working together with the Copenhagen utility company HOFOR, Environmental Centre Østerbro and the residents of the neighbourhood.

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MULTIPLYING THE POSITIVE CLIMATE IMPACT

Copenhagen is working internationally with other cities that are tackling climate change. By sharing its own solutions with cities globally, Copenhagen aims to see the positive climate effects multiplied

In a country of a little over 5.5 million people, Copenhagen may seem like a large city. But in a global context the Copenhagen region with its 2 million inhabitants is small. And its efforts to cut its annual carbon emissions of 1.4 million tons CO₂ seem insignificant when compared to the 9.795 gigatonnes (Gt) of global CO₂ emissions in 2014.

That is why Copenhagen puts a great deal of effort into working internationally with other cities. Because by openly sharing and developing solutions with other cities and working together with companies and universities, Copenhagen's climate work has a greater chance of inspiring other cities to take action.

And cities need to take action. Population projections estimate that the global population will rise to 10 billion people by 2050. In the same time frame, the global middle class is set to rise from 2 billion to 5 billion, improving the lives of millions but also potentially putting an even greater strain on natural resources and increasing carbon emissions.

Therefore, Copenhagen is working to develop universally applicable solutions to the climate challenges of cities.

C40 – MAKING CLIMATE CITIES HEARD

One important organization that the City of Copenhagen prioritizes is C40. The C40 Climate Leadership Group consists of more than 80 major cities, representing over 600 million people and one quarter of the global economy.

The mayor of Copenhagen sits on C40's steering committee that focuses on developing the organization, but C40 is also an important network for city officials to collect and share knowledge on issues related to climate change. For instance, C40 has a professional network on climate adaptation (Delta Cities) and Copenhagen chairs another network focused on green growth.

C40 has been the driving force behind establishing a global framework for monitoring cities' efforts and results on cutting CO₂ emissions. By establishing a global benchmark, cities around the world can work systematically on cutting emissions.

CARBON NEUTRAL CITIES ALLIANCE – CITY EXPERTS DEVELOPING SOLUTIONS

Still in its infancy, the organization Carbon Neutral Cities Alliance (CNCA) is a collaboration of 20 international cities committed to achieving major long-term carbon reduction



Copenhagen puts a great deal of effort into working internationally with other cities. At Copenhagen's climate conference in October 2016 the Mayor of Technical and Environmental Affairs Morten Kabell (second from the right) welcomed several international guests. In the picture (from the left) Maaïke Osi-eck from Amsterdam, Björn Hugosson from Stockholm, Tommy Wells from Washington, Morten Kabell from Copenhagen and Vincent Sapieza from New York. Photo by Troels Heien, City of Copenhagen.

goals. While C40 is also working politically to influence national and global policies on climate change, CNCA is primarily a practical network for city officials and experts to collect and share knowledge on climate challenges facing major cities.

The CNCA has its own innovation fund supporting city projects such as last year's project to find solutions to stimulate private investment in energy retrofiting. The project gathered investment experts as well as the construction industry. In another project on green mobility, CNCA brought together city experts as well as representatives from the auto industry. The project spawned another project aimed at gathering experience in procuring low-emission non-road vehicles in public tenders.

ASSOCIATION AGREEMENTS CITIES WORKING – BILATERALLY

2015 saw Copenhagen sign an association agreement with the City of New York related to climate adaptation. Both cities are familiar with the challenges facing cities as a result of rising global temperatures. In New York, hurricane Sandy wreaked havoc in 2012, and Copenhagen was hit by one of the worst cloudbursts on record in 2011. By signing the agreement, Copenhagen hopes to benefit from New

York's experience in tackling the rising sea levels of the Atlantic. Conversely, New York can benefit from Copenhagen's experience in handling precipitation.

A similar agreement was signed with the City of Washington in September 2016. This agreement relates both to the exchange of knowledge on district energy and climate adaptation. Finally, an agreement is under consideration with the City of Boston.

<http://www.c40.org/>
<http://usdn.org/public/page/13/CNCA>

WELCOMING VISITORS

Copenhagen is happy to share its knowledge on climate solutions. The city has set up a visitors' service with Copenhagen Capacity – the official organization to attract investments to the Greater Copenhagen area.

The service welcomes more than 300 delegations each year.

NEW YORK – USING DATA TO REDUCE EMISSIONS

New York has committed to reducing its emissions by 80 percent by 2050. To achieve that goal, New York’s buildings must become more energy efficient. The city has been successful when targeting the largest ones.

If you have ever visited New York during one of its freezing cold winters, you may have noticed something odd when passing by an apartment building: wide open windows on the lower floors, even in the middle of winter.

New York’s open windows are an example of the challenges facing New York as it strives to cut its greenhouse gas emissions by 80 percent by 2050, a key component of the Mayor’s OneNYC plan to create a more resilient, more equitable and more sustainable City. It also highlights one of the very different challenges facing cities trying to combat climate change.

In Denmark, the City of Copenhagen is aiming to reduce carbon emissions by replacing fossil fuels with biogas in the City’s heating system. In one of the world’s largest cities, New York, completely different measures are needed.

“Most of our buildings have on-site heat production. The heat is usually produced in boilers by the combustion of natural gas or oil and the heat is then distributed throughout the building by steam or hot water. Some of these older steam systems are from the Victorian era,” explains John H. Lee, Deputy Director for Buildings & Energy Efficiency in the New York City Mayor’s Office of Sustainability.

And it’s this uneven distribution of heat in poorly maintained systems that is causing the open windows during cold winters. When temperatures drop, the city’s many steam boilers in its buildings’ basements run on overdrive in order to ensure that heat reaches the furthest apartments, usually on the top floors. The result is that overheated residents on the ground floors open their windows, even though it’s freezing outside.

BUILDINGS AT THE CENTER OF THE TRANSITION

New York’s more than 1 million buildings are at the center of the City’s efforts to reduce its greenhouse gas emissions. In 2014, New York City presented the building sustainability plan, “One City Built to Last” which sets a target for reducing citywide greenhouse gas emissions by 80 percent by 2050. By 2025, New York has vowed to lower emissions from buildings by nearly 3.4 million tonnes, 30 percent reduction.

The energy used in buildings account for nearly three-quarters of the city’s entire emissions, and the solutions to reduce emissions will mainly have to come from energy retrofitting as 90 percent of New York’s buildings will still be there by 2050.

New York decided to focus its efforts based on extensive analysis of energy consumption data. A technical working group carefully examined data and engineering criteria and presented recommendations to the City policymakers on how to transform existing buildings for a low-carbon future. For example, the working group recommends requiring owners of large and mid-size buildings to improve heating distribution systems – especially steam systems. It also recommended that owners assess deep energy retrofit strategies as part of a long-term capital plan.

RETROFIT ACCELERATOR PROGRAM

It is no coincidence that New York chose to focus on its largest buildings first (50,000 square feet or larger). Even though these buildings only account for two percent of properties in the City, the largest buildings take up over half of the built floor area.

Since 2013, the City has mandated that the owners of the largest buildings perform an energy audit once every ten



Most of New York's buildings have on-site heat production.
Photo by Jørgen Abildgaard, City of Copenhagen

years. However, relatively few owners proceeded with the retrofitting recommendations of the audit. Recognizing the challenges associated with undertaking capital improvements and energy efficiency projects, the City launched a Retrofit Accelerator program that provides free guidance for energy retrofitting projects to owners.

“It is a completely free program for building owners to participate in and it has already proved successful. The project is in its first year and we already have a thousand buildings in the pipeline,” says John H. Lee.

He attributes some of the success of the program to the fact that the project stands on the shoulders of an earlier program, the Clean Heat program, that helped building owners convert from highly polluting heavy heating oil to cleaner alternatives.

CREATING INCENTIVES WHEN ENERGY IS CHEAP

One reason that building owners have had little incentive to upgrade their heating systems has been the low cost of heating. The cost of energy is still only a fraction of the tenants' overall rent and therefore New York has had to highlight other benefits of switching to cleaner heating.

“The Clean Heat program targeted heavy fuel oil users because we were able to document that the use of heavy heating oil contributed more to particulate matter air pollution than all the cars and trucks in the city combined. We now have the cleanest air in over 50 years and the air quality will continue to improve as we transform the way New York is heated,” says John H. Lee.

NEW YORK

– ENERGY EFFICIENCY IN BUILDINGS

- New York has created the Retrofit Accelerator program targeting the City's 26,000 largest buildings
- The largest buildings are 50,000 square feet or more but the City looks to expand the program to mid-size buildings as well (25,000 square feet or more)
- New York aims to cut greenhouse gas emissions from buildings by 30 percent by 2025
- New York's buildings sustainability plan is laid out in “One City Built to Last” from 2014
<http://www.nyc.gov/html/builttolast/assets/downloads/pdf/OneCity.pdf>

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WASHINGTON – MAKING THE CITY RESILIENT

Washington, D.C. wants to improve its resiliency – whether it be towards terrorist attacks or climate change. One tool is a new cooperation between D.C. and the City of Copenhagen.

A house overlooking the Potomac River is high on many a wish list in Washington, D.C. Properties on the river bank usually fetch good prices, which is why developers are eager to open up new areas near the river for development. But the city has recently taken a cautious approach to parceling out new land.

“Washington D.C. is a city on two tidal rivers so we are affected by rising ocean levels. Even without the rising sea levels, water would be rising as the land that D.C. sits on is gradually sinking. Furthermore, we are experiencing more and more violent storms causing flooding in parts of the city we are not used to. So, we are looking to make changes to our zoning laws,” says Tommy Wells, Director of Washington, D.C.’s Department of Energy and Environment.

He is especially referring to the 2015 violent storm (a derecho) that cut power for thousands of customers in the city. In addition, a series of weather records has put resiliency to climate change high on the agenda. In 2016, Washington, D.C. experienced the hottest summer on record, the longest string of hot days, as well as the longest string of rainy days.

IMPROVING RESILIENCY

Washington, D.C. recently released its first ever climate adaptation plan. The plan lists a number of initiatives designed to improve the city’s climate resiliency. For instance, the plan will mean changes to building codes and zoning laws.

“Resiliency, to us, means being able to respond to disaster in any form: From a train wreck with toxic materials to terrorist attacks to climate change. Therefore, a part of our effort will focus on educating building owners and citizens about preparing the city to be resilient,” says Tommy Wells.

To help Washington D.C. further in its climate adaptation efforts, the city recently signed a memorandum of cooperation with the City of Copenhagen.

“There is an urgency around managing flood events, and

D.C. has a river that has historically served the same purpose as the port of Copenhagen. Copenhagen has managed to turn its harbor into an asset where the citizens can swim and recreate, and we want to be able to that as well,” says Tommy Wells.

CITIES COOPERATING TO TACKLE CLIMATE CHANGE

Cloudburst management is just one of the areas that D.C. and Copenhagen will be cooperating on. D.C. will also be looking to learn from Copenhagen’s experience with district energy.

“District energy holds a lot of potential for us but also poses challenges. Individual building owners are not used to cooperating so until now, our primary experience with district energy comes from university campuses that have just one owner,” says Tommy Wells.

Recently D.C. also got its hands on an abandoned military base that will be converted to a residential area with schools, grocery store, and other retail uses. This area is ideal for testing district energy. In another project, Washington D.C. intends to use geothermal technology to use the heat generated from one of the city’s sewage pumping stations to heat buildings.

THE CHALLENGE OF HANDLING PEAK DEMAND

Most of Washington, D.C.’s heat is produced from electric sources. Electricity is produced through a mix of coal, nuclear, some wind, and some gas-powered plants. Recently, natural gas has substituted coal in many power plants because costs of natural gas have fallen as result of fracking. The shift has reduced the city’s greenhouse gas emissions substantially and improved air quality as well.

Tommy Wells also sees D.C. and Copenhagen facing similar challenges when it comes to energy storage and demand management.



Washington, D.C. is affected by rising ocean levels because of its location on two tidal rivers. Recently the city released its first ever climate adaptation plan that includes changes to its zoning laws.

“Copenhagen with its large share of wind energy obviously faces challenges in having enough energy when demand peaks. In the U.S., we are very dependent on air conditioning and almost all of our buildings are controlled by ACs. We, like Copenhagen, are looking to shift parts of our energy consumption away from peak hours so we might, for instance, start producing ice for cooling at night when power is cheaper,”

Tommy Wells

WASHINGTON, D.C. COOPERATING WITH COPENHAGEN

- Washington, D.C. and the City of Copenhagen signed a memorandum of cooperation in 2016.
- The memorandum details four fields of cooperation between the two cities:
 - Heavy downpour/cloudburst management
 - District Energy
 - Sustainable energy generation, distribution and efficiency projects
 - Regulatory frameworks to address climate change challenges
- The Sustainable DC Plan is Washington, D.C.'s strategy to make the District the healthiest, greenest, and most livable city in the U.S. by 2032.
- For further reading visit: <http://doee.dc.gov/service/sustainability>

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AMSTERDAM – GETTING SERIOUS ABOUT CIRCULAR

There has been plenty of talk about the need for a transition to a circular economy. Amsterdam however is putting its money where its mouth is.

In Amsterdam there is a residential building that is set to be demolished. As part of the demolition, the building's materials will be recovered, cleaned and transported to a regional material bank or straight to another building site, where it will be used in the construction of a new building.

At the moment, this is merely a vision of what the future could have in store for the circular chain of construction materials. At the moment, this is not much more than a vision for a circular chain for construction materials. However, unlike most other cities, Amsterdam has developed concrete strategies to make this vision a reality.

The 2016 publication "Circular Amsterdam" presents a framework for discovering and analyzing resource flows that have the potential to be organized circularly. One resource flow of particular interest is the building sector as Amsterdam is set to construct 50,000 new homes in the coming 10 years.

The analysis concludes that by organizing the building chain for newly built houses in a circular way, the City of Amsterdam can achieve at least a 3 percent productivity increase worth EUR 85 million per year. The potential may be far greater as the analysis only looked at a value chain for construction of new houses while Amsterdam's biggest challenge lies in sustainable (re)development of existing buildings.

THINKING CIRCULAR ACROSS THE ORGANIZATION

"Our sustainability efforts during this political term follows five transitions paths. On the first path, we work towards incorporating more sustainable energy into our energy system while increasing our energy efficiency. On the other path, we are trying to improve air quality in the city and have zero particulate emissions by 2025. Moving towards a circular economy is the third path and the overarching theme throughout the agenda. Lastly, we are working on climate

adaptation as well as working on becoming a sustainable organization ourselves," explains Eveline Jonkhoff, Strategic Sustainability Advisor from the City of Amsterdam.

In other words, circular economy considerations are being incorporated into the city's planning. However, Amsterdam is not pursuing circular economy goals blindly.

"We started by looking at sectors where a circular approach would have the potential to benefit the Amsterdam region financially. Secondly, we tried to determine what role, if any, the City of Amsterdam has in stimulating a move towards a circular economy. The construction sector is an obvious example because it is a sector that employs more than 75,000 people in Amsterdam and because the City of Amsterdam is involved when it comes to awarding land for construction," says Eveline Jonkhoff.

IDENTIFYING AREAS FOR THE CITY TO GET INVOLVED

Estimates suggest that by organizing the building chain in a circular way e.g. new build homes, Amsterdam could create 700 new jobs in the construction sector, while saving 500 tonnes of materials each year. The total potential will be far more. The researchers have advised the city government to start in three key areas where the City of Amsterdam can play a role:

Firstly, Amsterdam could support a circular approach in the building sector by allocating locations suitable for physical storage of reused building materials (regional material banks). Secondly, Amsterdam could help establishing a circular chain by looking into developing procurement guidelines with specific requirements for high-value reuse.

Lastly, Amsterdam could help by implementing a materials passport for buildings, which contains relevant information regarding materials and possibilities for reuse.



The City of Amsterdam is looking at the building sector as a resource flow of particular interest as Amsterdam is set to construct 50,000 new homes in the coming 10 years. Photo by City of Amsterdam

Amsterdam is preparing policy based on the research and the market consultation. At the same time, Amsterdam also believes in 'learning by doing' which is why the City is currently looking into testing circularity in a tender procedure.

MARKET CONSULTATION IS CRUCIAL

Though the City of Amsterdam has ways to nudge the building sector towards a circular path, whether or not a circular materials chain can be established will ultimately depend on the businesses. Therefore, the City of Amsterdam is working systematically on market consultations as well as establishing partnerships with businesses and research institutions.

In the short term, Amsterdam will test possible solutions during the course of three test projects.

“We started by looking at sectors where a circular approach would have the potential to benefit the Amsterdam region financially”

Eveline Jonkhoff, City of Amsterdam

AMSTERDAM AND CIRCULAR ECONOMY

- Amsterdam follows seven principles of circular economy. One of the principles is that resources must be used to generate value (financial or other). Another principle is that new business models should enable a shift from utilizing material goods to the utilizing services
- Amsterdam has examined possible circular chains in both the construction industry as well as in organic waste management from households and businesses
- You can read the report “Circular Amsterdam” here (LINK: <http://www.circle-economy.com/wp-content/uploads/2016/04/Circular-Amsterdam-EN-small-210316.pdf>).

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HAMBURG

- A “CLIMATE SMART CITY”

Germany’s second largest city is conscious of its global responsibility and has been promoting climate change mitigation for many years. At the same time, the measures required to adapt to climate change are being put in place.

The city of Hamburg is affected by climate change on several fronts. Firstly, Hamburg depends on its port and its dykes to protect the city from tidal influences, floods and storm surges. Without the dyke system, parts of Hamburg would be under water several times a day. For that reason, an extra 50 centimeters have been added to the height of new dykes. Further planning will secure accessibility to the port and protection against storm surges.

“Heavy rainfalls have become frequent in Hamburg and the surrounding areas, causing flooded basements, streets and houses. Therefore, the city has begun implementing measures to keep the rain water in place or store it, for example via our green roofs program,” explains Hans Gabányi, Director-General of Nature Conservation, Green Spaces and Energy in the Hamburg Ministry of Environment and Energy. He is also Hamburg’s climate coordinator.

Another issue is urban heat affecting the inner city and this issue will be of even greater importance in the future. Therefore, Hamburg’s future planning will consider the effects of rising temperatures, urban heat and building activities, and work towards leaving parks and cool air routes untouched.

However, Hamburg already has decades of experience with decisive climate action. With the Hamburg Climate Plan from 2013, Hamburg formulated a vision of a modern city in which climate mitigation and climate adaptation are fundamental components of society. With this climate plan, Hamburg set out to become a “Climate Smart City”.

BUILDING WITH TIMBER AGAIN

As a growing metropolis, Hamburg feels a particular responsibility – especially with regards to the housing sector – to support Germany’s national targets.

The city is focusing its efforts on residential buildings constructed before 1978 and on non-residential buildings for commercial or public use. To stimulate energy retrofitting, Hamburg has introduced several funding programs aimed at private owners, housing companies and businesses.

Based on its experience from the International Building Exhibition (2006-2013), Hamburg aims to continue implementing innovative building structures and funding them when appropriate i.e. using future-oriented construction methods such as timber construction (including for multi-storey buildings), modular constructions, self-builds, etc.

“We think it equally important, if not more important, to set an example of public ownership, particularly with regard to refurbishment, energy efficient modernization and the construction of new public buildings,” says Hans Gabányi.

THE DEFINITION OF CLIMATE SMART

“To us, ‘Climate Smart City’ means a climate friendly city which has adapted to climate change. We have defined the following four strategic clusters which indicate the fundamental direction of the transformation process towards becoming a ‘Climate Smart City’,” says Hans Gabányi.

Hamburg’s four strategic clusters are:

- Transformation of urban spaces – Integrating climate mitigation and climate adaptation into the city’s development goals will primarily take place at the neighbourhood level.
- Green economy – Hamburg’s industry will live up to its responsibility to society as a whole and make its contribution to climate mitigation and adaptation targets.
- The city as a model – As part of its activities, the public sector will make an exemplary contribution to reaching the climate protection targets.
- Climate communication – As many city stakeholders as possible need to work on developing the Climate Smart City Hamburg.

“Hamburg has already made great progress towards becoming a climate-friendly city worth living. But further efforts still lie ahead and we will need continued cooperation with all stakeholders as well as maintain transparent administrative procedures in order to be successful,” says Hans Gabányi.



*Green roof of HafenCity University Hamburg. Hamburg has started implementing measures to keep the rain water in place or store it, for example through the green roofs program.
Photo by Isadora Tast/Hamburg Ministry of Environment and Energy.*

HAMBURG'S CLIMATE EXPERIENCE

- Hamburg has been actively following a climate action policy since 1990
- By adopting the Hamburg Climate Action Plan 2007-2012, Hamburg bundled and extended its climate related activities to a central structure
- Hamburg initiated a comprehensive program with several hundred measures as well as a EUR 115.5 million funding program
- Hamburg reached its goal of reducing carbon emissions by 2 million tonnes in 2013
- After reaching the goals of the Climate Action Plan, Hamburg adopted the Climate Action Master Plan with the further aim of reducing carbon emissions by at least 80 percent by 2050
- In 2013, the Hamburg senate adopted the Adaptation to Climate Change Action Plan
- Parallel to the Paris climate negotiations in December 2015, Hamburg adopted its Climate Plan with the ambitious resolution to halve carbon emissions by 2030 compared to the 1990 levels.



Hans Gabányi. Photo by Cordelia Koenig/Hamburg Ministry of Environment and Energy.

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STOCKHOLM –THE WALKABLE CAPITAL

Sweden’s capital has close to 20 years’ experience in tackling climate change. After focusing its efforts on reducing emissions from heating, Stockholm is now successfully changing the way citizens transport themselves.

When you turn the tap in Stockholm and pour a glass of water, it will be from the lake Mälaren, located to the west of the city. The lake is Sweden’s third largest, covering 1,140 square kilometres and supplies more than 2 million Swedes with drinking water. However, a threat to this abundant source of drinking water has started to emerge.

- Stockholm is a city on water. To the west we have Lake Mälaren and to the east we have the Baltic Sea. But the freshwater of Mälaren is only 70 centimetres above the sea level. If sea levels rise much further we risk the Baltic Sea intruding into our drinking water reserve in Lake Mälaren, says Björn Hugosson Head of Stockholm’s climate unit.

Stockholm is determined not to let that happen and therefore the City has undertaken a large upgrade of its old lock system, Slussen, that serves as a barrier between the freshwater of Lake Mälaren and the saltwater of the Baltic Sea.

The rising sea levels may threaten Stockholm’s drinking water but, for the moment, citizens need not worry about the risk of floods. The land where Stockholm is situated currently rises at a greater rate than sea levels but projections show that by 2050, the sea rise will begin to overtake the land rise.

Temperatures in Stockholm have risen during the last three decades. The winters have become milder with more rain-fall. During some winters, unusually heavy snowstorms have gridlocked the Swedish capital.

SWITCHING TO BIOMASS

Anyone who has ever visited Sweden can perhaps quickly guess which sources of renewable energy the country relies on: the country has enormous forests to supply biomass and streams and lakes that are ideal for hydropower.

In Stockholm, 80 percent of residents get their heat from the district heating system, which has been developed over the last 50 years. Earlier, the City’s three Combined Heat and Power plants (CHP) ran mostly on fossil fuels, but Stockholm has gradually shifted towards a greater use of biomass and waste incineration. Today, only 20 percent of the City’s heat production comes from fossil fuels. At the same time, Stockholm has been working towards improving the energy efficiency of its buildings.

STOCKHOLM LOVES ITS CONGESTION CHARGE

Stockholm’s location right between a massive lake and the Baltic Sea means that the city relies heavily on bridges to tie the city together. The bridges create natural bottle necks for traffic and even with 57 bridges in total, Stockholm has struggled with heavy congestion.

- Ten years ago, Stockholm introduced a congestion charge that was hotly debated at the time. The proposal nearly didn’t pass due to rigorous opposition but traffic researchers insisted that a congestion charge would be the best way to alleviate some of the City’s traffic congestion. And they were right, says Björn Hugosson.



Stockholm Royal Seaport is the newest eco-district in Stockholm. Here, solutions on transport, waste management and energy efficiency are developed and then spread to other areas of the city. Photo by City of Stockholm.

After an initial trial period of six months, during which motorists were charged 20 SEK (about \$2.3), the congestion charge was made permanent. Traffic in the inner city dropped by 20 percent.

- Motorists were pleased with the charge because they felt they got something back as congestion in the inner city decreased. Later, it was decided to use the profits from the congestion charge to invest in improving infrastructure and that increased public support of the charge, explains Björn Hugosson.

The congestion charge is an example of how the City of Stockholm is working to use existing infrastructure to create more efficient transport.

CITY MADE FOR WALKING

Another guiding principle of Stockholm's transport planning is to improve conditions for pedestrians and cyclists. The City even has a masterplan focusing on the walkable distances in Stockholm.

- Perhaps due to our weather, we have not had much bicycle culture in Stockholm, but things have improved considerably during the last years. By focusing on creating safe and easy ways for cyclists and pedestrians to get about the city, we are encouraging people to forego using their cars in the city, says Björn Hugosson.

In Björn Hugosson's words Stockholm is a bit "envious" of Norway with its high percentage of electric vehicles, but EU regulation setting emissions limits for vehicles has helped to reduce emissions. Furthermore, the City of Stockholm has launched its own clean vehicles program together with car manufacturers in order to develop solutions towards reducing carbon emissions. There are now more than 20 refueling stations around the City for biogas fuel used by taxis, trucks and private cars, and municipal parking is now being equipped with charging facilities.



Björn Hugosson, Head of Stockholm's climate unit. Photo by City of Stockholm

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