Copenhagen, Nordhavn

Implementation Plan

Tina Hjøllund, City of Copenhagen
Jørgen Boldt & Niels Hendriksen, Greater Copenhagen Utility (HOFOR)
Per Sieverts Nielsen, DTU

December 2014

photo CCPD

Nordhavn today – a large construction site

Copenhagen has defined Nordhavn as its Smart Urban Lab (SUL) in Transform. Nordhavn is a filled in peninsula located in the Northern part of Copenhagen and has up until now primarily functioned as an industrial harbour. The planning process to transform Nordhavn into a vibrant city for residents and business began some 10 years ago and will continue over the next 50 years.

CONTENTS

Tables

Figures

Preamble

This implementation plan is a deliverable in the EU-transform project work packages 4. The aim is to describe how to develop Nordhavn into a smart urban lab and how and with whom to implement projects that will contribute to the TRANSFORM KPI's related to energy. Following this, the working with the Implementation Plan has been very helpful to accelerate part of the ongoing processes in our SUL. Some of our primary stakeholders HOFOR and DTU have taken part in processing this plan and the landowner CCPD has participated in workshop co-creating the concept for an early dialogue together with stakeholders lead by the municipality. Chapter 4 in the implementation plan will be used as roadmaps for the SUL in the future.

Used abbreviations

ÅHG	Århusgadekvarteret
CC	City of Copenhagen
CCPD	Copenhagen City and Port Development
CHP	Combined heat and power plant
CPH	Copenhagen
DGNB	Deutsche Gesellschaft fur Nachhaltiges Bauen, (certification norm like LEED) The DGNB standard is a German building standard that has been selected as the standard for sustainable areas and buildings in Denmark. (certification norm like LEED)
DSO	Distribution system operating companies
DTU	Technical University of Denmark
HOFOR	Greater Copenhagen Utility
ILS	Intensive lab session. Transform method where experts from the partner cities join for a 3 day intensive workshop to focus on 3 challenges chosen by the city hosting the event.
SUL	Smart urban Lab

Executive Summary

This implementation plan gives background information about Copenhagen and the development in the district of Nordhavn so far. The implementation plan focuses on ideas to increase the ability to realize the ambitious goals in the Master Plan from 2008, before the financial crisis, which was a setback for development also in Denmark.

The Transform group has decided to focus on three specific themes – smart buildings, early dialogue with developers and involvement of citizens – and the more general theme of energy to get new ideas, accelerate the process and increase the ability to implement. The aim is that the area will end up being a “state of the art”-district and a testing ground for new solutions.

The vision expressed in the Master Plan for Nordhavn is to create a new sustainable and vibrant city district for everyone. However, the prizes on land in Nordhavn are among the highest in Denmark, which leaves the city and developers with very little space for experimentations and test of new solutions. The variety of housing types is poor at the moment and expensive privately owned apartments dominate.

The City of Copenhagen has an Urban development agreement signed with the land owner, Copenhagen City and Port Development. This Urban development agreement enables the two parties to implement some of the elements in the planning and development of the area that will help meet the level of ambition on the Master Plan from the competition in 2008. In the agreement, the two parties do not commit themselves to different parts of the project that cannot be regulated in the Municipal Plan/zoning and land use) nor the detailed plan for the different parts of Nordhavn. The agreement is a voluntary agreement, whereby the parties agree to work for higher levels of sustainability, for certification, the Energy Partnership for Nordhavn, specific architectural processes for certain plots in the area etc. This is not possible as part of the normal planning procedure in Denmark, so the parties have invented the Urban development Agreement as a specific tool for Nordhavn. The development agreement underpins the specifics of the area and makes it easier to promote to investors and citizen.

One example on involvement of citizen is the architectural competition for the development of Nordhavn. The City of Copenhagen and the landowner Copenhagen City and Port Development hosted a big workshop for citizens and other stakeholders to discuss ideas for the new part of the city. The citizens participated together with other stakeholders such as developers, architects, cyclist union, and local city government representative. More than 800 people participated in the 3 workshops and their ideas were transformed into guiding objectives that formed the building stones in the winning project leading to the master plan.

The main energy supplies to Nordhavn will be in the form of the electricity grid and the district heating network. Electricity is envisioned to play a more important role than presently in Copenhagen, but the efficient Copenhagen district heating system will supply at least the first part of the area with heat.

The buildings in Nordhavn must all comply with the Building Regulation 2020 (BR20) requiring a very low energy consumption, stating a maximum external energy supply (all hot water, heating, cooling and electricity (except lighting) of 20 kWh/m2/year for dwellings and 25 kWh/m2/year for businesses. Since hot water and electricity demands typically exceed 20 kWh/m2/year, this essentially implies that there shall be no space heating demand, unless some energy is produced within the building's premises (e.g. by solar collectors or photovoltaics).

An important part of smart buildings is that their consumption is flexible and that they are able to react to signals both from the house itself but also from the energy systems. The house should then act according to these signals. A smart energy building is thus not only a question of having a low consumption, but also about comfort in the house and increase the overall flexibility for the energy system.

It thus seems reasonable to assume that all heat meters in Nordhavn (all buildings being new) will be electronic on-line meters, since traditional heat cost allocators are too expensive to operative (minimum 4 manual readings per year). Together with on-line electricity metering, which shall be implemented for all consumers before 2020, the heat meters form a sound basis for introducing smarter-than-today energy grids.

In the second phase, corresponding to one local plan area (including Aarhusgade Vest, Trælastholmen and Sundmolen), it has been agreed between the City of Copenhagen and Copenhagen City and Port Development that both the area as such and the

individual buildings must be DGNB-certified. Moreover, developers must participate in the process of dialogue with the City of Copenhagen and Copenhagen City and Port Development on sustainable urban development. The City of Copenhagen welcomes and has great expectations towards the early dialogue with the developers. Normally the City of Copenhagen does not talk with the developers until they have drawn their building and seek permitting to build it. Hopefully this will lead to a more open dialogue about other important issues such as energy supply, use of open space between the buildings not only with the energy provider or municipality but only between developers building in the same area.

From January 2015 a large team of partners including the City of Copenhagen will initiate a new research and demonstration programme “EnergyLab Nordhavn”, with a total budget in excess of 10 million Euros over the next 4 years. The project will focus on Nordhavn and will further research the themes which have been identified at the Intensive Lab session in April. This includes heat infrastructure, electrical infrastructure, heat pumps, smart network technologies, smart buildings, visibility and stakeholder engagement. The project is an innovation project and will demonstrate (test and evaluate) new solutions which can help develop the vision for Nordhavn. A number of specific projects associated with the EnergyLab Nordhavn project are outlined in chapter 4: Implementation measures. Although the project is not directly an outcome of Transform, the Danish Transform partners are involved and will further develop the Nordhavn vision within this project.

1. Background and context information on the SUL and the city

Copenhagen has chosen Nordhavn as the smart urban lab (SUL) in the Transform project. Nordhavn is Scandinavia's largest city development area with expected 40,000 new residents and 40,000 new working places. The vision is that the area will develop into a real-life energy laboratory and be a showroom for future energy solutions and smart energy technologies. The vision got life in a Master Plan for the area in 2008 at the top of a financial boom. However, the financial crisis challenges the high ambition. The development was paused and the ambitions seamed to lower a bit.

The aim of this implementation plan is therefore to get ideas to increase the ability to realize the ambitious goals in the Master Plan from 2008, before the financial crisis, which was a setback for development also in Denmark. To focus the work, the City of Copenhagen hosted a Transform workshop in early 2013 to generate ideas on how to realize the goals. Based on inputs from this workshop, the Transform group decided to work on three specific themes besides energy, namely 1) smart buildings, 2) early dialogue with developers and 3) involvement of citizens.

Facts about Copenhagen

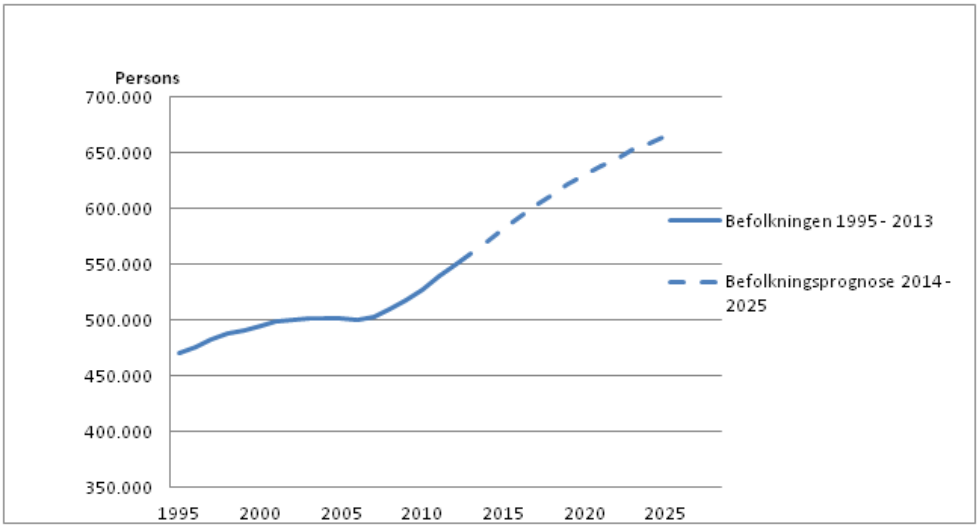
The City of Copenhagen has 550,000 inhabitants and is growing. The city increases with around 1,000 citizens every month. According to new population forecasts, Copenhagen's population will grow by more than 100,000 towards 2025, which means that the population is expected to reach 665,000 by 2025. The strong population growth is the result of increasing birth rates and an increase in the number of families and young people moving to the City. The expected increase in inhabitants is illustrated in Figure 1.

The increased number of inhabitants results in a high pressure on the real estate market. A lot of students move to the city and tend to stay in the city upon completing their education. More and more young people start their family in the city and they want to stay there with their children. This leads to greater demands for cheap flats, but they are hard to find.

Also, the increase in the number of inhabitants and new workspaces puts a pressure on the infrastructure. At present, 100,000 people use the Metro in Copenhagen every

day, and 36% of the people in Copenhagen use their bicycle to commute to work or school every day. The city has a goal for 50% of the Copenhageners to use their bicycle to cover their daily transport needs. In 2012, cyclists biked in average more than 1,270,000 km per day. Copenhagen has more than 300 km bicycle lanes and still the traffic on these lanes is heavy. With the increased use of bikes the cycle lane infrastructure will have to keep growing. The cycle pattern of modern Copenhageners is expected to be daily life in Nordhavn also. It is therefore extremely important to plan sustainable infrastructure in Nordhavn from the beginning, which will make it the easy chose to use a bike or public transport (new Metro line is under construction).

Figure 1: More Copenhageners: 665.000 EXPECTED INHABITANTS IN 2025



Copenhagen is aiming for CO_2-neutrality by 2025 as stated in the Climate Plan, CPH2025. This is a great challenge and ambitious goal as the city at the same time is expected to grow by almost 20% by 2025. The CPH2025 is therefore an important tool in controlling the development.

The focus in this implementation plan is on the smart energy city in Nordhavn. Since it is a new area in the city the planning and regulation of infrastructure and buildings are very important for the future use of the area and for energy consumption.

1.1 Description of the area and its overall development

Nordhavn is one of the largest urban development projects in Copenhagen and Scandinavia. It has been an industrial port, owned by Københavns Havn A/S, which today has become part of “By & Havn” (Copenhagen City and Port Development, CCPD). Nordhavn was filled-in in the end of the 19th century and beginning of the 20th century, where there was high demand for harbour capacity in Copenhagen. However, the harbour activities have changed over the last decades and slowly, the harbour and industrial activities has slowly decreased.

The owner of land in Nordhavn, CCPD, has been a vehicle to finance the establishment of the first metro line in Copenhagen together with the state and the City of Copenhagen by selling land owned by the city, mainly covering land in Ørestad, Nordhavnen and Sydhavnen. The company still has a significant debt from establishing the first metro lines. The selling of the land in Nordhavn is to be used to reduce this debt and finance additional metro lines.

With the history as an industrial harbour, Nordhavn, is regarded as a brownfield area. Its development was laid down in the “Act on urban development of Nordhavn” from 2007. Drafted by the national government. About half of the area is currently used for harbour-related activities, the rest is derelict or vacant land. The central and

Northwestern areas have mainly harbour-related functions and are characterized by large, asphalted surfaces regularly occupied by cruise ship passengers, containers, cargo, stones and scrap.

Nordhavn is to become a whole new part of the city, changing from an industrial area to a new vibrant urban district with offices, shops and apartments.

The decision to draft a long-term plan for Nordhavn dates back to 2005; in 2009 a winning architect and area planning proposal was selected and a Master Plan for the area was drafted by the City of Copenhagen and CCPD in collaboration with Rambøll Management Consulting A/S and architects from 3 companies: COBE, SLETH, Polyform. The time-horizon of that Master Plan extends to 2040. The goal is, mainly new-built, 3,5mio sqm. residential and commercial buildings, to welcome up to 40,000 inhabitants and 40,000 jobs in the area. The figure of 40,000 inhabitants represents seven pct. of the current total figure for the population of Copenhagen!

The development process consists of five phases. The first phase started in 2013 and concerns the first district of the peninsula with 3000 inhabitants and 7000 work places. There are no dates as of yet for the start of the following phases. According to the Master Plan for the development area, Nordhavn must be sustainable, in particular with regards to traffic structure and energy supply. The aim was, that the area should function as a green laboratory. And the so-called “Inner Nordhavn”, which to a large extent comprises the first phase, must at the same time be a vibrant and compact city.

Given the history of Nordhavn as an industrial port, there are virtually no residents living in Nordhavn at present. The greatest activity is that of the land owner negotiating with developers to sell land, and the City of Copenhagen seeking to influence the process to enhance sustainable priorities in the development of the area.

Energy supply

With inner Nordhavn as a brownfield area most buildings will be newly built with a very high energy standard. Thus the heat demand will be low, and it will be possible to introduce low-temperature systems.

To begin with, Nordhavn will be supplied by district heat generated by wood-fired combined heat and power (CPH) plants. Since wind turbines are nationally destined to dominate the power sector within the coming decades, it is envisioned that in

Nordhavn, electricity will become the main source for heating too; primarily through heat pumps using sea water as heat source.

In the SUL there are no specific goals for renewable energy or energy efficiency. To avoid “island thinking” and the risk of sub-optimizing vis-à-vis the energy system, the SUL is subject to the overall goals as defined in the city-wide Copenhagen 2025 Climate Plan, CPH 2025.

1.2 Structure of population and businesses – Nordhavn and its neighbourhood

There is water on three sides of Nordhavn. On the fourth side, there is a short stretch that borders a heavily trafficked regional road (Ring road 2) and a railway area. Behind these infrastructure installations, the closest neighbouring city district – Østerbro – begins.

Østerbro is a very resourceful city district, in socioeconomic terms. Its residents have generally higher incomes and higher levels of education than residents in the city as a whole. The spatial structure of inner Østerbro is characterized by dense buildings blocks, wide streets running through the area and large green recreational areas. In outer Østerbro, roads and railways divide the district into several small city areas with more open space and diverse buildings.

The marina linking Østerbro and Nordhavn hosts about 1,300 boats, and is the place where a lot of people from the neighbourhood meet.

To the southwest of Nordhavn is Søndre Frihavn. In this area, a major urban change started in the early 1990s. It is a mix of housing and service trades located on jetties and around open squares. Few children and elderly people live in this area, whose residents are in the high-income groups.

Over the past decade a lot of headquarters with high architectural quality have been built in the south of Nordhavn. The hope is that the area will be developed in sustainably way and with good architectural design.

Table 1: Basic data for the SUL, (beginning, Phase 1 Århusgadekvarteret (ÅHG), final)

	Status quo (2006)	AHG	Projection (2040)
Total area	2.5 mio. m^2	12,000 m^2	3.5 mio. m^2 (2022)
... of which built up area	429,300		
Nr of population	0-10	3,000	40,000
Nr of households	1 residential and 490 commercial	Residential	3.5 mio m^2 residential and commercial
Nr of enterprises, businesses	490		
Nr of jobs total	5,100	7,000	40,000
Structure of jobs in % (e.g. office, commercial, other services, manufacturing, logistics ...)	logistic, harbour, office	Service	Office, service, logistic, harbour

2. Development process (so far in Nordhavn)

This chapter describes the most important steps in the development of Nordhavn, from the beginning of the development process and up until today Figure 3 below shows the first phases of the development of Nordhavn.

Figure 2: Phases in the development

2.1 Insight in the ongoing development process

The timeline below shows the milestones in the process of developing Nordhavn.

2005 Agreement with the State about Metro Cityring and development of Nordhavn

2007 Law on urban development in Nordhavn

2008 3 public workshops

2008 International urban design competition

2009 Selection of the winning project and further processing of the project (the Master Plan)

2011 Public hearing on local detailed plan for Århusgadekvarteret (ÅHG)

2011 Approval of the local detailed plan for Århusgadekvarteret (ÅHG) in Nordhavn

2012 Agreement on Nordhavn metro

2013 Act on landfill

2013 Approval of the local detailed plan for ÅHG West and Trælastholmen

2014 Local plan for Sundmolen in Nordhavn expected approval

2014 District heating plan for ÅHG approved.

2014 Agreement on additional metro and roadtunnel under Svanmøllebugten to Nordhavn

2019 Metro-branch with Nordhavn St. and Orientkaj expected opening

As the timeline shows, the development process started nearly 10 years ago. It is important to notice that the City of Copenhagen is not the owner of the land in Nordhavn; the land is owned by the development company Copenhagen City and Port Development (CCPD). The city of Copenhagen are responsible to make a Master Plan and a local regulation plan together with the landowner and with involvement of stakeholders. The table show the most important stakeholders:

Table 2: Stakeholders and responsibilities

Stakeholder	Responsibility
City of Copenhagen	Municipality plan, regulation plan, building permits Authority on heat, waste and water.
CCPD, CPH City & Port Development	Develop and sell land
HOFOR, Greater Utility of Copenhagen	Supply of water, district heating, gas and district cooling
DONG	Electricity grid and power
Developers	Build dwellings and company houses
Citizen	Ideas and qualifying zoning plan

Landowner

CPH City & Port Development (CCPD) – who owns the land in Nordhavn – is an urban development company established in 2007. It started as “Arealudviklingsselskabet I/S” and got its new name in 2008. It is a merger of three area specific companies,

“Ørestadsselskabet I/S”, “Frederiksbergbaneselskabet I/S” og “Københavns Havn A/S” all originally owned by the City of Copenhagen and the City of Frederiksberg. In this was way CCPD got to own large areas for potential development in Copenhagen. The main idea with CCPD was to finance together with the state and the City of Copenhagen the establishment of the metro in CPH by selling land in Ørestad. The new metro line (City Circle Line) currently under construction in Copenhagen, is also partly finance by CCPD via its sale of land in Nordhavn. The primary tasks of the company are to develop Ørestaden and the Port of Copenhagen on a commercial basis, as well as to manage certain port operations. CCPD was originally jointly owned by the City of Copenhagen (55 pct.) and the Danish state (45 pct.).

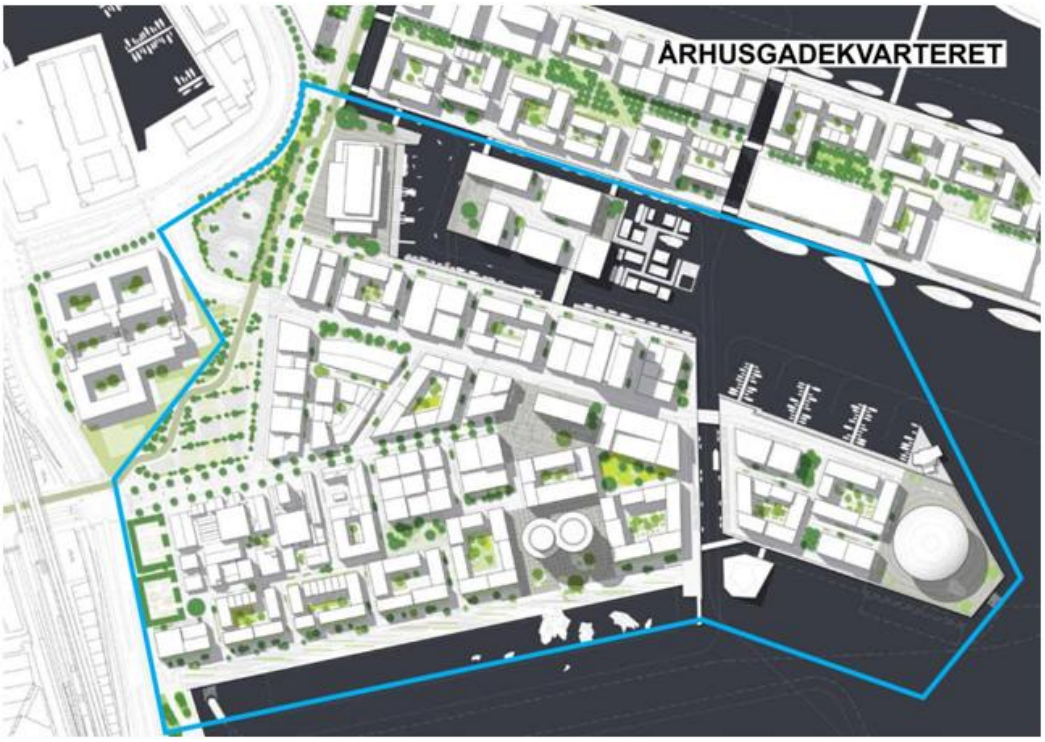
In June 2014 a new agreement between the City of Copenhagen and the state was signed. The agreement includes the establishment of additional metro lines and a road tunnel under Svanemøllebugten to Nordhavn, but also in a new ownership structure for CCPD. Henceforth, the City of Copenhagen now owns 95 pct. and the state 5 pct. of CCPD. This reflects a stronger role and greater responsibility of the City of Copenhagen for the development of the capital, but also the national government’s expectations that the City of Copenhagen function as a growth motor for Denmark.

The prices of the land in Nordhavn are among the most expensive in the Copenhagen. This is both due to location, and to the fact that the construction of the new City Circle Line (metro) in Copenhagen is financed through the sale of land in Nordhavn.(4.8 billion from CPH and 0.8 from Frederiksberg Municipality and about 4 billion from the state)

CCPD is cautious in making demands on developers that could further increase development costs, such as through strengthened sustainability goals suggested in local regulations plans or development agreements between CCPD and the City of Copenhagen. CCPD are according to its purpose to act like a private company and focus on economy. The role of the City of Copenhagen is to try to keep the ambitions on sustainability and architecture high.

The map shows the first phase of the development of Nordhavn. The area is called Århusgadekvarteret (ÅHG) and it is linked to the Østerbro neighborhood by the main road.

Figure 3: Development of Nordhavn



In the first phase of the building process in Nordhavn, existing building codes define the requirements for the buildings. In the following phases, buildings must be certified according to the Danish adaptation of the DGNB standard. In Nordhavn, the City of Copenhagen aims to test initiatives on top of the conventional planning tools. The conventional tools include municipal and local plans, local plan supplements and urban development agreements. In the next phase e.g. “early dialogue with developers” are to be tested. If successful, the City will develop these initiatives further and – perhaps – implement them elsewhere.

In Århusgadekvarteret,(ÅHG) the construction has already begun. The first new office building will be ready in 2014 and the first apartments will be finished in 2015.

Figure 4: Illustration of life in Nordhavn

This neighbourhood of ÅHG is projected to host 3,000 inhabitants and around 7,000 workplaces. The development started in 2009 when the city held an open international competition.

In the summer of 2014 a new showroom for the whole area have opened in the ground floor of the old silo. There is a small cafe, and developers and citizens can have a look at the big Master Plan for Nordhavn. CCPD plans to host different kind of events there and will use it for meetings with investors.

Involvement of citizens

Before the international urban design competition for the development of Nordhavn, the City of Copenhagen and CCPD hosted a big workshop for citizens and other stakeholders to discuss ideas for the new part of the city. The citizens participated together with other stakeholders such as developers, architects, the cyclist union and local city government representatives. The setting with different types of stakeholders brought a holistic approach and made a platform for good discussions in the groups. More than 800 people participated in the 3 workshops, and their ideas were transformed into guiding objectives that formed the building stones in the winning project.

Below is a short summary of the output from the workshops:

- An attractive city district open to everyone in Copenhagen: “put up a sign saying welcome”
- Intensive urban life with a multitude of activities- no-regulation zones

- A range of opportunities for experiences on the waterfront
- “it would be great to be able to plan unpolished”
- A sustainable city and building structure – zero-energy buildings on columns
- All income groups – affordable co-housing for older people

The output from the workshops with citizens in 2008 was transformed into guiding objectives for the further development (see below). The municipality refers to these guiding objectives in the regulations plans for Nordhavn and it gives the developers an idea of what kind of city the citizens want and the context in which they are building their dwelling. Besides these soft objectives the municipal- and regulation plan have a lot of quantitative goals that are mandatory to the area.

Guiding objective for Nordhavn:

- City for everyone
- A city at the water
- A dynamic city
- A city of sustainable mobility
- A vibrant city
- An eco-friendly city

Nordhavn – a city for everyone?

The City of Copenhagen refers to the above mentioned guiding objectives in the planning process for Nordhavn. But due to very high land prizes in Nordhavn, it is almost impossible to build “a city for everyone”. Currently there are impressive housing for people, who are able to pay more than 0.5 million euro for a flat. The 2015 fiscal budget for Denmark included an amendment to the law on planning according to social-housing (publicly owned dwellings), which allows the municipality to prioritize land for social housing to a lower price. The new law on planning prescribes that the municipality can require up to 25% of the dwellings to be publicly owned. This might have a great influence on how vibrant and dynamic the city may become and make it possible for publicly owned dwellings to invest in Nordhavn. At the same time the municipality is given an option to offer social housing companies long-term loans (up to 50 years) with zero interest and zero repayment. This will properly improve the situation in Nordhavn, making it possible for people with lower incomes to live there!

Figure 5: Illustration of Århus torv

one of the places to meet or shop in Nordhavn in the future Masterplan for Nordhavn (2012), by CPH City & Port Development

Source: http://www.byoghavn.dk/files/arhusgade_170912_low.pdf

2.2 Basis for decisions – available data and detailed knowledge

A focus on reducing CO_2 emissions and hence reducing the use of fossil fuel, has meant that energy use data has become important. A city uses energy for a large number of purposes including heating, cooling, mobility and a large number of electrical services. Historically, the city may only have got one heating bill and one electricity bill for their own heat and electricity use across all activities covering many buildings and/or many purposes. This makes it difficult to monitor and target the energy use. For instance if the city does not know how much electricity is used for lighting it is quite difficult to measure and monitor any progress made in this context. In the Copenhagen case, the city gets a bundled electricity bill from DONG and only by trying to un-bundle the bill, it is possible to get an idea of how much electricity is used for traffic lights in the city. When it is difficult to get the specific value on that particular use – even at a monthly basis, imagine how difficult it is to get hourly data on the use of electricity for traffic lights in the City of Copenhagen. It is just an example, but illustrates the major task it is for the city to get full understanding of its energy use. It also highlights how big a challenge it is to transform the energy system and how big a challenge it is to be able to measure and monitor and analyze the data.

Lighting is, though, a good example of how data can be utilized to reduce emissions. It is not only about how much lighting itself use electricity, but also how much electricity the lampposts can reduce of electricity indirectly. The lamppost will not be simply a lamppost in the future. It will have its own IP address and be equipped with a sensor, maybe even a camera and a wireless network. The equipped lampposts will be a virtual network across the city – a virtual network which can deliver new services to people living in the city and will be able to store large amounts of real time data, which can be used to regulate the traffic, lighting, energy use and much more.

This is the vision in Copenhagen Connecting. November 19 Copenhagen Connecting won the World Smart City Award at the Barcelona Expo for being the best project. In December 2014 Copenhagen City has granted more than 7 mill euros for the first step to develop an intelligent steering of the Copenhagen traffic. An example is that installation of cameras in a district of Copenhagen, Valby, has made it possible for a bus line, 4A to move 40% faster through the district for the benefit of the passengers and the city.

The city itself only controls a minor part of energy consumption in the city. It controls energy consumption in public buildings and some infrastructure but otherwise energy is consumed by other parties including the citizens of the city. Therefore the city only has control over a minor part of the energy related data or associated data which is necessary for planning purposes. If the city only consumes 5% of the energy it may also only own that 5% of the data which is related to its own use. The other 95% of the energy consumption the city does not have any ownership of or access to. A city like Copenhagen does not own the energy infrastructure, but may own it through self operating companies. However, the lamppost case above illustrates that new types of data “big data” may be useful indirectly to monitor energy consumption patterns and in this way use it to evaluating actual energy consumption.

The list of energy use purposes is long and highlights how diverse the energy issue is for a city and how spread the responsibility is in the various departments in the city. It also highlights that it is possible to make significant progress on this, However, the cross cutting data collection may need to be centralized in some form to make it operational for the city and in particular if it is going to be possible to develop a common energy data platform for the city.

We can reduce energy consumption through technical means, which does not require knowledge about behavioural patterns and how much behavioural change can help. Heat and electricity is provided in a distribution system so there is a chance that we can have a much more detailed picture of use of energy for heating and electricity use – although these data are geographically specific and hence personal. Reducing energy consumption through behavioural change requires a different set of data. All data which comes from sensors or use of mobile phones are also personal but not geographical specific and they are not regarded as sensitive as geographical heat and electricity consumption data. For Nordhavn, there is furthermore the challenge that there is not much built yet – so there is not much data to be acquired yet.

2.3 Legal framework, tax incentives, aid schemes

The main barrier for sustainable development is the high prizes on land combined with the financial crisis in Denmark. This is a huge impediment to creating a vibrant, varied urban district with different types and sizes of homes, affordable for different income groups and which is sustainable. The financing of the metro circle line has big impact on the development of the district, as the main purpose of selling land in Nordhavn is to obtain financing for the metro rather than developing a sustainable city district.

Spatial planning process in Denmark – making of regulation plans

The City of Copenhagen is obliged to make regulation plans for areas that are to be developed. The plan is usually made in a cooperation between the Municipality of Copenhagen, the landowner and private developers, who wants to realize specific projects.

It takes about 1 year to make a regulation plan for a new area in the city. Regulation plans for Nordhavn have to consider the framework laid out in the the Master Plan for the Nordhavn area, and – as for all areas – the Municipality Plan.

After a public hearing phase, the regulation plan is finally adopted by the Copenhagen city council. Herafter private developers are able to realize their different building projects. According to the guidlines described in the planning documents.

The development of the entire Nordhavn area is expected to continue over the next 30-40 years.

Description of the process to make a regulation plan

(1) Developers ask the municipality for a regulation plan when the company wants to invest in the area
(2) Feasibility study and consulting – how will the new buildings fit into the surroundings and how will it affect the neighbours?
(3) Draft of statement that describes the wish from the developer to build and the city's suggestion on how to meet this wish
(4) Presentation of the statement to the political committee within the City of Copenhagen. Approval of the work towards a new regulation plan
(5) Draft of a regulation plan
(6) Political hearing
(7) Public hearing (period of 8 weeks)
(8) Management of requests from the hearing
(9) Political evaluation and adaptation to implement the new regulation plan

The city of Copenhagen has already adapted the new regulation plan for Århusgadekvatret (ÅHG). The city is currently conducting a public hearing regarding the draft regulation plan for the next phase – Sundmolen.

The City of Copenhagen has the formal responsibility for energy planning based on project-by-project proposals elaborated by HOFOR. HOFOR is responsible for developing plans plus establishing, operating and maintaining the agreed energy plants and infrastructures. Other stakeholders are invited to submit comments and alternative proposals to draft plans in public hearing.

Urban Development agreement between CCPD and the City of Copenhagen

The land in Nordhavn is set at the high end of market expectation as CCPD has to finance the new metro line through the selling of land. This has a big influence on the development. There is not much variety of housing types at the moment. But according to the plan there will be a broad variety of flats from 50 m^2 and 70 m^2 and 60% of other types of sizes and types of housing with a average of 95 m^2. In ÅHG expensive privately owned apartments dominate, but this will not be the picture in the future.

Tthe City of Copenhagen and CCPD have made a development agreement. This development agreement enables the two parties to implement some of the elements in

the planning and development of the area which will help meet the level of ambition on the original Master Plan. In the agreement the two parties commit to different parts of the project that cannot be regulated in the Municipal Plan (zoning and land use) or the detailed plan for the different parts of Nordhavn.

The development agreement focuses on 13 themes:

- Retail
- Energy
- Architecture
- Housing (small/affordable)
- Municipal services
- Environmental sustainability – DGNB
- Waste
- Detailed local plan for subareas
- Local disposal of rainwater
- Harbour bath
- Parking
- Exemptions from detailed plan
- Silo 1.13 ”Århus Torv”

The agreement is a voluntary agreement, whereby the parties agree to work for higher levels of sustainability, for certification, the Energy Partnership for Nordhavn, specific architectural processes for certain plots in the area etc. This is not possible as part of the normal planning procedure. This is why the parties invented this “Urban development Agreement” – as a specific tool for Nordhavn, that the municipality will introduce to other future land owners in other parts of the cities where big projects are developed. The development agreement underpins the specifics of the area and makes it easier to promote the area to investors and citizens.

The City of Copenhagen has invested 4,4 billion in direct municipal spending and more will come with schools, day-care and sports facilities.

HOFOR will invest in infrastructures for district heating, district cooling and city gas, while DONG Energy Distribution will invest in electricity infrastructure. Building owners will invest in all internal equipments and land development. This is elaborated below.

Energy planning

The energy planning in Nordhavn will follow the typical process in Denmark given by the national framework and the specific development framework stated by the municipality.

The heat supply is planned on basis of a national Heat Supply Act stating that the municipality is responsible for making heat plans. This is done in co-operation with the utility company, which in Copenhagen is HOFOR. The municipality asks HOFOR to make an analysis of the best possible heat supply for Nordhavn. The evaluation concerns not only the economic feasibility for HOFOR, but also a socio-economic analysis and user economics. The socio economic feasibility takes into account only the actual cost for society, disregarding subsidies, taxes etc.. This way it is ensured that the solutions are actually the best and not only the most favourable due to the present taxes and subsidies. The comparison is in cities typically made between district heating and the best alternative, which in the case of Nordhavn is heat pumps. HOFOR uses a number of tools in this evaluation and planning process. This includes BALMOREL, an energy system model including the total Nordic electricity and heating systems (www.energyplan.eu/balmorel/). This is necessary as the electricity system is connected with other countries and because of the heavy use of CHP plants in this system. This way the effects on the total system can be included in the analysis. Also hydraulic models like “Termis” are used. For the economic evaluations excel based business case models are used.

The BALMOREL model is open source and is free to use. However, it takes a “solver” and programming expertise to use. Termis is a commercial software and the business case models can easily be created by economists or engineers. The Danish Energy Agency has set up the general framework that shall be used in the economic evaluations as well as in an emission evaluation.

From the above mentioned analyses the municipality then takes a decision, allowing the utility company to make district heating or not. If district heating is not the best solution, the municipality could in principle force the utility company to offer heat supply in another way.

The distribution of powers in the heat planning between the national government, the municipalities, utility companies and the consumers in the heat planning has recently been described in an article[1].

The district heating in Denmark must be operated on a non-profit basis.

Contrary, district cooling is run as a private business, but is also owned by HOFOR. This means that it will only be implemented if there is an economic incentive. The municipality must approve any district cooling applications, before HOFOR can establish such networks.

Electricity grid planning happens much differently than the heat planning. Denmark is electricity-grid wise divided into a number of different areas for which the different distribution system operating companies (DSO) are responsible. The DSO in Copenhagen, DONG, must therefore make sure that the electricity grid is established. The municipal influence on this is relatively small.

Due to the Master Plan, Nordhavn has to be an eco-friendly city and a city for everyone, which also means that people have to be able to pay their energy bills. There are no special goals for Nordhavn on energy.

But since virtually all buildings will be new in Nordhavn, a standard building has been assumed a size of 8,500 m^2 for all new buildings, whether used for dwellings, commercial or institutional purposes. The heating demand (space heating and hot tap water) of each building has been assumed in compliance with the national Building Regulation (BR 2020). According to this, space heating demand shall be zero in buildings built from 2015 onwards. In case heat is produced within a building's premises (e.g. by solar collectors), this may be used to counterbalance a positive heat demand. As a conservative precaution HOFOR has assumed a space heating demand of 3 kWh/m^2/year due to the fact that users of buildings seldom perform according to expectations.

[1] http://authors.elsevier.com/a/1Pvi-14YGgHHX2

2.4 Achievements and experiences

The United Nations City and the City of Copenhagen office building ("KMC-building") in the area are great examples of sustainable buildings in Nordhavn.

The UN building (left picture) is LEED-certified and received a platinum rating. At the very start of the project for a new UN City in Copenhagen, it was clear that the new building had to be very green. It was decided to register the project for certification under the LEED Green Building rating system. Participation in LEED ensured that sustainability was integrated in the project from the beginning.

The KMC-building (picture to the right) is certified by DGNB as the first DGNB building in Nordhavn. It is a building built and owned by CCPD but co-financed and used by the City of Copenhagen on the very outskirts of Nordhavn. The building received Bronze in the DGNB certification process.

Both partners (City of Copenhagen and CCPD) wanted to build a very green combined office and machine hall in Nordhavn. At the end of the projecting phase they decided to use DGNB to show how sustainable the building is. The building is now a symbol of the standard the city wants to achieve in Nordhavn.

DGNB

There are a number of certification systems for sustainable buildings. The DGNB System is special in the way that it provides an objective description and assessment of the sustainability of buildings and urban districts. Quality is assessed comprehensively over the entire life cycle of the building. The DGNB Certification System can be applied internationally and appeal to developers since it is well known in other countries.

The fulfilment of up to 50 sustainability criteria from the quality sections, ecology, economy, socio-cultural aspects, technology, process work flows and site are certified.

If a performance requirement is met, the Green Building Council in DK awards the DGNB certificate in bronze, silver or gold.

Next phase, new standards

In response to an increasing number of renters and building owners who demand certified buildings – that, among others, allow for international comparison of standards – CCPD engaged in a process to certify three districts and a building in Nordhavn. The three districts (Trælastholmen, Levantkaj Vest and Sundmolen covering a total of 26.2 hectares) received Gold in the Danish adaptation of the DGNB-certification in May 2013. The three districts belong to the areas of the second phase of the building process in Nordhavn. The certification implies that the CCPD agreed to demand that buildings in those districts be DGNB-certified too. This is a huge step to ensure sustainable development in Nordhavn!

Link to Green Building Council in DK and DGNB: http://www.dk-gbc.dk/english.aspx

Link to sustainability in construction and civil work:
http://kk.sites.itera.dk/apps/kk_pub2/pdf/762_9gqRMgTcg3.pdf

Energy Partnership

In 2009 the Energy Partnership was formed by the City of Copenhagen, CCPD (landowner), the energy suppliers HOFOR and DONG and the Ministry of Climate and Energy on very high level (CEO). The vision was at this very early state to talk about a new sustainable energy supply and the development of the Nordhavn area. Ideas of geothermal, solar, wind and low temperature district heating, electricity for cruise ships was discussed and business cases was made.

The expectations were high, but the results from this partnership has not been very innovative. The partners state that is has been very positive to meet early in the planning process to get an understanding of each partners' strategy, discuss the vision for the area and solve some of the problems together. But the conclusions from many of the business cases was that the return on investments was too low. Therefore the

vision of Nordhavn as a great test area was limited, because nobody had capital to risk on experiments.

The partnership is not active anymore. The partners tend to inform each other by mail and status reports. Andinstead a new project consortium, EnergyLab Nordhavn, has been formed.

Energylab Nordhavn

The city of Copenhagen is part of a new energy project under the research fund, Energy Development and Demonstration Programme (EUDP). The project is lead by DTU and Center for Electric Power and Energy at DTU. The partners are HOFOR, DONG, CCPD, ABB, CLEAN and the City of Copenhagen.

The EnergyLab Nordhavn project aims to support the transformation of the energy system to a reliable, cost-effective and sustainable system based on renewable energy. The transformed system utilizes the benefits of closely integrated and coordinated energy infrastructures (electricity, heat, cooling, gas, transport etc.) and takes benefit of smart energy solutions based on innovative technology, new operational approaches and commercial approaches.

The overall objective of the project is to develop new methods and tools for design and dimensioning of the future cost-effective multi-carrier energy system (electricity/heat/cooling/transport) based on Nordhavn as an energy lab. It includes development of novel business models, and experiments with smart energy technologies and new intelligent operational solutions.

The project addresses key challenges met in the development of the future smart energy system:

- Evaluation of the smart energy solutions for electricity, heat, cooling and transport which will be needed in areas with dense low-energy buildings, where heat demand is low and dominated by domestic hot-water demand and where buildings may be net energy producers (prosumers).
- Development of a coherent smart energy infrastructure where electricity, heat, cooling and transport are closely interconnected both physically and operationally. The infrastructure would thereby be able to provide the flexibility and services

necessary for absorbing the future energy production from renewable energy sources like wind and solar.

- Development and demonstration of innovative fuel-shift technologies, grid technologies, storage technologies and operational solutions.

The project will start in the beginning of 2015.

3. Status and visions of the themes chosen in the SUL and enabling themes

This chapter focuses on the status and visions of the Transform team's work with energy and the three selected themes, and reflection from our international Transform workshop held in Copenhagen April 2014 (the Intensive Lab Session).

The forthcoming three subchapters thus represent the *enabling themes* chosen for Nordhavn. In these, the status and overall visions will be described and in the corresponding subchapters in chapter 4 specific measures for these themes will be described.

3.1 Energy systems and networks (heating, infrastructure, heat pumps, electricity)

The main energy supplies to Nordhavn will be in the form of the electricity grid and the district heating network. Electricity is visioned to play a more important role than presently, but the efficient Copenhagen district heating system will supply at least the first part of the area with heat.

Because Nordhavn is a brownfield area with almost no residents, the present energy system and the consumption is hardly existing and therefore not of much interest. However, key energy data for the city of Copenhagen can be seen in the tables below.

The current primary energy consumption of the Municipality of Copenhagen (geographic area) is 6878 GWh/year, incl. 2463 GWh electricity. The total greenhouse gas emission is 2.1 million tonnes of CO_2-equivalent per year (please refer to the Status Quo Report for more information).

The total heat demand of a fully developed Nordhavn in 2065 is expected to be around 70 GWh/year. Renewable energy 100%, a large share hereof generated outside the area.

Table 3: Total primary energy consumption for electricity and heating, 2012. Copenhagen Municipality.

Primary energy consumption	6878	GWh/year
hereof:		
Coal	35	%
Oil	1	%
Natural gas	16	%
Nuclear	3	%
Energy from waste	4	%
Wind	33	%
Biomass	9	%

Table 4: Total electricity consumption, 2012. Copenhagen Municipality.

Electricity consumption	2463	GWh/year
hereof renewables:		
Biomass	484	GWh/year
Wind	96	GWh/year
Solar	0.1	GWh/year
Other renewables	133	GWh/year

Table 5: Total district heating supply, 2012. Copenhagen Municipality. 98% of all homes were connected to district heating.

District heating supply	4.745 GWh/year
Coal	22%
Oil	5%
Natural gas	23%
Energy from waste	22%
Biomass	27%
Other	1%

It is important to note, that for Nordhavn there are no specific measures that must be met for the energy supply system as it is a part of Copenhagen and hence a part of the overall goals from the Copenhagen Climate Plan, CHP2025 as well as the overall National energy requirements and goals.

So far, it has been decided to expand the present district heating grid to the first development phase of Nordhavn (Århusgadekvarteret). Figure 8 shows a part of Copenhagen which is supplied with district heating (DH)(blue) together with the planned first phase of Nordhavn for which it has been decided to expand the DH

network to (red) as well as the future development area for which the heat supply has not been decided yet (green). There are no networks for city gas or district cooling, but plans are in the making.

Figure 6: The district heating network being planned in the first part of Nordhavn

The district heating system of the first part of Nordhavn is considered as an extension of the greater Copenhagen system. This implies that most heat for this part of Nordhavn will be produced at biomass combined heat and power plants, waste incineration plants, and possibly heat pumps outside the area. Thus, there will be no local waste-to-energy plants.

Most district heat is entering the area from the South, and this supply mode is envisioned to remain dominant in the future. However, today there are a couple of very small isolated heating networks. One is a new terminal for cruise ships, which is currently being heated by oil-fired boilers, but will be replaced by heat pumps from 2015. In the longer run more such isolated networks may be established, if they are competitive with the greater district heating system.

The question is whether the district heating network should be further expanded to the next development phases or if the heat consumption will be so low that this will be economical infeasible and individual or more local heat grids will be a better solution.

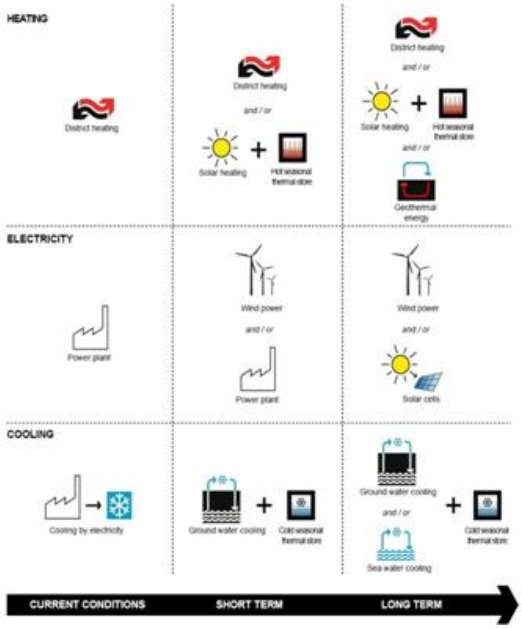
Nordhavn has a long coastline to the sea, and seawater heatpumps appear the most obvious local energy source. Some building owners may opt for solar heating, although the district heating system has abundant supplies of low-cost heat during the summer, e.g. from waste incineration.

Manufacturing industry is unlikely, but some enterprises may generate excess heat, e.g. from server rooms and small data centres. Such heat sources may also be utilized.

A former dry basin for ship building has been examined for the purpose of hot water storage for the district heating system. The feasibility of the store itself was quite good, but since it is situated far from the main district heating network, the total storage and pipeline costs were considered prohibitive. Therefore, other heat storage options outside Nordhavn are being considered.

The energy system in Denmark, and thus also Nordhavn, is expected to undergo considerable changes in the coming decades. This development is likely also to happen in Nordhavn and is illustrated in the figure 9 below

Figure 7: Possible future development of the Danish energy system



.

The general trends in this development are:

- Space heating, which is now dominated by district heating, may be supplemented by local renewable sources, such as solar, geothermal heat and heat pumps.
- A higher share of the electricity production will be based on wind turbines and solar cells rather than thermal power plants. However, the power plants are still important for periods without wind or sun. In the first half of 2014, more than 40% of all electricity consumed in Denmark was delivered by wind turbines.

Table 6: Basic KPIs for Nordhavn (GWh/year)

	2014	Expected 2065
Space heating	ca. 0	18
Hot water	ca. 0	48
Electricity	ca. 0	130
Emission of CO_2 and/or CO_2-equivalent	ca. 0	0
Local energy production from renewable energy sources	ca. 0	?

Note: Nordhavn is a brownfield development area with very few activities (i.e. almost no inhabitants), except some commercial activities. There is no area-specific energy data available for this former free-harbour area. Also, it does not make sense to compare the expected future demands with current demand. Therefore, all data for 2014 have been inserted as “approximately zero”.

3.1.1 Heat supply – visions

In Nordhavn, the choice stands between connecting the new buildings to the existing DH grid, establishing a new local DH network or have separate heat supplies for each building.

On the basis of the process described in section 2.3 it has been decided to extend the present DH network to the first part of Nordhavn as the business case for this is acceptable. This has been approved by the municipality.

For the remaining part of Nordhavn it is still very uncertain what solution will be the best. The heat consumption will be relatively low but the exact numbers are unknown. This makes it very difficult to make decisions about the choice of heat supply. The choice will have a relatively big impact in terms of both economy and environmental wise.

For the next phases it is to be decided in the further development process what solutions will be the best.

There is a proposal to build a geothermal plant in Nordhavn to produce heat for the Greater Copenhagen DH network. Presently there are no concrete plans about building the plant, as the economy in the project is not good. The plant is relatively small (approx. 75 MJ/s) compared to the overall DH system, and is therefore expected to have a relatively small impact, but will contribute with (partly) renewable heat for the system.

3.1.2 Electricity supply – visions

A number of developments are challenging conventional planning of power distribution grids. These concern new load profiles and probably more dynamic load with regard to time of peak due to deployed flexibility.

In addition, imbedded in the smart energy city concept are optimal solutions by embracing and integrating several different sectors – heat, power, transportation, cooling etc. Such integration might add to the dynamics of the load on the electricity infrastructure and offer new opportunities.

Thirdly, Nordhavn represents a “new” city area and buildings are expected to be low-energy and potentially meeting demands on maximum energy-use in future building codes. The low-energy consumption is however seen in an annual perspective and met by equipping the buildings with photovoltaic cells. While the modern city may also contain electrical vehicles, the in- and out-flow of energy in the distribution grid over the day may raise new challenges.

A particular challenge for the electricity supply is that it is quite uncertain, when and how visiting cruise ships will be constrained to receive land-supplied electricity in order to shut down their engines while in harbour.

3.2 Smart buildings – energy demand and energy efficiency

The buildings in Nordhavn must all comply with the Building Regulation 2020 (BR20) requiring a very low energy consumption stating a maximum external energy supply (all hot water, heating, cooling and electricity (except lighting) of 20 kWh/m^2/year for

dwellings and 25 kWh/m^2/year for businesses. Since hot water and electricity demands typically exceed 20 kWh/m^2/year, this essentially implies that there shall be no space heating demand, unless some energy is produced within the building's premises (e.g. by solar collectors or photovoltaics).

This is a rather strict requirement that all buildings in Denmark must comply with by the year 2020. However, all public buildings must comply with this from 2018 and all buildings being built in Nordhavn must presently comply with the BR20.

For comparison the heat consumption in the present Copenhagen is in average 100-130 kWh/m^2/year. On top of this comes the electricity consumption for cooling, air-conditioning etc.

For the first part of Nordhavn the buildings are assumed not to be able to comply with these strict requirements. Instead the heat consumption is estimated to be as showed in Table 7. Existing buildings typically consume 100 – 130 kWh/m^2/year total heat demand.

Table 7: The expected heat demands in the first phase of Nordhavn are (kWh/m^2/year)

	Dwellings	Commercial buildings and institutions
Space heating	3	7.5
Hot tap water	20	7.5
Total heat demand	23	15

An important part of smart buildings is that their consumption is flexible and that they are able to react to signals both from the house itself but also from the energy systems. The house should then act according to these signals. A smart energy building is thus not only a question of having a low consumption, but also about comfort in the house and flexibility for the system.

The flexibility – or "smartness" – of a building is very difficult to put certain measure on. The reason for this might be due to the dynamics of a smart building that is difficult to boil down to one measure but also because of lack of experience with smart buildings.

In order to have a smart building there is a great need for measurement and censoring equipment to generate information as well as equipment to analyse the data. This gives

a number of challenges related to data collection, sharing and use. These issues are not a specific Nordhavn challenge but rather a national challenge.

Smart meters are key equipment in a smart building as this monitors the consumption and might react on energy price incentives.

The current status of smart metering is:

(1) All major buildings have on-line heat metering. It is possible to transmit hourly data (or even 5-minute data), but for most buildings only monthly data are transmitted for billing purposes.
(2) All electricity consumers in Copenhagen shall have on-line metering before 2020.

In consequence of the EU Energy Efficiency Directive (EED) of 25 October 2012 (2012/27/EU), which was transposed into Danish legislation in 2014, individual consumption meters to measure the consumption of heat or cooling or hot water shall be installed in all new multi-apartment and multi-purpose buildings with a central heating/cooling source or supplied from a district heating network.

It thus seems reasonable to assume that all heat meters in Nordhavn (all buildings being new) will be electronic on-line meters, since traditional heat cost allocators are too expensive to operate (minimum 4 manual readings per year). Together with on-line electricity metering, which shall be implemented for all consumers before 2020, this forms a sound basis for introducing smarter-than-today energy grids.

The measurements from these meters bring out a number of new opportunities. Besides the easy access to meter readings, it has not been specified exactly what the measured data should be used for. However, these data can prove valuable in the development of a more flexible energy system.

3.3 Early dialogue with developers – about sustainable urban development

In Nordhavn, Copenhagen is testing how to improve dialogue with developers and landowners on sustainable urban development.

The question is how the City of Copenhagen can achieve this, given the fact that the City through local plans can make only very few firm requirements on environmental standards that bind developers. Therefore voluntary agreements are the way forward.

The City of Copenhagen and CCPD agreed that through the instrument of voluntary "city development agreements" ("Byudviklingsaftaler") between the city and CCPD, certain requirements will be made on developers.

Thus, in Nordhavn, for the second phase, corresponding to one local plan area (including Aarhusgade Vest, Trælastholmen and Sundmolen), it has been agreed between the City of Copenhagen and CCPD that both the area as such and the individual buildings must be DGNB-certified. Moreover, developers must participate in the process of dialogue with The City of Copenhagen and CCPD on sustainable urban development.

The City of Copenhagen welcomes and has great expectations towards the early dialogue with the developers. Normally the city does not talk with the developers until they have drawn their building and seeks permit to build it. Hopefully this will lead to a more open dialogue about other important issues – such as energy supply, use of open space between the buildings – not only with the energy provider or municipality but also between developers building in the same area.

In the City of Copenhagen, within the Transform project, we have worked with a project to form the dialogue with developers on sustainable urban development. The key purpose of the project is to strengthen a fruitful dialogue among developers, landowners and the City of Copenhagen about sustainable urban development in new development areas.

Moreover, the purpose is:

- That the City of Copenhagen speaks with one voice;
- Improvement of the dialogue with developers on sustainable urban development in Copenhagen
- To test the concept in Nordhavn with developers – possibly to extend it to other areas

The City of Copenhagen and the City of Malmö, Sweden collaborated in the EU and Interreg project "Urban Transition Öresund" on financial models to improve sustainable building. During that project, Copenhagen learned that Malmö had an interesting concept for their dialogue with developers and with very good results. Twice as many developers reached level A (Swedish norm) when they participated in early dialogue about sustainability. This is based on 95 cases from 2011-2013 in Malmø. This led to

the idea of developing a project concentrating on this particular dimension of sustainable building.

The Technical and Environmental Administration in the City of Copenhagen has, in collaboration with The City of Malmö, CCPD and stakeholders (including: developers, land owners, architects, consultants and various interest organizations), formed a concept for early dialogue with developers about sustainability. The work method consists in a mix of bilateral meetings between the Cities of Copenhagen and Malmö on the one hand, and workshops with stakeholders on the other. During the workshops, stakeholders were invited to voice their needs, assess the quality of the current level of dialogue, and suggest ways to improve it. This gave the City of Copenhagen a large catalogue of ideas and inputs to form the concept.

A key message from stakeholders was that the City of Copenhagen lacks internal alignment. This translates into differing sets of requirements from, e.g. staff responsible for the environment and energy planning on the one hand, and urban planners responsible for local plans, urban space and buildings in terms of architectural value, on the other.

Another key message is a question of finance, and the lack of a clear business case for building sustainable buildings as seen from a pure business perspective. In December a survey on different business cases will be made by CLEAN (cluster organization around cleantech). This will hopefully bring some best practice examples, which can be given to the developers to convince them to aim for even higher sustainability goals in the future.

The first meeting with developers in Nordhavn will take place in January 2015. The City of Copenhagen plans this meeting in cooperation with CCPD. The topic of the first meeting will be DGNB-certification, since this is a relative new tool for most of the developers and also for the municipality, it has been decided to organise this meeting together with Green Building council.

DGNB is a way of measuring sustainable urban development when more and more buildings get a certificate. In the Implementation Plan, DGNB-certification will be considered a measure. When a developer wants to get a certification, they have to consult a DGNB consultant to design a process for the documentation process and the monitoring of the building process. This will cost extra money, but it can also optimise

the process. The consultant will send all documentation to Green Building Council when the building process is finished. If the building meets all the criteria, the Green Building Council will provide the owner of the building a certificate.

The phase 1 area in Nordhavn has been pre-certified to Gold under the DGNB certification scheme. Once 25 pct. of the area has been developed, the area will be subject to a renewed test to assess whether it keeps the high standard.

In other places in the city, there is currently no mandatory use of DGNB-certification. Instead, the ambition is to use the City of Copenhagen's "Bæredygtighedsværktøj" (the "sustainability tool") that aims at achieving similar results as the DGNB certification process. The sustainability tool assists in the building process, but it grants no certification to the developer afterwards that allows the developer to show that they have achieved a certain level of sustainability.

Provided developers and land owners give positive feedback on the new concept (dialogue with developers) and, provided the concept delivers more sustainable urban development, the concept will be used in other areas of the city. Beyond TRANSFORM and the project Dialogue with developers on sustainable urban development, the new concept will continue and be introduced in local plans for the second building phase in Nordhavn.

As regards the further process for the strategic planning and implementation, the status as of December 2014 is that the new concept for dialogue with developers was adopted internally in the City of Copenhagen administration. The next step is implementation in the municipality and to present the revised concept to CCPD and the developers to get their feedback, and ideally, commitment to the concept and long-term goals of greater levels of sustainability in the area.

If successfully implemented, the new concept will put CCPD in a changed role, basically the City of Copenhagen is asking them to take a more proactive role in promoting sustainability in the area, for instance during negotiations with developers. But also in terms of a greater level of coordination between CCPD and the City of Copenhagen in the process.

While the new concept will expectedly allow for better coordinated processes, there are still many challenges ahead. In particular: How to persuade developers to aim for a

high score in the DGNB certification scheme? And how to develop a clear business case for higher levels of sustainable buildings? The municipality – through the dialogue process – have the opportunity to point at some criteria as leading points for the developers, which will make it easier for them to prioritize. (There are more than 50 criteria in the DGNB certification scheme.)

An important aspect is also to let developers inspire each other to build more sustainable, as they do in Malmø. The developers speak the same language and share ambitious and goals. They are therefore in a good position to inspire each other. The city of Copenhagen can play the role as facilitator and can kick-start the process by showing some best practice examples of sustainable buildings.

3.4 Sustainable living

Generally we have too little knowledge about the requests of the citizens. What kind of city do they want? What kind of smart solutions is required to act more sustainably in everyday life?

The city of Copenhagen has involved the citizens in the beginning of the process in Nordhavn, but where are their voices now?

To gather more information about the request and wishes for a smart city from the inhabitants' viewpoint the City of Copenhagenhad anthropologist interview inhabitants in Ørestad (appendix1) as part of the transform project. Ørestad was chosen, because the houses are similar to Nordhavn, and no one is living in Nordhavn at the moment. They were asked what expectations they have on living in a smart city and if sharing things with their neighbour might be one of the ways to save energy?

People want to be part of a network, where they can share tools, cars and reuse things especially if it is in their own neighbourhood.

They do not want to share their private room with others, but they would like to have access to a guest room, but they do not want to give up a room in their own apartment.

We can see these objections as part of a larger social culture where we associate great value with private life, and where private life is constituted along the lines of the core family – concretely along the lines of the private home. Working with this challenge then, is not only about convincing families to share things and space – maybe rooms.

But working towards creating a broader accept of such approaches in the future, to make it socially acceptable.

Since a lot of young people move into the city there are requests for small and cheep flats. One solution might be to able to share flats/room with each other, which students already do today. This is also a way of saving energy hence two people living in two flats use much more energy than two people living together in one flat.

At the ILS there was also a discussion about sharing and cohousing**.** This is summed up below.

Sharing

In Denmark people have to get some sort of individual advantage before it makes sense for them to participate in sharing. In Denmark people would never share their bicycle, as it is a symbol of individual personality. In Italy people would never share their kitchen, as it is a very important, private and individual room. This shows us that not all solutions can be applied anywhere. Solutions are bound by space and context. The more people have to share something, the less responsible they feel. The more people are part of a sharing project the more anonymous they feel. If you borrow something from someone (personal contact) you feel more responsible to returning it. Sharing builds on trust.

Co-housing projects

The prize on land is very high in Nordhavn, which makes it a big challenge to build co-housing which has a fixed price limit. The existing building code is tight (e.g. on parking space and housing size) according to a developer on the ILS. Developers have to get some profit and have very little room for experimentation. They therefore often build what most people want. “People will only pay for things in their own apartments, not shared space” according to a survey made by a big developer in Nordhavn. At the same time people enjoy green spaces and places to meet with the neighbours. This is what makes it nice to live in the city and is one of the reasons that CPH winds awards again and again for being a liveable city.

There is a fear that Nordhavn will not be a city for everybody, but become a money ghetto. The price for apartments starts at around ½ a million euro.

Next step

One of the ideas from the ILS was to use the Agenda 21 as a platform for innovation. Use existing social infrastructure, make platforms for citizen to discuss sustainable solutions for the city or more likely for their own neighbourhood.

Urban planners from the Technical and Environmental department within the City of Copenhagen has made a proposal for a project on the city budget 2015-2016 to involve citizen in the city planning – "open planning". The idea is to make it much easier for citizens to contribute and develop things together with the municipality. It could be online (e.g smart ways to adopt to heavy rain on private roads) or small workshops (e.g designing a local park) depending on the issue. This project did not get any funding on the budget for 2015. But the technical and environmental department in Copenhagen has a continued strategic focus to involve the stakeholders in the process – especially the end users. Hopefully this will help the city to meet some of the requests from the citizen.

3.5 Other important issues (ICT, Mobility, Water, Waste)

3.5.1 Use of ICT and smart grids

Nordhavn is Scandinavia's largest metropolitan development project. Sustainable urban

development is to be integrated into all aspects of the city district – green traffic, energy solutions and social diversity. Thus, it appears obvious to utilise Nordhavn as a live laboratory for future smart-energy technologies, innovative business models and new operational solutions on all scales – components, buildings, grid infrastructures and system level – and provide basis for design and dimensioning of the energy infrastructure of future sustainable dense low-energy cities.

The key challenges of the future smart energy system are:

- Development of a coherent flexible energy system (electricity/thermal/transport) with novel technical solutions like energy storage by variable district heating temperatures, dynamic grid topology configuration and more integrated markets, where infrastructures are closely interconnected and operationally co-optimized –

enabling flexibility for integration of more renewables with stochastic nature (wind, solar etc.).

- ★ Re-thinking energy infrastructure design and dimensioning methods to accommodate e.g. new low heat demanding buildings, new dynamic demand patterns from price responsive prosumers and fuel-shift technologies.
- ★ Development of energy technologies providing grid services by smart cost-effective controllers and
- ★ associated new business models and user interactions.

The Nordhavn city district will promote Danish energy solutions through high international visibility, emphasizing dissemination and involvement of the building sector to support future deployment.

Also, SME's will be engaged and invited to take benefit of the Nordhavn platform and take spin-off opportunities.

3.5.2 Mobility

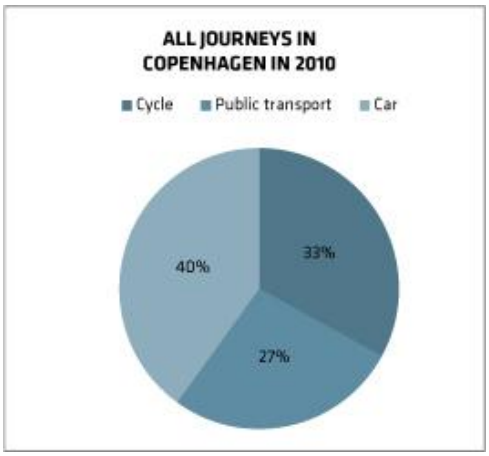
Copenhagen is to be an extremely accessible city, the world's best city for bicycles and a city with a modern cohesive public transport system. Congestion, CO_2 emissions, air pollution and noise from traffic are to be reduced, so that Copenhagen can be a clean and healthy capital city.

Goal for green mobility: At least one-third of all trips in the city are to be by bike, at least one-third to be by public transport and no more than one-third to be by car (Copenhagen Municipal Plan 2009).

A growing population From 2000 to 2010 the Copenhagen population increased by 7%, from 1999 to 2009 the total number of workplaces increased by 10%. This means more traffic. From 2000 to 2010 cycle traffic increased by 13%, the number of people using public transport increased by 10% and car traffic increased by 5%. Given the growth in population and workplaces, it is very positive that most of the growth in transport has been in green means of transport, especially by bicycle. There have been seven percent fewer car journeys. Significant efforts are needed if Copenhagen is to solve the environmental and congestion problems as well as move closer to achieving the City's long-term goal – that no more than one in three trips in Copenhagen is by

car. In 2010, 40% of all journeys in Copenhagen were by car as the primary means of transport.

Figure 8: Statistics of all journeys in Copenhagen



Transport in Nordhavn

The idea is that carbon-low transport (i.e. pedestrians, bicycles and collective transport) should be given priority in Nordhavn and that these modes of transport should benefit from as direct routes of transport as possible. Carbon-heavy transport (individual cars) should be second, and even subject to “reasonable” obstacles relative to the direct routes.

Fulfilment of the vision of Nordhavn as a city district with sustainable transport solutions (with bicycle traffic and public transport accounting for at least one-third each and car traffic making up no more than one-third of all traffic in the area) calls for a well considered organisation of the traffic structure.

Whenever a resident leaves his/her place of work, he/she should ideally first get to the bicycle parking area, then the bus stop or the Metro, and only then – at last – to the car park

Figure 9: Traffic plan for Nordhavn

Figure 9 above illustrates that it is easy for bikes and public transport to drive right through the area, while it is difficult for cars.

Nordhavn station will be the main public transport point for Inner Nordhavn. In 2019 there will be two stops on the new metro circle line in Nordhavn, which will connect the district to the rest of the Copenhagen.

A tunnel for cars will be build to make a better connection to the E4 motorway going from the coast to Helsingør. Car parking should primarily be located inside building structures in order to keep public and private urban space free of cars. The car parks will be provided with plugs for electric cars, and plans are made for a hydrogen fuel station.

Nordhavn will expand

Transport of goods and soil from the Metro will take place in the years to come.

Nordhavn will expand with more than 1 mio. sqm. Land reclamation has a capacity around 18 mio. tonnes of surplus earth and other materials from new building and construction projects in Copenhagen. The trucks which transport the landfill will be a part of the local traffic until 2022 when the project is expected to be completed.

Cruise ships

The cruise terminal in Nordhavn is the most visited cruise terminal in the whole Baltic Sea region. And it demands for big capacity therefore a new cruise terminal was inaugurated in 2014. It has a 1,100 meterslong quay with a capacity for 3 big cruise ships.

Passengers from the cruise ships have to be transported into the city center using the same roads as the trucks transporting soil from the metro to the landfill area right next to the new cruise terminal. This is likely to cause traffic problems in the years to come.

Also noise from the new cruise terminal will be a challenge at the eastern end of Nordhavn – the maximum noise threshold values set out in Danish regulations is likely to be exceeded.

A very important issue is energy supply. Today the ships use big diesel motors which have impact on the air pollution in the city. The politicians in Copenhagen are discussing a better – but more expensive – solution. They want CCPD to invest in infrastructure soDONG can deliver electricity from land. This will cost about 200 million Dkr. This is just one part of the investment because afterwards, the ships will have to be able to connect to the system. Therefore it is important to discuss this issue with other popular cruise destinations. CCPD have contact to others ports in the Baltic Sea and also to Hamborg and Oslo.

3.5.3 Water

The focus in this Implementation plan is on Energy. But it is relevant to mention that HOFOR will test the supply of water for toilets with a combination of slightly polluted groundwater and seawater which can substitute clean tap water with up to 50% in office buildings and 17% in private households. The goal for Copenhagen is to substitute clean groundwater with 4% reclaimed water. This is the outcome of a partnership focused on water supply in Nordhavn.

3.5.4 Waste

In Sundholm – a part of Nordhavn – CCPD and the City of Copenhagen wish to test a new waste management system called Centralsug. This system will be able to sort waste in 4 fractions (paper, municipal waste, cardboard and plastic). Beside this, there are going to be separate waste bins for e.g. metal and batteries. The new system is not going to save energy, but in a very tense city space (space is money) the system will save space. This green space between the buildings can be used by the residents for e.g. playground. The land owner will send out a tender in late 2014 and the hope is that the work will begin in April 2015. According to the zoning plan there will be built around 800 flats in this part of Nordhavn. This is just the start of the project. The management system – Centralsug – has a much higher capacity.

4. Implementation measures

This chapter outlines a number of measures for reaching the defined targets of the Implementation Plan, which has two time horizons:

- To ensure that the energy system of Nordhavn will contribute to the fulfilment of CPH 2025, the climate action plan, in which the ultimate goal is to make Copenhagen carbon neutral by 2025.
- To ensure that the further development of Nordhavn, beyond 2025, will be a process of enhanced environmental sustainability and establish the district as a lighthouse for the rest of city. A place to visit to see the most innovative sustainable solutions.

4.1 Energy systems and networks

This is the first of the two themes on energy. This one concerns initiatives that could either support the decision making regarding the development of Nordhavn or give useful knowledge on new energy systems in new developed areas in general.

Heating infrastructure	
Description of the measure	Supplying heat to Nordhavn poses new challenges: – The heat demand will become much lower than usual. – The heat consumption pattern will change from being dominated by space heating to become dominated by domestic hot water, since space heating will become very low. – The supply temperatures will be lower, possibly so low that a temperature boost is required to meet the required temperature for domestic hot water. A heat plan for the Southern district of Nordhavn has recently been developed. The supply temperature is about 20^{o}C lower than the rest of the city, and the heat demand of apartment buildings is assumed to be 3 kWh/m^2/year for space heating plus 20 kWh/m^2/year for hot water. A major reason for district heating to be the economically most attractive option with such a small demand is that the area is quite dense, about 1 m^2 floor area per m^2 land area. However, district heating may not remain the best option, when the Northern districts of Nordhavn is being developed, due to expected improvements in building design, lower building densities, and longer distance to the main grid. Therefore, new technical solutions and business concepts need be investigated and introduced together with an improved data infrastructure. The objective of this measure is to develop and verify district heating designs in dense, low-energy and low-temperature district heating areas taking into account smart energy network technologies, heat storage, energy flexible buildings, decentralized supply options and networks, and fuel-shift solutions. In the Northern part of Nordhavn even lower temperatures (e.g. 55/25 ^{o}C) may

	be chosen, among others to improve the potential for utilizing low-temperature heat sources. Thus it may be necessary to locally boost the temperature by e.g. an electric boiler. Also, it may be advantageous to supply groups of buildings by their own networks, separated from the main network. Criteria for selecting the island solution and business models (ownership, organization etc.) need be developed.
Implementation	Start: 2015. Expected completion of demonstration: 2019.
Key-actors	HOFOR, building developers and owners
Financing	Financial support has been granted by the national Energy Development and Demonstration Programme (EUDP).
Publicity, participation	All participants of the EnergyLab Project will participate in the project, and the results will be made publically available.

Electricity infrastructure	
Description of the measure	The objective is to develop and to experimentally verify selected electrical infrastructure solutions in dense low-energy areas with a view to reducing investment and maintenance cost for the distribution company. A number of developments are challenging conventional planning of power distribution grids. These concern new load profiles and probably more dynamic load with regard to time of peak due to deployed flexibility. Future grid dimensioning requirements (in normal state and/or peak capacity requirements in flexibility situations) from low energy apartment buildings/flats need be developed. Change of profiles/capacity requirements with regard to deployment of various flexibility solutions shall also be taken care of. In addition, imbedded in the flexible energy concept are optimal solutions by embracing and integrating several different sectors – heat, power, transportation, cooling etc. Such integration might add to the dynamics of the load on the electricity infrastructure and offer new opportunities. An assessment is needed of design principles for Nordhavn electrical infrastructure development and for similar urban areas with same consumption characteristics taken into account the uncertainty in planning, when large potentials of flexibility can be deployed and the influence of fuel-shift facilities may change the load pattern. Thirdly, Nordhavn represents a “new” city area and buildings are expected to be low-energy and potentially meeting demands on maximum energy-use in future building regulations. The low-energy consumption is however seen in an annual perspective and met by equipping the buildings with photovoltaic cells. While the modern city may also contain electrical vehicles, the in- and out-flow of energy in the distribution grid over the day may raise new challenges. This measure relates to these challenges that are strictly related to investigate future investments in the electrical grid, extension and reinforcement, with regard to the expected variable grid load.
Start of implementation	Start: 2015. Expected completion of demonstration: 2019.
Key-actors	DONG Energy Distribution, CCPD, DTU

Financing	Financial support has been granted by the national Energy Development and Demonstration Programme (EUDP).
Publicity, participation	All participants of the EnergyLab Project will participate in the project, and the results will be made publically available.

Heatpumps	
Description of the measure	Heat pumps may consume electricity, when it is cheap, and then produce cheap heat. The heat pumps may be large and owned by e.g. the district heating company, or small and then integrated in the buildings' heat supply systems. Since Nordhavn has a long shoreline, the use of seawater as a heat source for large heat pumps is obvious. Large heat pumps are expected to be an important technology towards a flexible energy system – especially with regard to integration of wind electricity and geothermal heat. Large heat pumps face a number of barriers preventing a large scale introduction. Main barrier is feasibility of investments – in particular in areas with low alternative heat costs as in Copenhagen. But also lack of knowledge; operation experience with large heat pumps, testing of smart operation strategies, assessment and localisation of heat sources, and reference data, plays a role. The aim of this measure is to accelerate the use of large electric driven heat pumps in Greater Copenhagen DH system through industrial cooperation and experimental development. This measure addresses the main barriers and ultimately accelerates the use of heat pumps using natural refrigerants in the district heating sector through the development of optimised systems with improved cost efficiency and feasibility with potentials for scaling up concepts from demonstration level at about 5 MJ/s to a size of 75 MJ/s.
Start of implementation	Start: 2015. Expected completion of demonstration: 2019.
Key-actors	HOFOR, CCPD, Copenhagen City Administration, DONG Energy Distribution
Financing	Financial support has been granted by the national Energy Development and Demonstration Programme (EUDP).

Smart network technologies	
Description of the measure	The objective is to develop, experimentally verify and evaluate various control-based enabling technologies and solutions for smart networks services with high efficiency and promising business potential, and provide elements for a smart energy infrastructure design and operation. Further, the practical design and development of the controllers will be aligned with a number of other activities regarding access to different data streams e.g. prices, but also data collection from e.g. measuring devices, regarding buildings for test and demonstration, and regarding business and market models. Smart network services refer to a range of services which can be provided by different kinds of flexibility enabling technologies (e.g. control solutions for using distributed energy resources to provide load balancing) as an alternative to

	traditional methods for network operation. In this task, the smart network services requested by the electrical network in urban areas like Nordhavn, such as voltage control, load following, peak load reduction, loss reduction and increasing the network hosting capacity for fluctuating renewables, etc., will be identified and characterized. Relevant network services for other kinds of energy carrier networks, e.g. thermal network and the e-mobility infrastructure, will also be investigated. Two different control systems will be developed and demonstrated: – Autonomous control solutions designed for using smart energy components (i.e. distributed energy resources and fuel-shift technologies) to provide smart network services have the potential to generate a new business option for the distribution network operators, as they are communication independent and require little investment on the communication infrastructure. – In contrast with autonomous control, coordinated control represents another state-of-the-art solution for managing the flexibility of smart energy components in a more centralized manner.
Implementation	Start: 2015. Expected completion of demonstration: 2019.
Key-actors	DONG Energy Distribution, HOFOR, DTU
Target group	Grid companies
Financing	Financial support has been granted by the national Energy Development and Demonstration Programme (EUDP).
Publicity, participation	All participants of the EnergyLab Project will participate in the project, and the results will be made publically available.

4.2 Smart buildings

Building a new city area from scratch gives a number of opportunities related to the building mass. The present buildings in Copenhagen range in age and are differently equipped depending on their time of construction, renovations etc. Building a new part of the city during a relatively short period of time gives the opportunity to test out new solutions, both regarding the energy system but especially also in regard to the actual buildings. This is a great possibility but must be thought through early in the planning phase.

This theme concerns the buildings in Nordhavn and measures to push the development of these in a more smart direction.

Intelligent service	
Description of the measure	Generally, energy savings in buildings may be achieved by two different means: Improved building envelope (e.g. better insulation and windows) and improved energy management. This measure is about the latter, intelligent energy management or intelligent service.

	A remotely read heat meter offers an opportunity to share detailed data between the heat supply company and the building owner. Combined with knowledge about the building's construction, the design of the internal heat supply system, and the energy management system, the online data will make it possible to develop a precise heat budget, on daily or hourly basis, and during operation to detect essential deviations from the budget, typically due to malfunctions or improper energy management. Experience with energy services conducted for Government office buildings in Copenhagen indicates potential energy savings of 10-15%, relative to the degree-days adjusted heat budget. The heat budget and actual consumption shall be determined by kWh and m^3, preferably also the forward and return temperatures. The objective of this measure is to ensure that all new buildings in Nordhavn will be intelligently serviced. When efficient energy service has been implemented, further energy savings by improving the building envelope is much easier and much more accurate monitored and documented.
Start of implementation	2015
Key stakeholders	HOFOR, Copenhagen Municipality, Copenhagen City and Port Development, building developers and owners.
Financing	The meters and the data management system will be financed by HOFOR, while the building owners will pay a fee for the services rendered.
Publicity, participation	Copenhagen Municipality and HOFOR shall publicize the results in order to motivate other building owners in the city to follow suit.

Smart buildings	
Start of implementation	Start: 2015. Expected completion of first group of demonstration buildings: 2019.
Description of the measure	The objective is to provide a new understanding of low-energy buildings with their occupants and users as active energy-flexible elements in a smart energy system, and to develop and showcase associated novel control solutions for smarter operation and monitoring of energy in modern buildings. The aim is to provide a new understanding of the possibilities that arise from using low energy buildings of Nordhavn – including occupants and users – as active components in the future smart energy system. The consumer side will be investigated to see if lower or more flexible energy consumption is feasible without loss of comfort due to actively controlled living and working space. Objectives include development and verification of smart energy building models and simulations, design of predictive controllers based on the models and simulations and the implementation and operation of the controls developed.
Key-actors	Building developers, CCPD
Target group	Building developers and owners
Financing	Financial support has been granted by the national Energy Development and Demonstration Programme (EUDP).

Publicity, participation	All participants of the EnergyLab Project will participate in the project, and the results will be made publically available.

Energy labelling of buildings	
Description of the measure	The buildings in Nordhavn will have to comply with the building regulation scheme BR20, stating a maximum energy consumption (all hot water, heating, cooling and ventilation) of 20 kWh/m^2/year for dwellings and 25 kWh/m^2/year for businesses. This corresponds only to hot water consumption, i.e. zero energy consumption for heating. This is a rather strict requirement that all buildings must comply with by the year 2020. This will cause a significantly lower energy consumption compared to the other part of the city. The experience with low-energy buildings is not profound which might make the measure difficult to meet. This measure will evaluate the energy consumption in the buildings and compare this to the calculated theoretical energy consumption. Introducing intelligent service of all buildings in Nordhavn, cf measure describes above, will by itself enable such comparisons. Besides being used to improve building designs and the energy operation of buildings, this measure may be used to make energy labelling of the buildings based on measurements rather than design figures.
Implementation	The evaluation of the energy performance can start in 2016 when consumption measurements starts to be available
Key-actors	CCPD, the Danish Energy Agency and the Danish Building & Property Agency.
Financing	The financing for this measure has not been decided. It is likely that the building developers, the Danish Energy Agency or the Danish Building & Property Agency or CCPD would support this measure.
Publicity, participation	The result from the work will be for the use of the national agencies and for the developers but is likely to be published for public use later.

4.3 Early dialogue with developers

Copenhagen had a strong outset for developing a sustainable Nordhavn with the agreement between Copenhagen and the Danish Governments. It allowed Copenhagen City to define a way to develop the land, the buildings and the infrastructure to achieve the vision. In the case of building development the choice of using DGNB as a certification procedure allows the city to set requirements for the development. The city is therefore identifying how to establish an early dialog with the developers. Otherwise an important initial opportunity in the development process may be lost.

Early dialogue with developers about DGNB	
Start of implementation	Spring 2015
Description of the measure	Early dialogue with developers aims to ensure more sustainable solutions and an easier way to achieve these goals by discussing ideas and methods among the group of develops. In phase 2 the goal is to get DGNB certifications for all buildings. And hopefully very low energy consumptions. It is very important that CCPD have an early dialogue with the developers about certification since it is important to document decisions from the start of the process, optimize and make the right contracts with the builders e.g. to sort and recycle construction waste. The DGNB certificate proves that the building is sustainable. This is very important for both renters and buyers and for the developer who might be able to get a good price. The first meetings with developers will concern DGNB since it is a new concept and has influence on the building process.
Key-actors	Developers, City of Copenhagen, CCPD. GBC-DK will support the process in the beginning hence the DGNB system is relative new. The third building phase will properly involve energy providers since the heating system might be a discussing point.
Target group	Developers in the building process. Renters and owners, who hopefully will experience low running costs for energy and maintenance in the new certified buildings
Financing	The developers have to invest in sustainable solutions. But as the markets works at the moment it seems that certified building are easier to sell and the developers might get payback on the extra investments.
Publicity, participation	The public will be invited to come to the exhibition area in Nordhavn. Some of them will move into the new houses and the hope is that they will share their experiences with developers and architects. This could take place in CCPD´s new showroom in Nordhavn?

Visibility and stakeholder engagement	
Start of implementation	Start: 2015. Expected completion of demonstration: 2019.
Description of the measure	This measure is a cross-cutting and overriding measure related to all above measures. The Nordhavn area and the ambition to create a remarkable sustainable development is an important cornerstone in the Copenhagen City Climate Strategy. Nordhavn is acknowledged in many circles for its potential as an early mover intelligent energy hub. Several of the above-mentioned measures provide intelligent energy solutions and demonstrates their real-life applications and value. These results can potentially have major impact and influence on the industries and consultants engaged in designing new sustainable urban areas, if made visible and transparent to all interested parties.

	Moreover, if made visible, the demonstration could create significant value for professional visitors to Copenhagen and the public in general. The objective of this measure is to ensure stakeholder engagement, support the dissemination of the SUL implementation plan, and to utilize the visibility of Nordhavn and to support an associated SME innovation arena in Nordhavn. The specific objectives are: – Primarily to develop and implement facilities in the show room in Nordhavn: virtual presentations, conferences and seminars – for the professional societies etc., and – Secondarily to support – together with the relevant stakeholders in the Copenhagen area and Denmark – the international visibility of: – In general, the Nordhavn Development Area – Potentially, other related and relevant Danish smart energy solutions developed by SME's and tested in practice The activities will be anchored around the establishment of a showroom facility in Nordhavn.
Key-actors	Copenhagen City and Port Development, City Administration
Target group	The public
Financing	Financial support has been grantedby the national Energy Development and Demonstration Programme (EUDP).
Publicity, participation	All participants of the EnergyLab Project will participate in the project, and the results will be made publically available.

From January 2015 a large team of partners including CC will initiate a new research demonstration programme, EnergyLab Nordhavn, with a total budget in excess of 10 mill euros over 5 years. The project will focus on Nordhavn and will further research the themes which have been identified at the ILS. This includes heat infrastructure, electrical infrastructure, heat pumps, smart network technologies, smart buildings, visibility and stakeholder engagement. The projects is an innovation project and will demonstrate (test and evaluate) new solutions which can help develop the vision for Nordhavn. A number of specific projects associated with the EnergyLab Nordhavn project are outlined in chapter 4: Implementation measures. Although the project is not directly an outcome of Transform, the Danish Transform partners are involved and will further develop the Nordhavn vision.

5. Reflections

75 percent of the city's CO_2 emissions relative to the buildings and the people living in them. Therefore the CPH Climate Plan 2025 pays considerable attention to reducing building related emissions, heating as well as electricity consumption. Many of Copenhagen's buildings were built in the 60s and 70s and do not conform to new energy efficiency standards. The strategy is not to demolish the old buildings and replace with new more efficient buildings. The focus is on renovating and upgrading the existing building infrastructure except of a few new areas like Nordhavn where it is possible to build with the new building standards.

The Transform project has accelerated the process on early dialogue with developers in Nordhavn. The municipality has held workshops together with the landowner (CCPD) and developers to form a new concept for an early dialogue about sustainability. Transform gave a very good opportunity to work intensively to form a concept and test it in our smart urban lab (Nordhavn). The method to work in an urban lab has made the process much easier since it is concrete and foreseeable. It also helped the process a lot to have the intensive lab session with experts and colleges from our partner cities to contribute with their experiences and ask a lot of good questions and bring new perspectives into the process. Copenhagen has learnt a lot from the other cities during the Transform project, which has run for 2 years now. It has been most inspiring to attend the ILS in the other cities to learn about their challenges and best practise. In Aspern in Vienna they have a big challenge about feasibility of district heating, which is very interesting since Nordhavn might face the same kind of problems in the next phase where the dwellings are built to use zero heating from the grid. Copenhagen can also learn a lot from the way Lyon has got commitment from big stakeholders towards the big ambition to double square meters in the area and still use the same amount of energy! It is a huge project and the stakeholders have to invest a lot of money, but they have bought the vision and Grand Lyon seems to lead this project excellent. We have also learnt from Amsterdam that it is possible to commit stakeholders to a climate agenda and help them set up high goals. It has been fascinating to see e.g. the energy manager at Ajax soccer stadium explain the very high goals saying "I can´t remember why we agreed to such high goals but we are trying to reach them" . He said this with a

smile and it showed us that our partner colleges in Amsterdam had done a very good job.

The city cannot require the owners of the existing building stock to renovate their buildings. However, it still needs to be done. So the city also in this case the city has to get involved with the owners to encourage renovation to a higher energy standard if suitable. In some cases the city is supported by new national or EU policies such as the required implementation of smart meters.

The city has a stronger deciding power in changing the energy supply sector. Strong collaboration with HOFOR for on the heat side and DONG on the electricity side. Even though HOFOR is a private company, Copenhagen City as its sole shareholder has very good changes of a close alignment. With regard to the electricity sector the city has the advantage of the Danish national target of becoming fossil fuel free also but only in 2050. So although the national electricity sector is changing in Denmark, it is not changing fast enough for Copenhagen to rely on this. This is not easy and in this case the city will have to work with landowners, outside of the municipality in establishing 105 wind turbines. The city also aims to make district heating and cooling carbon neutral, and recently opened its first district cooling plant, using seawater, and plans as many as seven over the master plan period to meet the city's growing need for air conditioning.

The last two pillars in the climate action plan is mobility and city administration. Mobility has not been one of the elements chosen in the Transform project so it has only been touch sketchily. This is not because it is not important. The city has a significant focus on investment in the public transportation sector and in enabling a higher use of bicycles for transportation in the city. The first "bicycle superhighway" – designed to connect outer districts and suburbs to the city centre – opened this year, with 26 more set to be developed over the coming years.

One of the networks Copenhagen participates in is the cluster CLEAN. It is a clean-tech cluster with 170 institutions and industries in Denmark. The participation in CLEAN is a strong network for the city in particular towards developing Copenhagen as a smart city. The aim of CLEAN is to create green growth and green jobs through innovation, development and export of Danish energy and environmental solutions. Through this

network Copenhagen has access to and a direct link to the strong innovation activities in energy and environmental area in Denmark

Trible Helix

Copenhagen has made collaboration with the industry and the universities a key part of the development strategy in developing a smart city (a trible helix model). Copenhagen cannot make the transformation alone. Copenhagen City therefore participates active in networks, research projects innovation promoting activities. Obviously in particularly the smart city context the three parties are depending on each other. Copenhagen City needs the support from the innovative and the knowledge sectors. And the industrial sector as well as the universities benefit with the strong collaboration through a continuing aim of supporting innovation and implementation of new and smart solutions. Furthermore Copenhagen encourages the involvement of its citizens not only through the normal Danish planning procedure but also encourage direct engagement in the projects. Without everyone's involvement Copenhagen will not be able to reach is 2025 target.

Appendix: Living sustainably in homes …

Anthropologist and Phd. at university of Copenhagen, thesis on local climate change mitigation governing and behaviour.

Study in Ørestad, neighbourhood similar to Nordhavn, difficulty in getting respondents so I draw on the few interviews we have managed to make, as well as my own research to share some general reflections with you on the subject

General conclusions from research

To start with, when we pose questions such as “how can we design housing that creates sustainable behaviour” there are some important issues to pay attention to. There is often a tendency towards this implicit idea that choices and specific actions can somehow be isolated in time and space. These are the kind of assumptions behind approaches where we think, that if only we reach an individual with the right kind of information, the right sentiment or the right economic incentive, she will act differently at a given point in time.

When we look closer at this, at the micro-dynamics of how and why people do what they do, it is in fact, of course, somewhat more complex than that. Our actions are part of a bigger society: and they are certainly embedded in a vast range of rationales, relations, material structures and symbolic meanings which are all at the heart of why we do what we do at an everyday life basis.

The point I want to make here, then, is that choices cannot be isolated in time and space. This is an artificial separation that makes for poor intervention initiatives. We could acknowledge instead, that living in modern society brings with it an unavoidable burden of mobility and energy use. It makes little sense to isolate a moment in time where a person either turns the heat up or down for instance, from his or her learned ideas of comfort, urge to make the best possible home environment for his or her family, or to isolate use of electricity to a matter of choice, ignoring the wish to be in touch with others and work via computers, the need for household appliances that makes it easier to clean and cook when we are asked to work 50 hours a week, as it makes little sense to merely inform people that they should consume less stuff, without considering the cultural meanings attached to consumption or the way entire societal infrastructures are built around consumption.

In this way, when looking at sustainable behavior in houses, it is important to understand its context since *normality* – what is considered normal to do and what becomes common sense – is constituted in the social.

A good example is cleaning ourselves. If we see it in a historical light, it becomes clear that it has changed beyond what can be explained with individual isolated choices. The entire materiality around cleaning ourselves has changed from shared showers or water fountains to pluming inside the house providing warm water at any minute, individual bath rooms, and so on. The meanings of what it means to be clean has changed over time, so whereas before we might have showered once a week, today most people shower at least once a day, and so on. So there are many factors implicated in this development over time.

This means that interventions should be holistic or acknowledge that they are only part of the bigger picture – there are no magic bullets. In this perspective, material framework that housing is, is actually extremely important, even though certain changes won't lead to automatic behaviour change.

Interview illustrate this

People want to be part of a network, there they can share tools, cars and reuse things especially if it is in their own neighbourhood.

They do not want to share their private room with others

They would like to have access to a guest room, but they do not want to give up a room in their own apartment

So we can see these objections as part of a larger social culture where we associate great value with private life, and where private life is constituted along the lines of the core family – concrete along the lines of the private home. (this is not so other places) Working with this challenge then, is not only about convincing families to share rooms, but working towards creating a broader accept of such approaches in the future to make it socially acceptable.