TRANSFORMATION AGENDA for COPENHAGEN (D.2.2)

Final draft, 20 March 2015

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ACKNOWLEDGEMENTS

This report, and the lead author in particular, owes a lot to many people (including apologies to the ones whom this list might miss):

HOFOR, project partner and co-drafters of the report, Jørgen Boldt and Niels Præstegaard Hendriksen generously shared ideas, and engaged in the process with knowledge and wisdom, not forgetting the good laughs. Jørgen and Niels drafted the actions proposed for Flexible Energy Buildings and the Flexible Energy System in Part C, they co-drafted certain chapters in Parts A and B, and commented on quite a few bits of the rest.

DTU, project partner, provided great help and input for the City's dealing with data. Ola Solér, together with Kai S. Kanafani (City of Copenhagen), carried out work on WP3 and the online tool exercise, summarising lessons learned in a thorough case-description, as well as providing more general input about city roles in urban planning. Per Sieverts Nielsen gave feedback on the entire draft Transformation Agenda in November 2014, and carried out a mapping exercise of the City's energy data (provided in the Annexes).

CLEAN (formerly: Copenhagen Cleantech Cluster), subcontractor to Copenhagen in TRANSFORM. While formally referring to WP4, the fruitful and inspiring collaboration with Peter Bjørn Larsen, Michael Johansen, Peter Kjærgaard Svendsen, Bjarke Kovshøj and Amanda Borup Pedersen yielded analyses and stakeholder involvement that was equally guided by, and in turn giving insights to, the analytical focus of the Transformation Agenda.

Technological University of Delft, subcontractor to WP2, submitted on 26 February an insightful cross-case analysis of all six city's Transformation Agendas in TRANSFORM.

Advisory Board, TRANSFORM provided useful feedback on the draft Transformation Agenda – through a report from the City of Amsterdam collecting input from all members in February 2015 while also the Danish Advisory Board member Marianna Lubanski (Director, Copenhagen Capacity) gave great feedback in person.

The Technical and Environmental Administration of the City of Copenhagen hosted the project. CEO Torben Gleesborg, Department manager Brian Hansen and the two Heads of unit, Charlotte Korsgaard and Ole Vissing, provided general feedback on project development. So did even more the project team, counting: Elisabeth Kongsmark, project leader (as of November 2014), Tina Hjøllund and Hong Song – all of them being great, fun and encouraging colleagues at the same time. Emilie Sofie Hvidtfeldt, project leader (January through June 2013), introduced the project and her visions for it with great eager. When she left, Hans Christian Christiansen acted as project leader (July through Mid-November 2013) until Elisabeth took over that role, although Hans Christian assisted the team in doing the accounting of the project throughout. Student assistant Maria Amanda Beydin joined the team at the end of February 2015, diligently helping out on numerous matters. Hanne Coco

Arildsen taught the art of developing road maps and generously shared ideas and visions. And Katrine Guldager (secretary and so much more) helped out in ways far beyond the expected, balancing competence, empathy and charm perfectly well.

The Climate Secretariat, the Technical and Environmental Administration, deserves special mentioning: Jørgen Abildgaard (extremely knowledgeable on anything from overview to devils in the details, and whether the focus is politics or technical elements), Anders Brix Thomsen (very helpful on strategic energy planning, general advice and introductions to the fruitful collaboration with HOFOR), Mariann Andersson (buildings, action plan for retrofitting), Inge Nilsson (the economics of the Climate Plan, the emergence of the Climate Plan: History, conditions, and 'forgotten' details), Martha Sørensen (buildings and data), Annette Egetoft (dialogue with developers), Hanne Christensen (strategic energy planning) and Per Steen Boesgaard (stakeholder mapping).

City Data, the Technical and Environmental Administration, Head of unit Winn Nielsen (feedback on WP3 online tool), Tyge Pontoppidan (data on solar cells and general GIS data), Stine Balslev (Copenhagen Green Accounts), Jens Sperling (CO2-accounting models and CO2 figures for Copenhagen), Kim Spiegelberg, Kim Stannov Søvsø and Rolf Vibe Rønnow Foxby (collaboration on, and input about, smart city processes in the City).

KEjd, the City of Copenhagen's building portfolio manager, the Finance Administration: Jesper Samson, Björn Espen Magnusson and Sten Erik Drønen, provided input about KEjd's priorities and strategies as regards buildings and smart city development.

Copenhagen Solutions Lab, serving the City across Administrations since November 2014, inspired through input from Søren Nørgaard-Madsen, Søren Kvist, Henrik Aagaard Sørensen and Rikke Margrethe Meller Gram-Hansen (current smart city and data projects in the City).

Stakeholders, last but not least, contributed in particular during a workshop on smart city development in Copenhagen on 31 October to 1 November 2013 (participants are listed in the Annexes), and during a workshop in April 2014 (participants are listed in the so-called ILS-report, WP4 of TRANSFORM).

EXECUTIVE SUMMARY

Purpose, background and highlights from the Transformation Agenda

The task of the Copenhagen Transformation Agenda – as a delivery within the FP7 EU project 'TRANSFORMation Agenda for Low Carbon Cities' (TRANSFORM), running from 2013 to mid 2015 – is to accelerate the development of Copenhagen as a 'Smart Energy City' through an action plan. The purpose of the Copenhagen Transformation Agenda is already largely defined through the Copenhagen Climate Plan, CPH 2025, which was politically adopted in 2012. The goal is for Copenhagen to become the world's first CO2-neutral capital by 2025. This plan contains an elaborate action plan regarding the City's ability to work with energy in intelligent and integrated ways.

To comply with the focus on energy in the EU project's call, the Copenhagen Transformation Agenda (as a delivery in TRANSFORM) first of all consists of describing, evaluating and supporting the Climate Plan. Second, in line with City executives' desire in recent years to advance the role of data and ICT in the City's smart city approach, particular emphasis is placed on the use of data, which, moreover, has not been significantly developed within CPH 2025.

The addressee of the Transformation Agenda is first of all the executive level, the Technical and Environmental Administration, and within this Administration, in particular Executive Climate Project Director, since 2010: Jørgen Abildgaard, heading the Climate Secretariat. Second, European institutions, networks, partner cities or other associate and interested partners are natural addresses too. The sender, in turn, is the drafting team, counting Else Kloppenborg, City of Copenhagen, Jørgen Boldt and Niels Præstegaard Hendriksen, both from HOFOR (the City-owned utility company), basing ideas and the Transformation Agenda, to some extent, on internal consultations and stakeholder involvement. When handing in this report by the end of March 2015 to the Executive Climate Project Director, the authors at the same time submit the Copenhagen contribution to delivery D.2.2, WP2 in TRANSFORM.

In terms of method, the Transformation Agenda builds on input through dialogue with the Climate Secretariat, the City's unit for City Data and other staff working on data, but also stakeholders, networks and, obviously, desk research in addition to workshops, informal working groups and various analytical tools (e.g. SWOT-analyses).

Parallel to the Transformation Agenda, the Climate Secretariat carried out a partly overlapping process of evaluating CPH 2025. This was done from November 2014 through March 2015 with a view to briefing the Technical and Environmental Committee, prior to the formal, external evaluation of CPH 2025 that will take place in 2015 through early 2016.

The Climate Secretariat's evaluation is structured around an assessment of the quantitative progress, measured in tonnes CO2-reductions relative to the *ultimate target in 2025* (CO2-neutral by 2025). The Transformation Agenda has relied on its analyses on public data about

the current state of affairs in CO2-reductions in comparison with the *set goals for 2015* (e.g. through the annual Green Accounts). Hence the Transformation Agenda opted for a more qualitative assessment of CPH 2025: Its emergence in the first place, and required conditions for CPH 2025 to succeed in the long run.

With a slightly different timeline, the Transformation Agenda could have included a fuller picture, including the quantitative progress of CPH 2025. Yet the advantage of the actual situation is that A) the City, through the Climate Secretariat, analysed CPH 2025 in quantitative terms, and will expectedly act on it, and B) the Transformation Agenda, driven by necessity, took a different approach and thus offers a supplementary view on CPH 2025, its challenges, gaps and potential solutions (summarised in the next section on key findings).

The two evaluations converge in observing that the City is on track in terms of CO2-reductions as per 2015. Yet at the same time, CPH 2025 appears deficient and less robust in some respects. Moreover, another challenge is, in a one-liner, that the City already picked all the low-hanging fruits.

The internal evaluation by the Climate Secretariat notes that to stay on track – that is, close the CO2-gap and reach the target in 2025 – the City has to upgrade and sustain efforts over time. Action is required in a number of fields, including: Reduce energy consumption from buildings, accelerate efforts to make mobility 'greener', decrease CO2-emissions from energy production, including from waste handling, and step up action across initiatives and sectors to involve citizens and stakeholders.

The Transformation Agenda, supplementing this analysis, points to challenges that stem from strategic and organisational choices regarding: The funding structure of CPH 2025 (too short sighted), the recruitment policy for the Climate Secretariat (staff on a contract implies instability), strategy to involve citizens (missing), and policy coordination with other City Administrations (no *formal* linkages to other units (on, e.g. retrofit, or the minds of the 'future' through children, schools)).

Second, the Transformation Agenda considers challenges in the City's work with three specific themes:

- *Dialogue with Developers*: How to get more sustainable new built through enhanced and better timed dialogue with developers?
- *Flexible Energy Buildings*: How to make buildings more intelligent, whether regarding their use of energy, resources or data, and how to enable buildings to interact more with the surroundings and in particular the energy system?
- *The Flexible Energy System*: How to make the energy system more flexible with regard to energy production and measures to accommodate more flexible energy consumption?

The two themes Flexible Energy Buildings and the Flexible Energy System come with a rather future oriented flavour. Yet, as is well-known, the changes in the energy system that must take

effect in the next decade have to be figured out and planned for today – due to the long-term investment profile of the sector.

If there is one lesson learned that cuts across the three themes, then it is the need for the City to develop a more systematic approach to stakeholders, and to use business cases (currently lacking). The reason is that the City has only few formal powers over the three themes (e.g. authority over heat planning is the one major exception to this rule). This means that the City has to work with 'soft' power, that is, as a broker, a facilitator, or platform promoter and manager, who proactively engages in the role that in each case seems most likely to generate the desired result.

The next section elaborates on the key findings of the Transformation Agenda regarding identified challenges and proposed recommendations to solve them.

Cartoonist, Suus van den Akker, April 2014

Findings of the Copenhagen Transformation Agenda

The following is an outline of the Transformation Agenda: First, it describes CPH 2025, and how it was enabled (Part A), then moves on to discuss current challenges or gaps at strategic and thematic level (Part B). After this, it suggests initiatives that could improve the overall concept or one of the three themes of Dialogue with Developers, the Flexible Energy System and Flexible Energy Buildings (Part C), and, eventually, the Transformation Agenda assesses how far the City has gotten to date concerning the raised issues (Part D).

The remainder of this section outlines the identified challenges and recommendations. While the overall, strategic challenges and recommendations are not prioritised, the

recommendations in response to challenges with the specific themes are. All recommendations are *supplementary* to the City's, and in particular the CPH 2025 Plan's existing roadmaps, strategies and initiatives.

Strategic challenges
Among the challenges at strategic level, the Transformation Agenda focused on the following four, including recommendations to solve them:

- CPH 2025 suffers from short-sighted funding, and consequent difficulties in proper long-term planning, that follows from *annual* Budgets. *This creates a risk of delay in the implementation of initiatives*.
    - Recommendation: Request long-term budgets that cover required funding for each four-year roadmap period to enable more efficient planning (– and thus follow the advice from the IPCC scientific community that action *now* is better and cheaper than postponed actions)

- The use of staff on a contract creates instability. *This creates a risk of delay in strategy development or implementation, and of loosing essential competences owing to frequent staff-turnover.*
    - Recommendation: Offer permament positions to key staff with specialised competences required to implement CPH 2025.

- The lack of a strategy for citizen involvement makes CPH 2025 vulnerable where citizen actions are required for the implementation of the Climate Plan. *This creates a risk of no or less effect of strategies, including the structural solutions that partly depend on whether or how people use the solutions.*
    - Recommendation: Develop and fund initiatives to involve citizens in actions required to implement or even improve CPH 2025.

- CPH 2025 functions as a stand-alone plan with no or little *formal* integration with other projects or across City Administrations (e.g. vis-à-vis schools, children – the future citizens – or any unit working on e.g. retrofit). *This creates a risk of reduced effects at any time and a too slow shift of mind-sets generally over time.*
    - Recommendation: Strive to make CPH 2025 mainstream and broaden the ownership of the project.

Concerning the three specific themes, the challenges and proposed recommendations can be summarised for each theme as follows:

Theme 1: Dialogue with Developers:
To improve the impact, the City could:
- Develop business cases for Flexible Energy Buildings;
- Ensure access to data and to the required steps and agreements (legal, technical, financial etc.) at an *early* stage in the building process;

- Find alternatives to the DGNB-certification that ignores whether an *advanced* use of data takes place or not in building management and urban development.[1]

As a precursor to a thorough business case exercise, the case study, which CLEAN carried out (as a sub contractor to the City of Copenhagen during TRANSFORM), yields a series of learnings. The case study offers insights to both the '*MBA*'-revision[2] process and the Climate Secretariat's continued efforts to increase the speed and scope of the retrofitting of buildings and implementation of higher energy standards in new built. The learnings are:

- Integrate energy investments/sustainability targets from the start, whether in new built or retrofit projects;
- Do a pilot to get a better result in the end;
- Execute retrofit in phases to avoid empty buildings, and allow for adjustments throughout the project;
- Involve users of the building to increase performance levels of implemented solutions;
- Realise that it takes a lot of resources to do the business case.

Theme 2: Flexible Energy Buildings:
To improve impact, the City could:

- Prioritise Flexible Energy Building initiatives;
- Lobby national Government;
- Team up with 'play mates' to test ideas, learn more and scale up initiatives.

In more technical detail, prioritised, recommended actions include:

1. Intelligent service
2. Flexible heat load
3. Flexible use of electricity
4. New services for consumers
5. Electricity generation from the building
6. Heat generation from the building

The introduction of suggested solutions in new built depends to some extent on the City's ability to strengthen its Dialogue with Developers. When it comes to existing buildings, building owners must be targeted in a dialogue about options and benefits.

Theme 3: Flexible Energy System:
To improve impact, the City could:

- Create the required coordination (between, for instance, the City's urban planners and utility companies);

[1] This latter point refers to the chosen filter in the Dialogue with Developers that turned DGNB into the prioritised lens of observation to assess and promote the degree of sustainable development in new built and new city districts.

[2] MBA refers to the City framework for environmental standards and demands to the City's own buildings, City-subsidised social housing and urban renovation projects, and, finally, the City's construction sites (*Miljø i Byggeri og Anlæg* (MBA)).

- Engage stakeholders and proactively facilitate collaborative efforts;
- Lobby national authorities (on, e.g., tariffs, taxes or counter-productive regulation).

In more technical detail, prioritised, recommended actions include:

1. Large heat accumulators
2. Large electric boilers and heat pumps
3. Interruptible heat customers
4. Data management and sharing
5. Smart charging of EVs
6. Dynamic electricity consumption
7. Bypass steam
8. Prosumers
9. Integrated district cooling and district heating
10. Upgrading of biogas by flexible use of electricity
11. Storing heat in the distribution network
12. Fuel shift
13. Sale of comfort rather than hot water in the pipes.

Generally, across all three themes, the recommendations show that the immediate role of the City is relatively weak – or, in other words, the need for lobbying (national Government) and strengthening dialogue with stakeholders is great. The implications of these recommendations, however, reflect the general spirit of CPH 2025: Alone, the City will not get far. Performance and progress hinge on the City's ability to build alliances, partnerships and momentum around ideas so as to persuade others to engage in collaborative efforts. This requires to a lesser extent new technologies – but certainly the right competencies within the City and a clear understanding of the need to communicate, coordinate and create engaging, proactive facilitation of processes.

Next steps, following the Copenhagen Transformation Agenda

The next step is to assess which of the proposed recommendations should potentially be followed. To do this, a process involving the Climate Secretariat in particular, but stakeholders too is required – both to match recommendations with existing plans and processes, ensure the rights competences, refine ideas and gather support for funding options.

The decision to pursue these steps depends on the executive level, especially the Climate Secretariat.

INTRODUCTION

Project framework for the Transformation Agenda for Copenhagen

The Transformation Agenda is a delivery within WP2 in the FP7 EU project TRANSFORMation Agenda for Low Carbon Cities (TRANSFORM), running from early 2013 to mid 2015 and including 19 partners in total across Western Europe. The structure of the Transformation Agenda therefore follows a template, common for all six cities in the project (Amsterdam, Copenhagen, Genoa, Hamburg, Grand Lyon and Vienna).

The purpose of TRANSFORM is to support cities in reaching the European Union's '20-20-20-targets' of promoting energy efficiency and renewable energy sources (RES) while reducing CO2-emissions. To this end, the goal in TRANSFORM is, at a more specific level, to develop and accelerate the participating cities as 'Smart Energy Cities'; and, last but not least, to share lessons learned.

Objective of Transformation Agenda in Copenhagen

The purpose of the Transformation Agenda of Copenhagen has already been largely defined through the Copenhagen Climate Plan, CPH 2025, which was politically adopted in 2012. The goal is for Copenhagen to become the world's first CO2-neutral capital by 2025.

The vision for the Copenhagen Transformation Agenda (as a TRANSFORM delivery) is therefore to support and accelerate the implementation of CPH 2025. Hence the primary addressee is the Climate Secretariat, headed by the Executive Climate Project Director, and the executive levels within the Technical and Environmental Administration. For this reason, an overview of the Climate Plan will be outlined for the sake of context or foreign audiences (Part A), but it will not be outlined in detail. The accompanying roadmap for all 65 initiatives of the Climate Plan can be found in the Annexes (cf. Annex 1). Readers not familiar with the Climate Plan can read it online in its entire or short version.[3]

This means that the Transformation Agenda is not in itself a *comprehensive* strategy with an action plan. The Transformation Agenda presents a more limited series of analyses and proposals for new initiatives, and reads as a catalogue of ideas, developed during the TRANSFORM project period (by the authors, during workshops with stakeholders or in working groups etc., from June 2013 through March 2015). This series of analyses and proposals for new initiatives target a limited share of the entire set of purposes and projects of CPH 2025. The key point is to leverage the transforming powers and potentials of CPH 2025.

[3] Read more here: http://international.kk.dk/artikel/carbon-neutral-capital

The sender of this report is the drafting team, thus fulfilling requirements in the TRANSFORM project (WP2, delivery D.2.2). The first draft version was done in June 2014, the final one in March 2015.

The Transformation Agenda addresses two levels. First, at the overall strategic level, we describe and assess the overall concept of CPH 2025.

Second, we describe three specific themes and how they could support CPH 2025: One of them, Flexible Energy Buildings, could be seen as input to the theme of Dialogue with Developers. But at the same time, the theme also depends on the City's ability to upgrade the theme of Dialogue with Developers. In that way, the themes become codependent.

One overall criterion of success for the Copenhagen Transformation Agenda is that it contributes to improvements in CPH 2025 – by promoting strategic initiatives, specific actions and methods that will lead to the delivery on set goals faster, better, or at lesser cost.

Cross-cutting two of the specific themes of the Transformation Agenda, another criterion of success at a more technical level is to provide clarity to key concerns in the analysis of *flexibility* of the energy *system*, of energy *consumption*, and of energy *production*: What are the key challenges? How can we get closer to an understanding of actual needs and potentials for flexibility? What is the City's role?

Smart City: A concept with many or no particular meaning

This introductory section on the concept of 'smart city' gives a brief and by no means exhaustive overview of some of the challenges in working with the concept. And it explains why the Transformation Agenda chose to avoid the term.

Examples of the use of smart city

The concept of smart city could point to any or a combination of the following meanings[4]: To some, it is about an enhanced use of *digital* data and ICT (i.e. a particular set of means to reach some kind of goal). To others, it is a prolongation of the concept of the *sustainable* city (e.g. a holistic and long-term approach, including environmental, cost-efficient and social aspects of urban development). Yet others argue that it is the *integration* of a whole series of systems that make a city smarter, ranging from the economy, to people, governance, environmental concerns, transport and living generally. Finally, combinations exist as well, such as in the observation that the smart city, in terms of *goals,* echoes the 'eco, or sustainable, city', but, in terms of *means,* gives priority to technological and digital solutions.

[4] I owe this list to the author of an informal working paper on the concept of smart cities: Mikkel A. Thomassen, Leader of Secretariat at Smith Innovation, a consultancy in Copenhagen concentrating on the building industry.

The origins of the concept are hazy. In the early 2000s, multinational computing and software developing companies began to promote the concept. It was not until almost a decade later that, for instance, blogs dealing with sustainability took up the concept.

Lack of a clear smart city definition

As suggested in the listed examples of the use of smart city, one of the greatest difficulties we have found in our work has to do with the *concept* of smart city. What does it mean, or refer to? A catchy phrase indeed – perhaps too catchy at the expense of being meaningful? Critics find the concept a little too open to interpretation, because it is often used to suggest intelligence, sustainability or innovation yet without defining what the 'smart' element is actually about.[5] The thing is that there is no consensus among practitioners and in academia on the meaning or importance of the concept. This leads to the question of how to strengthen one's city as a smart city if the concept itself evades a clear understanding.

The catch 22 of 'smart' terminology?

The more limited 'smart' is defined, and in particular if connected to a set of means only, the greater the risk that the terminology produces meaningless situations, whether in terms of logic, project management or common sense.

For instance, if the focus in the smart city work is 'enhanced use of data', then the overall project is actually a matter of running an advanced ICT project. But if the official story of the overall purpose is said and believed to be something else – say, better service – then there is a risk of confusion in the process of implementation: Is the goal *better service*? Or is it the *use of data* in the service? While data and ICT are necessary in the second case, they might not be the only and perhaps not even the most important means in the first case. The problem arises if the purpose is something else than an advanced ICT project but the winner in terms of means is picked before there is a proper analysis of the challenges, and the full range of means and solutions that would seem most adequate in the situation.

Second, consider the example of a building that is 'smart' in the sense that smart meters have been installed and real-time data-feeds connects the building to a series of data hubs and service providers. But the building is poorly insulated, endowed with windows of low energy standards, and nothing was done to ensure that the users of the building understood properly how to ideally use and understand the smart meters and their messages. In that case, the total 'intelligence' of the building becomes highly questionable.

Or, consider the situation of a building being retrofitted for energy, and equipped with smart meters and devices but ending up with a poor indoor climate that allows too little room for variations in the needs of building users to live comfortably (e.g housing) or perform well (e.g. schools, work places) in the building.

While these examples appear absurd when written down, they might come close to reality.

[5] Cf. Franz, Yvonne: 'Smart or not smart: what makes a city intelligent?', in: *Smart City. Viennese Expertise Based on Science and Research*, Vienna: Schmid Verlag.

If swithing from the building to the city-level, it is evident that when considered from a user-perspective, a city is only really 'smart' and livable if all relevant aspects of city life are taken into account – regardless of which City Administration be responsible, and no matter whether data and ICT is required for their handling. For instance, a city that is very smart in terms of energy planning or traffic flow but in which poor air quality threatens people's health is hardly attractive. Likewise, the City Administration can solve problems efficiently or, alternatively, get mired in bureaucratic dead-ends if the administration operates in too old-fashioned ways, that is, in the 'silo mode' as opposed to coordinated services across administrative borders. In the latter case, civil servants work together in a spirit that seeks to understand the city from a user perspective and puts the users first.

On the other hand, the broader the understanding of 'smart' becomes, the greater the risk is that the concept becomes over-crowded and thereby stands poor to the chances of fulfilling all expectations. If everything the City does is done with the goal of being 'smart', then the fundamental issue will probably be that of government, coordination and organisational set-up.

Either way, a clear understanding of the purpose of the City's smart city work is of key importance. What is the vision: Why do it? What is it that the City wants to do better? The importance of that clarity is usable *within* the City Administration to ensure shared understandings as basis for coherent implementation and well-coordinated efforts across services in the City. Clarity is also important for external communication, which is to explain citizens, business and knowledge partners why the City is aiming to become a smart city, what it means, and what it aims to change or improve. This is the best condition for stakeholders to buy into the vision and find ways to capitalise on the opportunities and provide the growth most cities are after.

TRANSFORM-definition and vision for the 'Smart Energy City'
As a WP1-delivery within TRANSFORM, the project partners co-developed a definition and vision for the Smart Energy City together with local stakeholders:

'The Smart Energy City, as a core to the concept of the Smart City, provides its users with a liveable, affordable, climate-friendly and engaging environment that supports the needs and interests of its users and is based on a sustainable economy.

The Smart Energy City is highly energy and resource efficient, and is increasingly powered by renewable energy sources; it relies on integrated and resilient resource systems, as well as insight-driven and innovative approaches to strategic planning. The application of information, communication and technology are commonly a means to meet these objectives.'[6]

[6] Deliverable 1.2: *Definition, Key Elements and Indicators* in: TRANSFORM, Work Package 1: 'Becoming a Smart Energy City, State of the Art and Ambition', June 30, 2014. See page 8.

This definition and vision emphasises *energy* (due to the focus on energy in TRANSFORM), but also opens up for much broader concerns, such as 'liveability', social aspects of policy through a requested 'affordability' and democratic or stakeholder oriented assumptions of 'engaging' or 'innovative' environments as a key to success in making the city smart. Many different means can, and must most likely be used to produce the 'energy and resource efficient' city, but only a few ones are singled out here: Integrated planning, stakeholder involvement, communication and use of technology.

City of Copenhagen: The ongoing work of defining the smart city
A series of processes within the City Administration contributed to the smart city understanding – from the first piece-meal attemps in 2010 through 2012 to current, still ongoing work to develop a more comprehensive and coherent approach.

CPH 2025, whose development phase dates back to 2010, contains a roadmap with around 65 initiatives, including five initiatives under the title 'The Smart City'. The five initiatives are: A digital infrastructure for public data, support of flexible energy consumption, support of 'smart house solutions', local hydrogen production, and an improved framework for onshore electricity to cruise liners.

Four out of the five initiatives presuppose data and ICT in new key roles. Three initiatives target consumption of electricity or heat. One initiative concerns a new fuel-type for mobility. In brief, technological development stands at the centre as the defining characteristic, and energy comes in as the second element that unites these initiatives.

Early in 2013, the City initiated a cross-departmental process to describe the ways in which the City more broadly (than in the Climate Plan) wanted to work with smart city. This resulted in seven criteria to characterise smart city projects in Copenhagen:

- Use of data
- Use of new technologies/using old technologies in new ways
- Efficient use of resources
- New ways to involve citizens and stakeholders
- Innovation or technology-based growth
- Public-private partnerships
- Solve more than one problem at a time.

Whether all, just one, or a couple of the criteria (but which ones?) must be fulfilled, for a project to qualify as a smart city project, was left an open question in the process.

At a more strategic level, the seven criteria-approach leaves open the question of a vision for Copenhagen as smart city, that is, what is the overall purpose that can guide and motivate a wide set of services and administrative units in their work with smart city? *Why* is the City striving to become a smart city? What should it help the City to do better? And does it appeal to, or engage citizens and stakeholders?

In early 2014, a new process was initiated, in a follow up on the City's Budget14 decisions, giving some priority to the smart city area, although no new funding.[7]

The two primary tasks, introduced through Budget14, were: 1) Support the new Smart City Project Council (which is headed by the Technical and Environmental Administration, and is later to include all seven City Administrations). This includes a proposal for the Project Council's terms of reference (e.g. a smart city definition to delimit activities under the mandate of the Project Council; adequate organisational set-up and processes to support smart city initiatives in daily operations, and 2) Promote the two designated flagship projects of an 'open data' platform for some of the City's own data, and 'Connecting Copenhagen' (a digital infrastructure for the whole city, advocating an integrated approach to the use of data to leverage efforts across services and deliver better solutions across sectors).[8] In both cases, work (as of spring 2015) is still in progress.

The negotiations for Budget15 allocated 10 million DKK (€1.34 million) to smart city projects.

Generally, the smart city agenda in Copenhagen devotes special attention to data and ICT (e.g., one particular set of *means* within the wider smart city understanding in academia and among practitioners). The idea in Copenhagen is to apply the means of data & ICT to a few areas first: Climate, energy, mobility, citizen services and, cross-cutting these themes while allowing for yet others: innovation and growth. More areas may be added before the strategy is adopted.

The outline of the process of developing a smart city strategy for Copenhagen over the past five years, show that the focus has shifted from a very *open* approach with an emphasis on the use of technology, data & ICT in particular, to a more *goal*-oriented approach in which the areas that should be supported are named (e.g. climate, energy, mobility etc.). This outlined shift reflects a typical result of coordination across the City Administration. And the outcome of this process has increasingly evolved into a more comprehensive smart city understanding.

It should be noted that it is to be expected that the introduction of new concepts in old organisations is time-consuming: How to integrate them? How much should they affect the existing organisation? How is the timing, vis-à-vis other (big) organisational changes? How ready is the organisation to welcome a new, potentially re-organising principle?

And last but not least, the need to differentiate Copenhagen from other cities, makes the smart city definition the 'Copenhagen way' necessitate an original touch in the race to attract foreign capital and investors to the city, or to win prizes in international competitions and city ratings – whose categories for the smart city, by the way, vary widely.

The Copenhagen Transformation Agenda approach to the smart city

The Transformation Agenda starts with the overall approach to energy planning and CO2-targets in CPH 2025 (i.e. not only looking at the five smart city elements of CPH 2025). In CPH 2025 the primary lens of observation is CO2 as the focus point of defining goals and strategies.

[7] http://www.kk.dk/da/om-kommunen/nyhedsliste/2013/3-kvartal/okf-faktaark-budget
[8] http://copenhagenconnecting.com/

This implies a strong focus on energy, including governance around energy and methods to advance intelligent and integrated energy policy such as data & ICT. Consequentely, the Transformation Agenda leaves out smart city ambitions of City services that deal with, for instance, joined-up governance, care for the elderly, educational initiatives, or swifter passport delivery.

This solution implies a more narrow understanding of the smart city but it is manageable and a reasonable choice, given the strategic work in progress to define the smart city in Copenhagen. And furthermore, it fits the EU call to which the TRANSFORM project responds, and which emphasises 'energy' (rather than the full range of potentially 'smarter' city services).

1 CO2, Energy: The role of the city

A few general observations on the role of cities apply in the case of Copenhagen too.

Why a strategy for energy and CO2? And why would a *city* take the responsibility to make such a strategy? The question is why did Copenhagen adopt CPH 2025? What is the purpose? And how does the City imagine implementing it?

CPH 2025 is the first of its kind: A comprehensive response to climate changes adopted politically by the City Council. The issue of climate changes was high on the agenda internationally, and in Denmark in particular, back in 2009 when Copenhagen hosted the UN Climate Summit, COP15.

Although inadequate in terms of an internationally binding climate agreement, COP15 did contribute to raising awareness of the responsibility that we all, willy-nilly, share to contain climate changes – cities too.

Accepting the shared responsibility of the challenge to contain climate changes thus contributes to explaining *why* Copenhagen chose to take on the responsibility to act. A series of specific projects that promises to bring down the carbon footprint with estimated tons CO2, in turn, add up to answering the question of *how* to deal with the challenge.

Among experts on climate change it is a general assumption that, by and large, we already have technologies, or sufficient knowledge to develop new ones, to solve the majority of the known climate change and related energy and resource challenges. The Danish interest organisation for engineers, IDA, pusblished in 2009 a report showing that Denmark can reduce its greenhouse gas emissions by 90% in 2050.[9]

What is needed is political will and (fresh) collaborative models among private and public actors to co-develop models, solutions and business models that can implement and deliver

[9] https://ida.dk/sites/prod.ida.dk/files/Klima%20Hovedrapport%20UK%20-%20WEB.pdf

on the solutions. In brief, it is largely a matter of decision-making powers addressing the challenges and allocating sufficient resources to handle them, including re-designed organisational structures and ownership models.

The role of cities is complex.

Cities globally host the largest and a growing share of the world population. In 2014, the urban population accounted, according to WHO, for 54% of the total global population, up from 34% in 1960. The expectation is that the urban population will be increasing approximately 1.84% per year between 2015 and 2020, 1.63% per year between 2020 and 2025, and 1.44% per year between 2025 and 2030.[10] The urban growth rates are superior to estimates on total world population growth. Currently, the total world population grows at a rate of around 1.14% per year. Growth rates for the total world population are expected to continue their decline ever since the peak of 2.19% in 1963, going down to less than 1% by 2020 and less than 0.5% by 2050.[11]

In sum, while both urban and total growth rates are expected to fade in the future, urban growth rates will decline from a higher level (currently, 1.84% urbanisation growth rate compares to 1.14% global world population growth rate). Moreover, while declining in intensity, continued urbanisation trends do imply that the share of people living in cities will be on the rise for decades on. By international comparison, the impact of urbanisation in Copenhagen is modest at a current growth rate of 0.2% (in absolute figures, the population currently counting 0.57 million inhabitants (2014) goes up with roughly 1.200 people per year).

C40 points out that while cities only occupy about 2% of the world's landmass, they account for more than two thirds of global energy consumption, and more than 70% of global CO2-emissions.[12] Due to the urbanisation trends, these figures, if nothing changes, will only grow in the future. With more than 90% of cities moreover being situated on coastlines, cities have a major interest in the mitigation of climate changes, e.g. to contain the risk of sea level rise and flooding. However, cities are also home to the majority of business and growth opportunities, that is, the actors that can develop solutions to contain climate changes.

These facts and trends in combination indicate the stakes cities have in climate change, and why cities are natural candidates for identifying challenges and solutions – and leading action in close collaboration with stakeholders.

Cities, however, in general have limited powers for setting framework conditions, proposing incentives or standards for the industry, building codes etc. And while the nation-level is key to address these questions, they are often heavily influenced by international developments; such as European Union (EU) processes and politics that, however, represent a level of complexity that few cities in Europe can match. In addition, city budgets are limited and

[10] http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/
[11] http://www.worldometers.info/world-population/#growthrate
[12] http://www.c40.org/why_cities

manpower often insufficient in terms of competences, mandates and organisational support to handle identified challenges.

So what can cities, and a city like Copenhagen, do?

A key role for cities is that of facilitating processes and defining a direction for desired developments. This involves, inter alia, planning for the future in long-term perspectives, co-developing new ideas and projects, initiating pilots, offering limited 'seed funding', and communicating with constituencies and stakeholders – both to raise awareness of solutions and challenges, and to foster shared ownership to the creation of solutions.

The facilitating role of cities can also imply 'to lead by example', and show the way in specific projects such as through progressive use of public procurement. In this way, cities can push the market to deliver new, innovative or better-standard solutions.

This is most likely to happen when not only 'price here and now' decides who wins a tender. Instead intelligent procurement takes long-term economy or functional quality dimensions into account too. This may apply to a series of situations, including: when the City builds and retrofits existing buildings. Or when the City transforms its mobility scheme and car pool in a shift from vehicles powered by fossil fuels to EVs and hydrogen cars – if not to mention bicycles for short-distance CO2-free rides.

To sum up, climate changes and actions to contain them are, as seen from the city perspective, a complex mix of geographies, overlapping decision-making structures and many stakeholders. It is not a closed system – whether in terms of functional systems, trade and collaboration, or in terms of the decision-making realms that govern, regulate or seek to influence other parties.

But a city like Copenhagen can – and wants to – make a positive difference, not the least by leading by example. While modest in terms of the potential CO2-impact in global context, CPH 2025 may if successful in the role of setting an example, make a difference all the same.

The timeliness is acute, according to the 2014 report from the UN Intergovernmental Panel on Climate Change (IPCC): The IPCC this time leaves no room for interpretation. The risk of irreversible and imminent climate changes sets the tone of the report to a degree hitherto neither documented, nor communicated so clearly from the scientific community. Action is long overdue. Yet the good news is that action is possible: Required technologies are available today, and to implement them would cost less than 0.1% of the expected growth; much less than the cost of postponed action.

A national report, using IPCC and other climate scenarios, suggests about climate changes in Denmark, if nothing is done, that: '*Climate changes are expected to increase towards 2100 in terms of higher temperatures, more winter precipitation, more frequent and more extreme*

weather events as well as sea level rise'.[13] This could in Denmark, depending on the scenario, result in a temperature rise of 1.2 to 3.7 degrees Celsius by 2100.

The range of outcomes suggests ample room for action and influence on the course of events. And with more than one third of the Danish population living in Greater Copenhagen, the capital has a major role to play in drivng the agenda to contain climate changes. But *how*? That is the question.

2 Overview: Scope and content for the Copenhagen Transformation Agenda

In at least three respects, the Copenhagen Transformation Agenda needs a framing comment: In terms of geographical scope, the status of the Copenhagen Transformation Agenda vis-à-vis existing strategies, and the relation of the TRANSFORM smart *energy* city focus to a more encompassing understanding of smart city development.

First, by 'Copenhagen', the capital of Denmark, we mean the geographical entity governed by the City Council of Copenhagen that is home to approximately 569,557 people (as of 2014). Greater Copenhagen covers a much larger area. It is governed by 34 local governments and counts approximately 1.95 million inhabitants (2013). The Copenhagen Transformation Agenda concerns mainly the city of Copenhagen. And by 'City', we imply the City Administration for Copenhagen.

Second, the status of the Copenhagen Transformation Agenda is defined by the fact that Copenhagen already has a politically adopted plan since 2009 to transform the City's work with energy fundamentally, namely the Climate Plan, revised and renamed in 2012, henceforth: CPH 2025.[14]

The ambition of this plan is to turn Copenhagen into the world's first CO2-neutral capital by 2025. This is why the present Transformation Agenda, instead of proposing a full-fledged Transformation Agenda, functions more like an amendment to CPH 2025. To avoid confusion in *this* document, we use 'CPH 2025' when we imply the existing plan, and Trasnformation Agenda about the present document.

Third, the focus on the 'Smart *Energy* City' in the Transformation Agenda translates the wording in the FP7 EU-call that TRANSFORM responds to. Thus the project contributes to a fraction only, albeit a key one, of the entire smart city agenda (as discussed at more length in the smart city introduction). As a delivery within the TRANSFORM project, this report gives

[13] http://www.kebmin.dk/sites/kebmin.dk/files/nyheder-presse/DMI-rapport/fremtidige_klimaforandringer_i_danmark.pdf

[14] http://subsite.kk.dk/sitecore/content/subsites/cityofcopenhagen/subsitefrontpage/livingincopenhagen/climateandenvironment.aspx

priority to energy as opposed to any other dimension or type of city services that could become smart.

The Copenhagen Transformation Agenda falls in four parts, A, B, C and D. Parts A through C are descriptive, analytic and suggests a series of potential next steps while part D takes stock of the actual progress of the suggestions.

- ***Part A - The story (Status-Quo, vision and quantitative goals)*** presents the general framework, CPH 2025 vision and goals, and gives the background for the CPH 2025 emerging at all and in the way it did;
- ***Part B - Evaluation of CPH 2025 and the transformation process*** evaluates CPH 2025. The chapter identifies gaps as regards both specific themes and strategic elements that need improvement if the city is to reach energy and climate goals.
- ***Part C - Improving abilities to implement – selected themes*** suggests a series of ideas that Copenhagen could decide to implement to improve the energy strategy, detailing both specific projects and strategic directions. Particular attention is paid to the two issues of: Flexible Energy Buildings and the Flexible Energy System.
- ***Part D - What has been achieved so far and impact on existing energy strategies*** sums up progress of the proposed steps so far (as of March 2015).

PART A
THE STORY (STATUS QUO AND THE VISION, QUANTITATIVE GOALS, BACKGROUND CONDITIONS AND METHODS)

1 *Status-Quo and the Vision: Carbon Neutral By 2025*

The starting point of the *status quo* as regards Copenhagen's integrated energy and climate planning to meet the EU 20-20-20 targets is the City's ambition to become the world's first carbon neutral capital by 2025. The current status (as of autumn 2014) is that overall the City is well on track.

But what is CPH 2025 in more detail? Which sectors does the CO2-reducing initiatives target mostly? Which CO2-emission method is used, and what are the current levels of energy consumption in Copenhagen? How was the Climate Plan enabled, politically and regulatory? How is it funded? And who are the stakeholders?

These questions will be dealt with in turn in the remainder of this chapter. The starting point is the current situation of CPH 2025 today, but of course the current climate plan rests on a series of both external sources of influence and City-internal ones – such as, in particular the first climate plan that was adopted in 2009 but replaced by the current one in 2012. Key internal and external influences will be pointed out at a later stage in this chapter.

The current climate plan: CPH 2025 – key achievements and goals at a glance
The key achievement of CPH 2025 is the *politically adopted goal* – to become CO2-neutral – that commits the City Council to allocate resources on a continued basis to reach the goal. A total of 2.7 billion DKK (€ 363 million) public money was agreed for the entire period of CPH 2025, that is, from 2012 to 2025.

Second, the *roadmap* for CPH 2025 (see Annex 1 for the full roadmap) with 65 specific projects, including budgets, time-horizons and desired impact, fleshes out the overall goal and *makes the climate plan tangible* to stakeholders, citizens and observers more generally.

The CPH 2025 plan is organised in four pillars with each their specific goals and initiatives. The four pillars and their planned contributions to CO2-reductions are:

- Energy consumption – 7% of the total CO2-reductions in CPH 2025
- Energy production – 74%
- Green Mobility – 11%
- The City Administration's own climate initiatives – 2%, and New Initiatives – 6%

A Climate Secretariat shaped up in 2010 to ensure a clearer organisation and mandate for the implementation of CPH 2025. The Climate Secretariat currently employs around 10 people with eight in permanent positions, and currently three on a contract.

Given the importance of the Energy Production pillar in CPH 2025 – accounting for 74% of the planned CO2-reductions – and the key role in that regard of HOFOR, the City-owned utility company[15], it is timely at this stage to single out HOFOR's vision and primary actions in support of CPH 2025.

HOFOR supports CPH 2025 in a number of ways. The primary strategic actions are to substitute fossil fuels with biomass (wood chips) at *Amagerværket*, the Combined Heat and Power (CHP) Plant, henceforth (as of January 2014) owned by HOFOR. Second, HOFOR establishes wind farms primarily outside the City that, essentially, will result in a surplus production of RES relative to the total energy consumption in Copenhagen. This wind power may serve not only to 'cover' the energy consumption in the city but also to compensate CO_2 emissions from traffic in Copenhagen.

Moreover, HOFOR creates energy savings in the district heating grids, facilitates energy savings at end-users', and invests in climate change adaptation (e.g. rainwater management).

To widen the scope of HOFOR's strategic approach and actions, HOFOR's executive management adopted a new vision in 2013: '*HOFOR creates sustainable cities*', supplementing the still valid vision that '*HOFOR delivers green, reliable and cheap heat*'. The added element vehicles the idea of taking resources more broadly into account.

2 Quantitative goals

The overall vision and goal of Copenhagen wanting to become CO2-neutral translates into a change in absolute figures of bringing the city's figure for CO2 emissions for the baseline year 2005 of 2.4 million tonnes CO2 down to zero by 2025.

Figure 1 shows the change in carbon emissions *without* implementation of CPH 2025.

[15] A fuller presentation of HOFOR will be given in the section on the regulatory framework for energy.

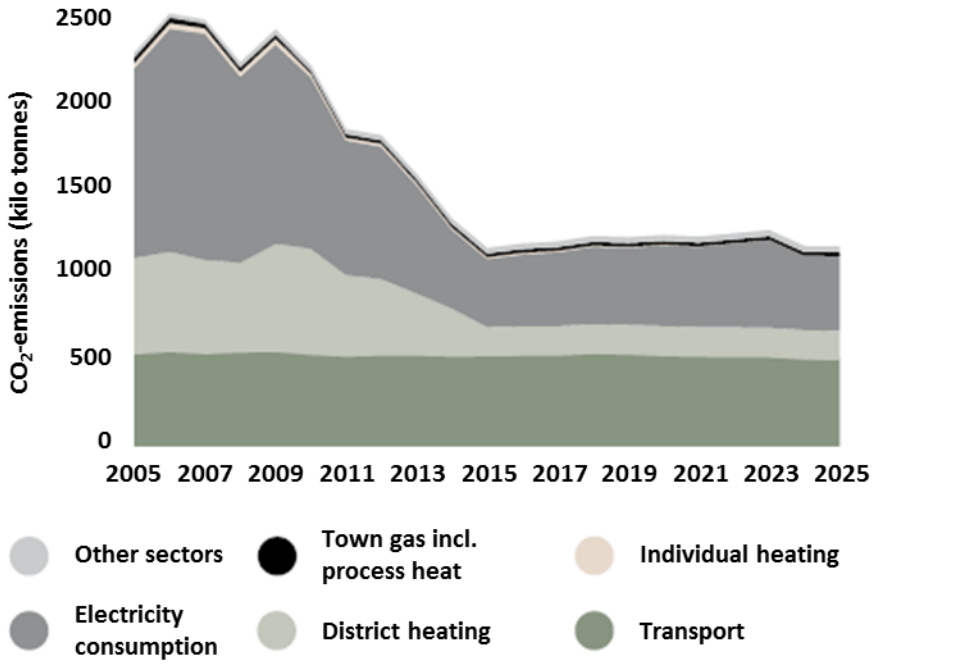

Figure 1:
CO2-emissions from 2005 to 2025, provided no further initiatives be adopted than already decided, that is, without CPH 2025.

The figure shows the development in carbon emissions for Copenhagen with no further initiatives planned than already agreed prior to adoptation of CPH 2025. By 2025, the CO2-emission for Copenhagen would thus be an estimated 1.2 million tonnes. The goal of CPH 2025 is to drive that figure down to zero.

The initiatives preceding CPH 2025 include, in particular, the shift from coal to biomass in CHP plants in the Capital Region of Copenhagen, a generally greater share of RES in the Danish electricy production, expected energy savings due to the energy savings obligation (nationally and through the EU Energy Efficiency Directive), and stricter EU regulations on fuel efficiency for vehicles.

Thus, for instance, electricity consumption will be CO2-neutral in the whole country of Denmark but only once the entire energy production for electricy is based on RES – by 2035 according to the visions in the national Government's *Energistrategi 2050* ('Energy Strategy 2050'), to make Denmark independent of fossil fuels.

Despite the implementation of CPH 2025, however, the figure for CO2-emissions must in reality not drop to zero CO2 by 2025 for Copenhagen to be seen as CO2-neutral. This has largely to do with the opportunity to off-set carbon emissions through additional RES, and thus handle one of the most difficult challenges, CO2-wise: Transport.

It remains to date highly unlikely that all transport needs could be met in a manner that is independent of fossil fuels by 2025 for a variety of reasons that are *inter alia* technical (e.g. EVs suitable for short trips but inconvenient for longer trips, such as holidays across the

continent), economical, fiscal or market-related (e.g. national fiscal schemes unclear as of 2015 when the current exemption from taxes on EVs stops), or psychological (most people remain unconvinced of the fit of EVs to their needs – habits are, by nature, difficult to change).

The way Copenhagen envisages nevertheless to become CO2-neutral by 2025 is by off-setting the transport related amount of tonnes CO2 through RES-production, wind power in particular. Most wind turbines will be installed outside of Copenhagen both on- and off-shore because of limited numbers of sites in the city appropriate for wind turbines, if not to mention wind farms.

The share of the City's planned 360 MW wind power by 2025 in terms of crediting on the carbon balance amounts to 360.000 tonnes allowed CO2-emissions by 2025.

The four pillars and their contribution to carbon neutrality

The relative share of each of the four pillars in CPH 2025, 1) Energy Production, 2) Energy Consumption, 3) Mobility and 4) City Administration climate initiatives, is shown in figure 2.

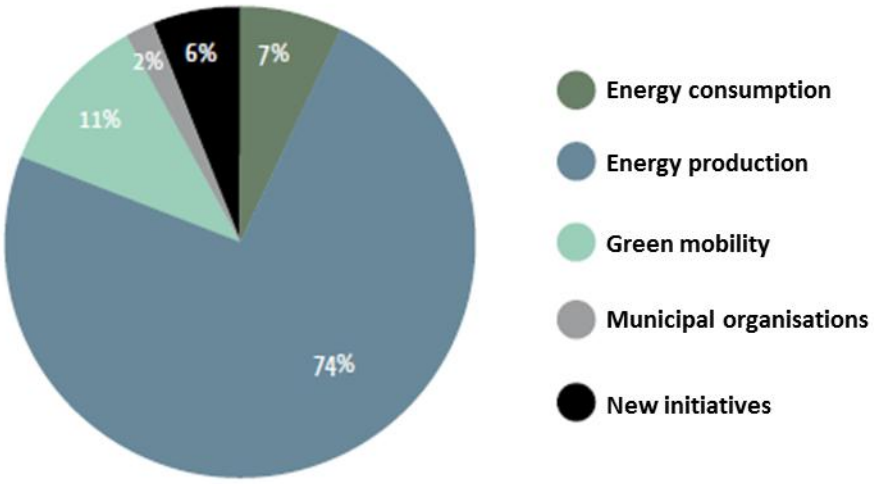

Figure 2:
Relative share of CO2-reductions as a result of initiatives in the four pillars of CPH 2025 and 'new initiatives'. By Energy 'consumption' is meant the goal in CPH 2025 espressing the *required reduction* in energy consumption.

CPH 2025 defines goals within each pillar, and singles out a range of specific measures targeting s well the energy system level as urban space, individual homes and transport behaviour.

As of ultimo 2013, some 50 projects have been launched, and approx. 700 million DKK (€94 million) allocated to implement the plan. A few examples of launched projects include 1) the conversion of coal-fired CHP plants to biomass (significant, as district heat covers 98% of heat in Copenhagen); 2) the introduction of LED street lights (50% energy savings); 3) the separation of plastic through more fractions in household waste.

Annex 1 gives the entire roadmap for CPH 2025 lists all current and forthcoming projects.

When broken down to key initiatives, the four pillars contribute reduced CO2-emissions in absolute figures as shown in figure 3.

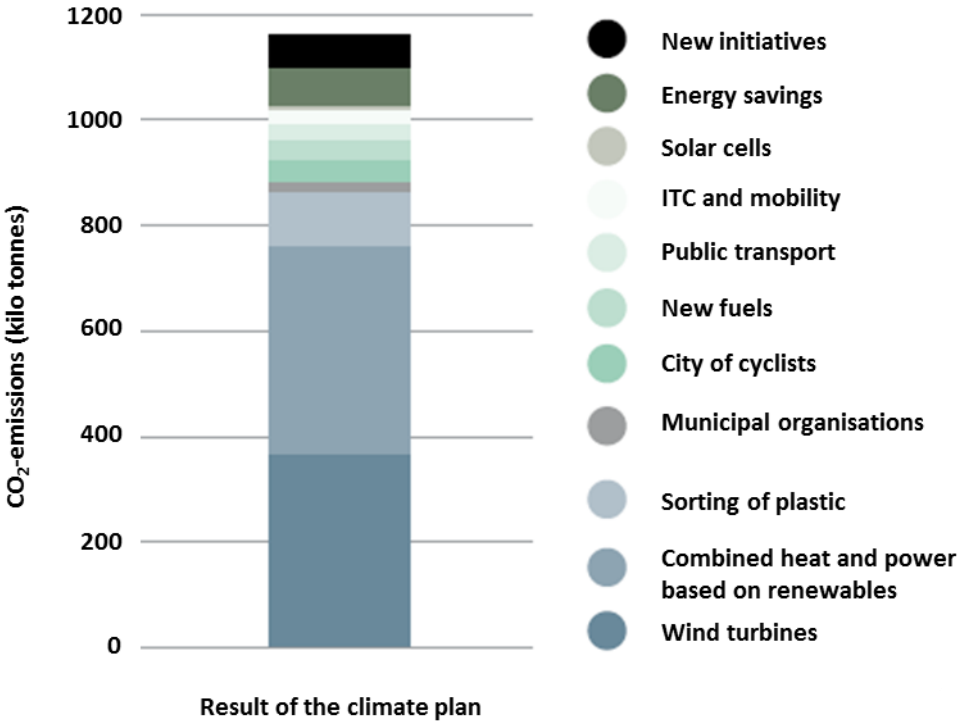

Figure 3:
CO2-reductions as a result of initiatives in CPH 2025.

The big bulk of the change stems from Energy production: Wind power, CHP from RES, and the sorting of plastic represent together by far the greatest share of the reduced CO2-emissions. Second comes transport initiatives via the pillar Green mobility. Energy consumption is third in line and, last but for image and credibility reasons very important too, the impact of the City's own climate initiatives.

When broken down to relative shares, figure 4 shows that the pillar of Energy production can be seen to hinge, in particular, on wind power and RES-based CHP in roughly equal shares of 42-43% each. As mentioned already, the by 2025 planned 360 MW wind power corresponds to a crediting from the carbon emissions for electricity consumption in Copenhagen of 360.000 tonnes CO2. This figure is bigger than the expected consumption of electricity, and thus enables the off-setting of carbon emissions from e.g. transport. For the sake of clarity, this accounting is, on the one hand, a limited Copenhagen picture that allows the City to count the effects of all initiatives on CO2-figures. On the other hand, in national accouting, the wind power affects the carbon emission factor.

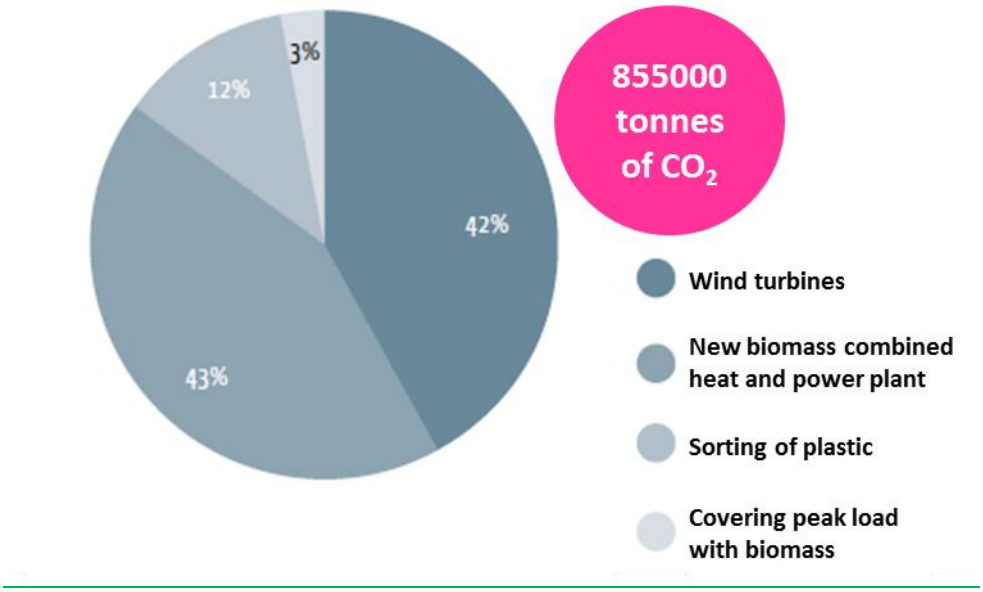

Figure 4:
CO2-reductions from energy production within the total CO2-reduction, and shown as relative shares of initiatives.

The focus in CPH 2025 on Energy production (74% of the CO2-reductions) implies a predominant focus on institutionalised and market actors but to be sure, certain structural solutions require some degree of citizen and end user collaboration or use of the solutions too (e.g. waste collection at the source, shifting from car to bicycle transport, using the upgraded infrastructure that the City offers to people choosing the bike).

In turn, the reason the City choose to concentrate on institutionalised actors hinges on the fact that Copenhagen, contrary to many other cities, benefits from a publicly owned energy supply system (e.g. distric heat), and thus may actually control development in this sector.

Monitoring of CPH 2025

At administrative level, the steering group for CPH 2025, in the Technical and Environmental Administration oversees the progress of work throughout the year. There are three meetings per year, and two of them involve evaluations of the three following items: CO2-figures, status of Budget allocations and other finance, and status of each initiative in the roadmap (is the initiative on track, so far and with regard to expectations to meet the target for the current year? If not, what to do?).

There is also a politically adopted series of major evaluations that will take place roughly every fourth year (in 2016, 2020) to ensure that needs for revisions are integrated in the implementation of CPH 2025. This may include adjustments in light of new technologies, new national energy bills, new tariffs, analyses or competences. Whether these evaluations will take place primarily based on in-house revisions or through external consultancy review is yet to be defined.

But *how* does the City measure its level of CO2-emissions? Which methods are used, which assumptions lie behind the choice of method – and what is the current level of energy consumption in Copenhagen? These questions will be raised and dealt with in following sections.

3 Background conditions and methods

3.1 Energy consumption and CO2 emission methods

This section first explains the chosen method in Copenhagen for reporting on carbon emissions, second gives the current figures for energy consumption and CO2-emissions compared to the baseline year of 2005.

Method to report on carbon emissions
As stated in the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC), 2012: '*To effectively manage CO2-emissions, cities must first measure and report them publicly.*'[16]

But *how* cities measure and report, that is, using which method is decisive as well: Hamstrung by the lack of an international standard allowing for unequivocal comparison of city reporting on CO2-emissions, international dialogue is difficult (whether about CO2-figures and what they actually refer to, or about barriers and solutions to driving CO2-figures down). The GPC – promoted by C40 Cities Climate Leadership Group, ICLEI Local Governments for Sustainability and the World Recources Institute (WRI) – address this internationally and propose better reporting solutions. The approach was presented in September 2014 in New York during the UN Climate Summit, and officially launched during COP20 in Lima on 8 December 2014.

It was to avoid a similar situation, and more specifically, the risk of double counting at national level that a Danish model was launched in December 2008 – the so-called CO2 Emissions Calculator ('*CO2-beregneren*'). Based on existing standards for national reportings to the European Commission (EU) and United Nations (UN) Framework Convention in Climate Change (UNFCCC) (e.g. the IPCC 1996 guidelines), the method, that cities can use for free, was co-developed by the Danish Ministry of Climate, Energy and Buildings, the interest organisation for municipalities '*KL*'[17], and, at technical level, by the consultancy COWI and '*Danmarks Miljøundersøgelser*' (DMU), the National Environmental Research Institute.

[16] Working paper by WRI, C40 and ICLEI. The GPC homepage announces the official launch of the Global Protocol for Community-Scale Gas Emission Inventories (GPC) on 8 December 2014, during COP20 in Lima, cf. http://www.ghgprotocol.org/city-accounting
[17] 'Local Government Denmark'. KL is based on voluntary membership. All 98 Danish municipalities are members.

The CO2 Emissions Calculator reports on activities and sources within the geographical scope of the city. Moreover, it provides a catalogue of measures to help cities identify what to do to reduce effectively their carbon footprint.

The City of Copenhagen did not yet formally evaluate in which way the CO2 Emission Calculator translates into the GPC Standard, that is, the three different Scopes using the terminology of the GPC, pilot version 1.0, 2012.[18] Also, the City did not assess the consequences of a translation into the GPC Standard's three Scopes in terms of total CO2 emissions of the City and initiatives to reduce emissions. With these reservations in mind, the CO2 Emissions Calculator corresponds, roughly speaking, to Scope 1 and Scope 2 to some degree.

One key exemption from the geographical scope of the methododology in the CO2 Emissions Calculator, is that it allows cities to be credited for investments in RES, installed outside of the city. The *raison d'être* for this is the resultant incentive to carry through investments although a city itself may dispose of no or a very limited number of sites for RES installation. This opportunity is expected to lead to overall more municipality-driven investment in RES production nationally than would otherwise be the case. This created the situation that while each City's carbon accouting is locally 'correct', at national level, the maths do not add up, and the sum total of installed RES exceeds 100%. Although different methods exist to ensure correct national carbon accounting, this is a big issue. The next generation of the CO2 Emissions Calculator is expected to solve the problem.

Copenhagen chose to use the CO2 Emissions Calculator for a number of reasons. First, to comply with the national Government's proposal to use the same method in all Danish cities. Second, incentivised by the CO2-credits for investments in RES outside the city. And, last but not least, because the City considered it more manageable to focus on Scope 1, and expected a greater ability to create results than if broadening the perspective to Scope 2, if not to mention Scope 3.[19] Results were assumed more likely to happen through dialogue and partnerships with a limited number of institutionalised actors regarding activities *in* the city than if the entire city population (citizens and business alike), all consumption patterns, services, imports and travelling to and from the city would have to be taken into account – monitored and acted upon.

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[18] GPC defines the differences among scope 1, 2, and 3 with reference to whether the reporting concerns direct or indirect greenhouse gas (GHG) emissions. Moreover, this question links to that of ownership or control over GHG emissions. The GPC Protocal defines direct and indirect greenhouse gas (GHG) emissions, using the following distinctions: '*Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity. Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity*', cf. http://www.ghgprotocol.org/calculation-tools/faq. Based on this primary distinction, the differences between the three scopes are defined in the following manner: '*The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions*', cf. http://www.ghgprotocol.org/files/ghgp/public/FAQ.pdf.

[19] For an explanation of the different scopes, cf. the previous footnote.

In addition to staying abreast of national proposals for revisions of the CO2 Emissions Calculator, Copenhagen, as a member of C40, follows the ongoing work with GPC. To Copenhagen, it would be most relevant with an international framework to replace the many national methods whose 'devils in the detail' impede true comparison and dialogue among cities world-wide on how to make efficient carbon reductions.

Figures for Copenhagen energy consumption and carbon emissions

The annual report *Copenhagen Green Accounts* publish (since 2008) key figures from the City's CO2-Accounts, such as energy consumption and CO2-emissions by sector.[20]

The consultancy COWI delivered CO2-accounts for the City of Copenhagen for the first time in 2005, and every year since 2008, accessible online (although in Danish only).[21] As of 2014, the City of Copenhagen will take over the reporting itself.

The energy consumption in Copenhagen can be seen in figure 5 split into the volume of electricity, district heating and town gas and oil, but not including transportation. As seen, district heating accounts for around 2/3 of the energy consumption, and electricity for almost 1/3 with only a very small consumption level for town gas and oil.

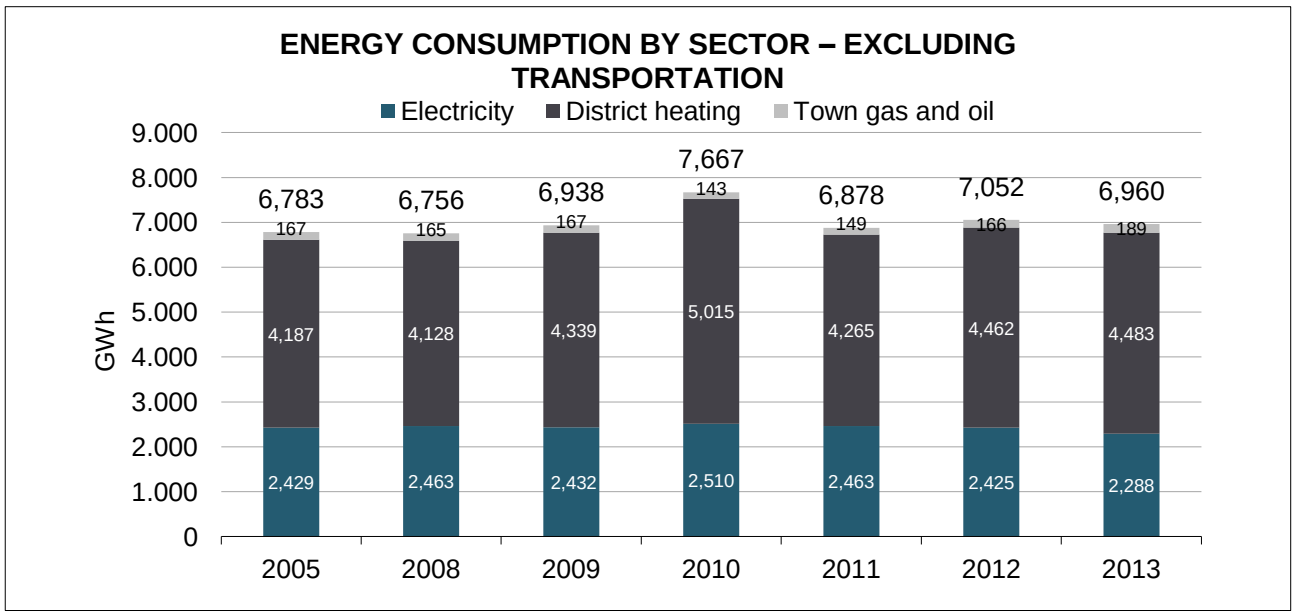

Figure 5
Source: Copenhagen Green Accounts 2013.

[20] http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment/CopenhagensGreenAccounts.aspx
[21] http://www.kk.dk/da/om-kommunen/indsatsomraader-og-politikker/natur-miljoe-og-affald/klima/co2-neutral-hovedstad/opfoelgning/co2-regnskaber

The energy consumption was remarkably higher in 2010 than the other years. The reason for this is that 2010 was a cold year with 20% more degree-days and thus an unusually high heating need.

From 2005 to 2013 the total energy consumption is roughly the same every year in spite of an increase of the population in the city by 12% during the same period. This implies a decreasing energy consumption level per capita.

In terms of carbon emissions, figure 6 illustrates the development in the period between 2005 and 2013. Carbon emissions went down to 1,874 kilo tonnes in 2013 from 2,358 kilo tonnes in the baseline year of 2005 (a 21% decrease). The striking thing is that CO2-emissions went down in spite of a fairly constant level of energy consumption. With the consumption for town gas and traffic at a steady level, the main CO2-reductions stem from production of electricity and district heat.

These CO2-reductions, however, reflect other energy trends than phenomena that can be isolated to the context, and inititives, of the City of Copenhagen.

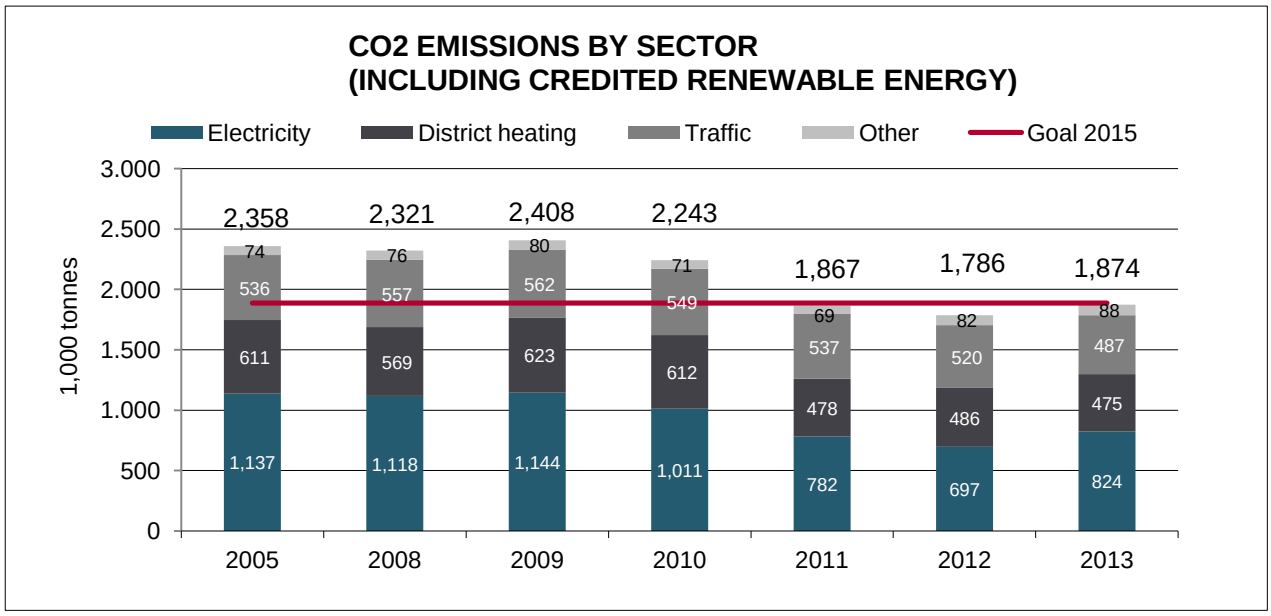

Figure 6
Source: Copenhagen Green Accounts 2013.

During the period from 2005 to 2013, a major change in carbon emissions from district heating and electricity production is seen in the decreasing figures from 2010 to 2011 and onwards, that is, so far stabilising at generally lower levels.

The combined heat and power (CHP) plants in Greater Copenhagen played an important role in the CO2-reductions. Since 2010, the powerplant *Amagerværket* 1 can use biomass as a fuel.

Likewise, *Avedøre 2* was adapted to allow for a gradual fuel shift from coal and gas to biomass, and as of 2014, the fuel shift is complete, allowing for 100% biomass fuelled production.

For electricity, the drop in CO2 emissions from 2010 to 2011 onwards reflects the higher share of RES, especially wind, in the energy mix. In 2005, wind power accounted for 19% of the electricity consumption in Denmark and in 2012, the figure was almost 30%.[22] Moreover, CHP plants produce both heat and power and thus may also contribute to a reduction in CO2-emissions from electricity.

It is noteworthy that CO2-emissions from traffic went down by approximately 10% from 2010 to 2013. This change is due to less km driven by car, and a relatively greater share of smaller cars.

On the basis of in particular the RES-based production of district heat, the mid-term goal in CPH 2025 of reducing carbon emissions by at least 20 pct in 2015 (relative to 2005) was reached already in 2011.

From 2005 to 2013 (when the population in Copenhagen rose by 12%), energy consumption in all sectors (transportation excluded) dropped 6% for electricity, while it rose 7% for district heating and 15% for town gas and oil, respectively.

Given the 12% rise in population from 2005 to 2013, the figures are relatively good. They suggest that a decoupling of carbon emissions and energy consumption from the growth of the city be possible – although the figures for the drop in carbon emissions so far are partly accounted for by national trends.

In addition to the figures showing CO2-reductions at city-level, the following two figures show, first, the amount of CO2 emitted per inhabitant (figure 7) and, second, tonnes CO2 per 1,000 DKK brutto regional product (figure 8).

[22] Energistyrelsen 2012: *Energistatistik 2012. Data, tabeller, statistikker og kort*, København: Energistyrelsen

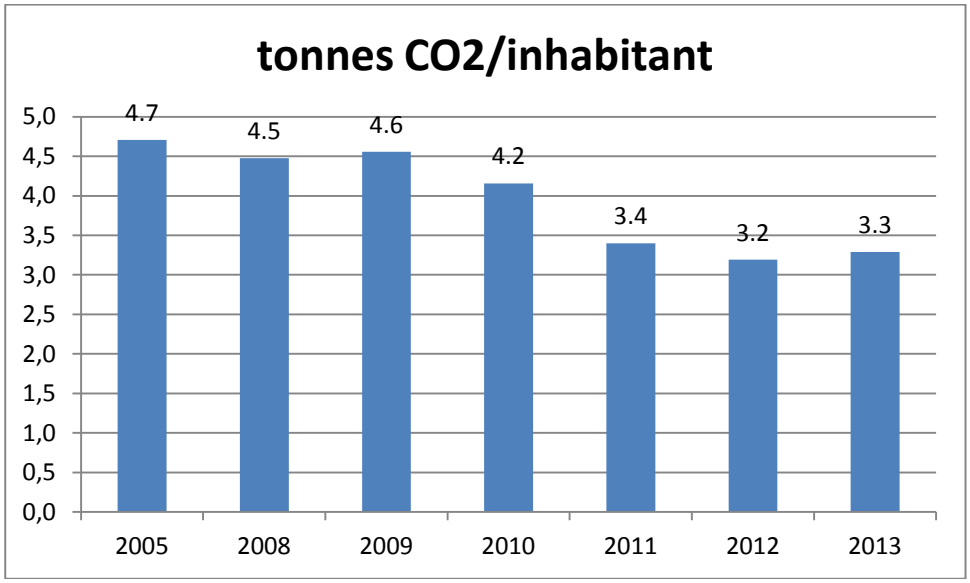

Figure 7:
Tonnes CO2 per inhabitant in Copenhagen. CO2-credits from investments in RES have been deducted from the figures.

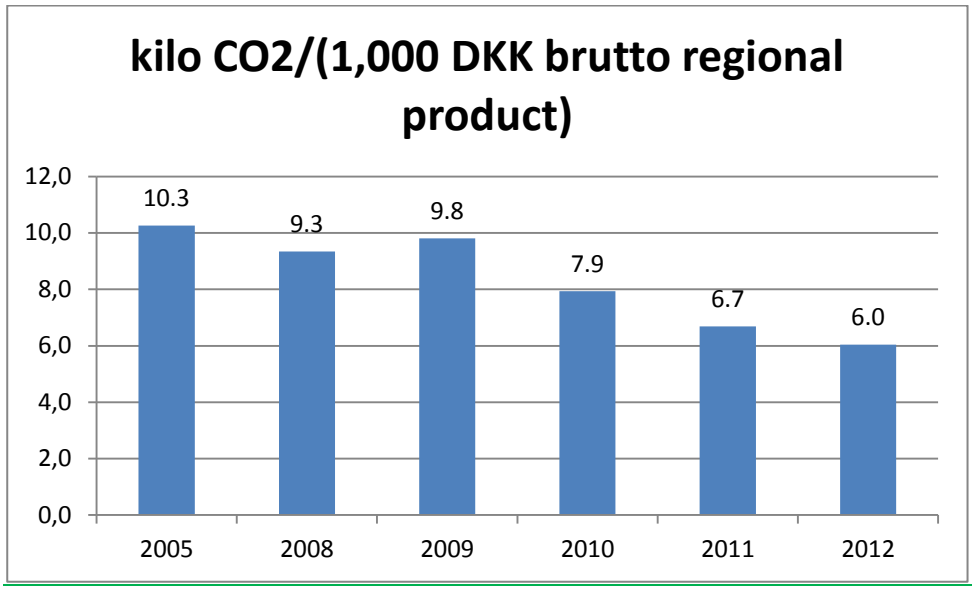

Figure 8:
Kilo CO2 per 1,000 DKK brutto regional product. Running prices.

Last but not least, it should be noted that in the current energy system and situation, there are two factors that tend to account better for variations in CO2-emissions than other factors do. These two factors are:

- Degree days
    - A proxy that indicates how much colder or warmer it was during a certain time period relative to an index-value considered a 'normal year';
- Total amount of CO2 per kWh in Denmark as a whole
    - *Energinet.dk* (the Danish non-profit TSO company for both the gas and electricity grid)[23] calculate this figure on the basis of the *actual* mix of primary energy sources used for electricity production in the grid. This means that the figure is dependent on the wholesale import and export of energy on the energy exchanges – in other words, it is by and large the wholesale *market*, and not Danish energy *consumption* that defines this mix.[24]

This means that CO2-accounts should be degree day corrected and the effect of the wholesale market estimated, lest the *real* impact of City initiatives is impossible to assess. It should be noted that the figures in the previous sections have not been corrected for degree days or the impact of the wholesale market.

The following sections provide a brief overview of the regulatory frameworks that either pull in the same direction, enabled, impede or onwards support CPH 2025.

3.2 Energy transition Regulatory Framework

There is both a hard and a soft answer to the question of the regulatory framework for the energy transition. The hard one has to do with the formal set-up of powers and mandates, the soft one with influence, conjunctions, inspiration and the formation of political will that changes or add something to the usual set-up of things.

The hard answer can be addressed in terms of formal powers and mandates. A recent article identified five levels and actor types that have different powers but all a say in the typical Danish set-up for heat planning.[25] These actors and their powers are listed in figure 9. And although the energy transition is a much broader topic than that of heat planning, the pattern in the distribution of powers among different actors is roughly similar within different subject areas that together add up to the total energy transition framework. This makes it useful to set out with a picture of the situation, as seen from the vantage of Danish heat planning.

[23] Energinet.dk is owned by the Danish Ministry of Climate, Energy and Building, and is amongst others the owner of the Danish transmission lines for gas and electricity as well as responsible for balancing the system and optimising wholesale markets.
[24] Figures are available her: http://energinet.dk/DA/KLIMA-OG-MILJOE/Miljoedeklarationer/Sider/Miljoedeklarering-af-1-kWh-el.aspx
[25] See Chittu, Anna and Poul Alberg Østergaard (2014):'How Danish communal heat planning empowers municipalities and benefits individual consumers', in: *Energy Policy*, Vol. 74, pp. 465-474.

CRITICAL HEAT PLANNING POWERS AND RESPONSIBILITIES IN DENMARK

European Union

- Develops binding and non-binding energy goals
- Requires national heat plans

Danish National Government

- Establishes national legislative framework
- Frames socio-economic cost-benefit tests
- Determines which costs can be recovered in DH prices

Cities and Municipal Governments

- Responsible for planning local heat projects that promote local interest
- Power to approve or reject proposed changes to heat infrastructure

District Heating Companies

- May recover costs and assign costs to specific users
- Must share benefits among all applicable customers and respond to requests made by local government

Individual Consumers

- Directly or indirectly influence investment decisions of local DH companies
- May contest requirement to connect to DH

Figure 9:
Adapted from Chittum & Østergaard (2014): Powers and responsibilities held by different levels of government and heat system users in Danish heat planning.

Further to the impetus to act, following one's mandate, and as identified through the formal powers, the question remains: Where did the momentum that led to CPH 2025 come from? The short answer is: From the City's desire to change things that, however, benefited from – perhaps even greatly depended on – the window of opportunity opening with the 2009 UN climate summit, COP15 that took place in Copenhagen.

This section first outlines key framing events internationally, nationally and in the city that paved the way for CPH 2025, or henceforth support it. Second, owing to the key role of energy production – having to deliver the 74% CO2-reduction in CPH 2025 – the framework for energy systems in Copenhagen is described too.

Internationally

The build-up towards COP15 in deceber 2009 provided a platform on which some city-leaders, encouraged by the Danish Government to show what cities could contribute, took the opportunity to break with a decades-long tradition of not doing a great deal about the

changing climate. Indeed, climate change, first studied in the 19th century, became a well-studied phenomenon in scientific research since the 1990s, and was on the agenda during the 14 UN COPs preceeding COP15 (i.e. since the mid-1990s).

As will be recalled, COP15 far from delivered on the expectations of an internationally binding climate agreement (formally, only some three pages resulted, the so-called Copenhagen Accord, essentially committing states to respect a max growth of temperatures by 2 degrees Celsius[26]). Yet, the event did contribute to building momentum, raising awareness, and it fuelled ambitions and action plans both nationally, at city-level and in business.

European Union
A series of Directives and decision-making processes at EU-level influence energy and climate developments in Copenhagen too.

Liberalisation
One of the most important changes in terms of both regulation and stakeholders in the energy sector resulted from the liberalisation of the energy sector that the European Union promoted, and which resulted in the two Directives for electricity and gas, respectively, in 1996 and 1998. In essense, these Directives served the purpose of introducing more competition. To this end, the Directives demanded:

- The end of favouring public companies;
- Unbundling of functions (e.g. production, transport, sale of energy);
- Free access to transmission grids (otherwise the reason for natural monopolies);
- Transmission grids should be owned and operated by companies acting in a neutral manner vis-à-vis the competition in the sector.

20-20-20
Another major driver in energy and climate politics is the triple 20-20-20 target, proposed in 2007 and enacted through the climate and energy package in 2009. The ambition is that the EU by 2020 will have reduced CO2-emissions by 20% from 1990 levels; will ensure that RES accounts for at least 20% of energy consumption, and that the EU will have become 20% more energy efficient.[27]

EED
The Energy Efficiency Directive of 2012 strengthened the ambitions of the EU, and put a series of specific obligations on Member States, such as to set national targets, report on them and with an obligation to reach certain goals, to make the public sector lead by example by renovating 3% of buildings owned or used.[28]

[26] Cf. http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf
[27] http://ec.europa.eu/clima/policies/package/index_en.htm
[28] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

EU initiatives, measures

Generally, initiatives and measures that make a difference and accelerate action, whether nationally or in a city, include in particular:

- Goals (e.g. RES-increase or CO2-reduction, including for transport)
- Energy standards (e.g. requirements to components; building codes)
- Upgrades of the grid across the EU (e.g. focus on the need for an efficient grid with fewer bottlenecks, or the role of grid operators)
- Research programmes to test approaches and support initiatives (e.g. FP7, Horizon 2020)
- The carbon market – should have been an important measure, but is inefficient.

Mayors' Covenant

The EU's outreach to and convening of the Covenant of Mayors, translating the EU 20-20-20-targets to local government's focus – and adoption of each their Sustainable Energy Action Plans (SEAP) – enjoyed some momentum in its *upstart*, and during the platforms provided by COP15.[29] This, to be sure, contributed to awareness-rising and the creation of connections among cities. Currently, however, the Covenant of Mayors seems to have lost steam. The idea of reviving the movement in a UN context has been suggested.

National level

Traditionally, that is, at least since the oil-crises in the 1970s, energy politics in Denmark relied on a trio of priorities that over time resulted in different equilibria amongst security of supply, reasonable energy prices, and impact on the environment.

In 2008, the Danish Government, hosting COP15 one year later, commissioned the 'Climate Commission' with the task of calculating and describing if, and how Denmark could become independent of fossil fuels. The Commission delivered its positive answer by September 2010[30], and in February 2011, the Government presented a national energy framework (*Energistrategi 2050*) that lays down the ambition that Denmark must be independent of fossil fuels by 2050.[31] An historical conciliation followed in 2012 that set out directions and specific goals for 2020.[32] In 2013 came the Government's national climate plan, including a catalogue of Danish Climate Change Mitigation Measures.[33]

The Danish government has a vision for the electricity sector, heat and industry sectors to become carbon neutral by 2035; the transport sector must be carbon neutral by 2050 only.

[29] http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html

[30] http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danish-commission-climate-change-policy/green-energy/green%20energy%20GB%20screen%201page%20v2.pdf

[31] http://www.kebmin.dk/sites/kebmin.dk/files/news/from-coal-oil-and-gas-to-green-energy/Energy%20Strategy%202050%20web.pdf

[32] http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/accelerating_green_energy_towards_2020.pdf

[33] http://www.ens.dk/en/policy/danish-climate-energy-policy

Thus, for instance, all heat and electricity consumed in Copenhagen should be carbon neutral in 2035.

Before that, the idea to create a market for energy savings, and to make utility companies key actors in driving the market resulted in the energy savings obligation. The energy savings obligation requests that energy and utility companies ensure the realisation and documentation of energy savings on an annual basis.

The energy savings obligation was first introduced as a voluntary agreement with energy and utility companies in 2006, requiring energy savings at the level of 2.05 PJ per year 2006-2013, a level that was tightened in the energy bill of 2008, requesting 5.4 PJ per year 2010 onwards.[34] The energy bill in 2012 tightened demands yet more, and increased the level to energy savings of 10.7 PJ in 2013 and 2014, and 12.2 PJ each year from 2015 to 2020.[35]

The energy savings obligation
How does the energy savings obligation work in practice? The energy utility companies companies are given each an amount of energy savings that they must create – whether directly through energy consultancy or indirectly, buying them in the market. In other words, the utilities are free to choose the method allowing them to meet their individual energy savings target.

Examples of directly created energy savings include, *inter alia*, reduction of losses in the grid, assistance to industries, public companies or private customers to help them optimise processes, retrofit buildings or reduce their consumption levels through changed behaviour.

Utility companies can also be credited for energy savings in new built if they suggest energy reducing investments, provided the initiative reduces the consumption level to below required standards. Closer collaboration among, for instance, developers and utility companies could therefore result in more energy efficient new built.

Central principles of the Danish energy savings obligation were integrated into the EU Directive on Energy Efficiency in 2012, implying that all member countries in due time must ensure annual savings.

The idea of making Denmark independent of fossil fuels prolongs the tradition since the 1970s of balancing security of supply with reasonable energy prices and environmental impact, and pays due respect to all three dimensions. But, at the same time, the new ambition breaks fundamentally with the conventional reliance on (heavily subsidised) fossil fuels. Instead, it projects a series of goals from the present through 2050 that necessitates environmentally cleaner alternatives.

[34] http://www.ea-energianalyse.dk/reports/815/815_b1_energiselskabernes_energispareaktiviteter_dec08_revised.pdf
[35] http://www.ens.dk/forbrug-besparelser/energiselskabernes-spareindsats/aftalegrundlag-kontrol-resultater

City-level
At city-level, a series of traditions, strategies and goals formed a natural backdrop for CPH 2025, and continues to play an important role.

At the most fundamental level, the decades' long majority of leftwing voters translated into a stable focus on environmental concerns. The importance of this can hardly be overestimated, whether in terms of the historical heritage or expectations for future voter support to a continued environmentally ambitious City Council.

A key reference among the examples of strategies preceding CPH 2025 would be the first Traffic and Environmental Plan, dating back to 1997, and a more recent one the vision for Copenhagen as the 'Eco-Metropolis 2015' (*Metropolvisionen*), adopted by the City Council in November 2007.[36]

In addition to the overall vision of having by 2015 the world's best metropolitan environment and being the city others look to for solutions, the Eco-Metropolis singles out four key areas of intervention:

- The world's best city for cyclists
- World centre for climate politics
- Green and blue capital
- Clean and healthy city.

Following the City Council decision in 2007 to adopt the Eco-Metropolis vision, the 'green accounts' became the chosen instrument to report on progress of the Eco-Metropolis' 13 specific goals. The first version of the Copenhagen Green Accounts was published in 2008. Each year, the green accounts and their assessments as to whether Copenhagen is on track or not as regards the 13 goals are presented to the Environmental Committee and the City Council.[37]

The goals and monitoring cover the areas of CO2, water, waste, noise, air pollution, traffic and the City Administration itself (e.g. a key goal in this latter respect is to meet requirements of the ISO 14001 Standard, regarding environmental management). Thus relative to CPH 2025 the Eco Metropolis concerns a *wider* set of environmental concerns.

CPH 2025 is today more or less closely linked to a series of other plans, including *inter alia*:

- Municipal Master Plan 2011, entitled 'Green Growth and Quality of Life';
- City of Copenhagen Climate Adaptation Plan, adopted by the City Council in 2011;
- Local Master Plans;
- Agenda 21 Plan for 2012-2015, adopted by the City Council in January 2013;

36 http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment/Eco-metropolis.aspx

37 http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment/CopenhagensGreenAccounts.aspx

- Action Plan for Green Mobility, adopted by the City Council in autumn 2012 ;
- City of Copenhagen Resources and Waste Plan for 2013-2018, adopted by the City Council in 2012;
- Cycling Strategy 2011-2025, adopted by the City Council in April 2011.

To understand the current Climate Plan, CPH 2025, one has to understand what enabled the first one as well as the requests for change from the first to the second version. In 2009, COP15 represented a window of opportunity that the national Government moreover actively encouraged cities to use. In Copenhagen, the dialogue between the Mayor for the Technical and Environmental Administration and consultants with in-depth knowledge about opportunities resulted in the Mayor's belief that Copenhagen could opt for not only an ambitious but a complete CO2-reduction. The outcome of that process was that the City Council unanimously adopted the first version of the Climate Plan in August 2009. In this version, the Climate Plan articulated the *vision* of Copenhagen as the first CO2-neutral capital by 2025, including a series of initiatives to make it happen, but it only contained specific goals for the period until 2015.

However, the 2009-version, developed in the run-up to COP15, was mainly preoccupied with CO2 from the vantage of the climate, that is, the question of how to reduce CO2 technically for the sake of containing climate change. Post-COP15, and at the back drop of the economic crisis that lingered on, a conditional agreement to implement the plan shaped up in 2010. The City Council requested in line with the simultaneously developed 'Copenhagen Story' (see below) that more than 'just' solving the climate issue, the Climate Plan had to contribute to growth, on the one hand, and it had to foster a greater involvement of stakeholders, on the other. Moreover, the City Council asked for the (2009) Climate Plan to be evaluated in 2012.

These requests led to it that the second Climate Plan, CPH 2025 (as of 2012) was turned into both a *revised strategy*, accommodating climate and growth ambitions at the same time, and a *process*, throughout 2011, with 200+ private companies, organisations and universities on how to succeed in implementing the strategy. The resulting input from stakeholders in the process influenced the level of ambitions, specific goals, and technological choices.

For instance, innovative ways of collaborating in public-private partnerships were suggested as means in addition to urban development agreements, or the offering of Copenhagen 'as a lab' to test new solutions.

As to the impact of the request that the 2009-Climate Plan be evaluated in 2012, the adoption of the second version of the Climate Plan was eased by the fact that the mid-term goal for 2015 (a 20% CO2-reduction relative to the baseline year of 2005) had already been reached in 2011.

In 2012, the City Council adopted the second, current plan, *CPH 2025. Carbon Neutral. A Green, Smart and Carbon Neutral City* – known as CPH 2025. In this version, budgets and a detailed road map with action plans were added to the overall vision and broad outline of areas to target. As requested, some 200+ stakeholders were involved in the revision of the Climate

Plan to ensure ownership to the agenda among private companies too; with a view to creating growth and jobs on the road to carbon neutrality.

This combined approach rimes well with the dominating City philosophy: that of the 'Copenhagen Story' that gained traction in the City in 2010. While not exactly *regulatory*, the Copenhagen Story guides virtually all policy-making and thus requires mentioning as guiding principle. Tellingly, the very introductory remarks in CPH 2025 states that 'Copenhagen wants to be carbon neutral by 2025. It is a political ambition that Copenhagen as Metropolis and capital must assume responsibility for the climate and show that it is possible to *generate growth and progress while also reducing CO2 emissions*' (my italics).[38]

The 'Copenhagen Story': A master frame for the city's politics and policy-making
Since 2010 the City of Copenhagen operated with the 'Copenhagen Story' as *Leitmotif* for the development of the City. The Copenhagen Story is less an historical rendering of past developments than a *vision* for the city's development in the future. Relative to more issue-specific strategies and plans, it functions like a master frame.

The Copenhagen Story originates in a response to an OECD report from January 2009, a so-called 'Territorial Review' about greater Copenhagen. This report observed that while Copenhagen is a great city in terms of life quality, it lacks behind when it comes to creating economic growth. This analysis became the starting point for a commitment to create more growth whilst preserving the high levels of life quality of the city. Although not formally adopted by the City Council, the Copenhagen Story was presented several times to the Economic Committee and taken notice of as a useful Master Frame for partly existing goals already adopted by the City Council – such as Copenhagen as CO2-neutral capital by 2025, based on the premise of creating growth and involving stakeholders to reach this goal.

In the early versions of the Copenhagen Story, the promotion of life quality and growth are seen as key for the city to remain attractive for citizens, business and tourists alike. Over time, the story evolves. Whilst concentrating on 'growth' and 'life quality' at all times, it also sometimes singles out 'sustainability' on a par with the two other – or, alternatively, substitutes 'growth' for 'green growth'. The latter is seen in the 2011 Municipal Master Plan which carries the title 'Green Growth and Quality of Life'.

But more than guided by 'soft' master frames, the energy sector, key to any major CO2-reduction plan, is regulated in formal ways. The following sections outline some of the regulatory framework with an emphasis on the heat planning that is closely intertwined with local government.

The role of energy systems and their regulation
In CPH 2025, the great majority of carbon reduction must happen in the energy sector, in particular in the way energy is *produced*. 74% of the planned carbon reduction in CPH 2025

[38] http://kk.sites.itera.dk/apps/kk_pub2/pdf/983_jkP0ekKMyD.pdf

must come from changes in energy production. This makes the City's ability to influence and negotiate with actors in the energy sector a critical factor.

This section gives a brief overview of actors, regulations and frameworks, further to already mentioned national legislation and conciliations that define goals, means and obligations for the energy sector in the Capital Region of Copenhagen. First, trade in power is briefly touched upon, then follows a description of the heat system that differs from the electricity market in it that the City formally is the authority for the heat system.

International trade and wet or dry weather co-define national production of energy
Following the deregulation of power markets in the 1990s in the EU, international wholesale trade of energy emerged as a new factor in the energy sector. The international wholesale market to a large degree defines which energy actually goes into the grid (i.e. whether it is water power from Norway, wind power or coal-based CHP production from Denmark, nuclear power from Sweden etc.). In 2000 Denmark joined Nord Pool Spot which was in 1996 the world's first international energy exchange, allowing for power trade between Norway and Sweden. Nord Pool Spot now connects the four Nordic countries, Germany, the UK and Baltic countries.

Another defining factor for the mix of primary energy sources in Danish electricity grids is whether it is a wet or dry year. In 'wet' years, large amounts of water power from especially Norway make up larger shares of the trade on Nord Pool Spot and squeezes our the more expensive production of energy at CHP, whether they are RES- or fossil fuel based.

The importance of understanding the role of international trade of energy and wet/dry years has to do with them being factors *beyond* the control of the City and which, nevertheless, influence the extent to which the City will meet the CO2-goals (e.g. how much CO2 per kWh). It is useful to understand and assess these factors' impact on the City's CO2-results and-reporting – to be able to filter out their importance and better identify which measures the City *can* control, and assess the impact of these measures. The CO2-accounts of Copenhagen, for instance, come in two versions, one incl. and one excl. the import/export factor.

Owing to this international character of the trade in electricity, it does not make much sense to discuss electricity as a *system* in Greater Copenhagen, let alone the City of Copenhagen.

With regard to the ownership and operation of the electricity grids, the grid operators at distribution level are designated according to national-level processes, and municipalities have no formal role as authority vis-à-vis electricity (i.e. whether grid operation, electricity production or trade).

In Copenhagen, the distribution system operator (DSO) for electricity is DONG Energy Distribution, while (in entire Denmark), Energinet.dk is the Transmission System Operator (TSO).

Greater Copenhagen heat systems and forums over time

Municipalities are by Danish law, since 1979, the formal authorities as regards the planning of supply of heat. To simplify a bit, there are two critical dimensions to understand in heat (and power) supply. One is the choice of fuel, the second is who has the power to make that choice (e.g. the market, public authorities).

In terms of fuels, the industrial age is synonymous with the Oil Age. The Oil Age refers both to the widespread, dominant use of coal from the early 19th century well into the 20th, and to the use of oil that also expanded from the mid-19th century. As long as oil was plenty and available at low cost, it appeared the ideal solution (except for unacknowledged environmental impacts). With the oil crises in 1973 and 1974, that situation changed.

In the Danish context, this is the moment when the second question – that of who has the authority to make the fuel choice – became important. The choice of fuel changed status from a non- to highly politised issue. The state gave local government new tasks and powers, and in turn introduced new expectations as regards local government's strategic, long-term planning and coordination with stakeholders and surrounding municipalities.

The district heating system in Denmark saw the light of day in 1903 in the municipality of Frederiksberg (geographically situated like an island within the municipality of Copenhagen), and began from the 1930s to factor properly in Copenhagen. The system expanded in the 1950s and 1960s, but it was not until the 1980s that today's levels of near-total coverage within cities was reached. In Denmark as a whole, approximately 60% heat supply is district heating, and in Copenhagen, 98% heat supply is based on district heat. The condition for this change came about in the early 1980s when national legislation ruled that local governement could oblige both new build and existing buildings to connect to district heating.In Copenhagen, it was decided in June 1993 that within 9 years, all new built and all existing buildings had to connect to district heating, or, to be more precise: to either connect and pay or pay the 'effect fee' if not connecting.

First Danish Heat Supply Law, 1979 : Efficient use of energy and environmental concerns

The first Danish heat supply law was passed in 1979, in a response to the oil crises of 1973-1974. Part of the national Government's ambition to become less dependent on foreign, instable regimes for energy/oil import was to shift to alternatives (coal, in particular; later natural gas (own production) and explorations and demonstration of the use of RES). Another priority was to introduce a much more efficient use of energy. To this end, municipalities and the then regional authorities, were endowed with the responsibility to map heat supply needs, existing heat sources and make estimates for future needs.

The heat supply law also gave local authorities the power to oblige new and existing buildings to connect to public supply. Most consumers were obliged to connect to either individual natural gas or district heating systems. This is still the case. In 1988, a ban on installing electric heat in new build was introduced – and is still in effect – with the aim of ensuring a more efficient use of energy, promoting public heat supply, and ensuring a better business

case for the heat suppliers (i.e. avoid that heat suppliers' investments were undermined by insufficient numbers of customers).

From the late 1970s, the ambition to introduce co-generation of electricity and heat gained traction; with the aim of exploiting the surplus heat from electricity generation. In 1986, with the adoption of the Co-generated Electricity and Heat Agreement, this approach turned into a major political priority.[39]

In the 1990s, the major changes to the system consisted in strengthening co-generation, and in particular, in shifting to more environmentally friendly fuels (e.g. less oil and coal; more natural gas and biomass).

In essence, the history of the change in Denmark from the first, small-scale introduction of district heating in 1903 to the obligation in cities to connect from the early 1980s tells the story of how much government, both national and local, *can* influence the choice of fuels. And considering the importance of the fuel-choice, it shows the difference concerted efforts and strategic thought-through solutions can make – and lead to the politically desired impact on the long-term socio-economic and environmental outlook.

'Heat Supply 2.0 ?': Strategic Energy Planning

Introduced in the 2010s, the core idea of the current voluntary instrument of strategic energy planning is to set long-term goals for a socio-economically balanced transition to a more flexible energy system with less consumption of energy and greater shares of renewable energy. Collaboration among cities and with stakeholders is considered necessary to avoid local sub-optimising, on the one hand, and to strengthen ownership to the creation of solutions, on the other.

According to the reasoning of a working group among the Danish Energy Authority, KL and a couple of municipalities, the reason for the introduction of strategic energy planning as approach must be found in the heat supply heritage. The working group found that after the introduction of 1) the heat supply law in 1979, 2) CHP and 3) more environmentally friendly fuels throughout the 1990s – nothing much happened. From the early 2000s, it became business as usual for local authorities to handle heat supply; a little too often in a one by one project manner. This led to a loss of the long-term perspective and socio-economic considerations at system level in favour of short-term, single project calculations.[40]

This is very unfortunate at a time when big changes *must* happen in the energy systems at large to contain climate changes – and more specifically, to implement the political visions for a Denmark independent of fossil fuels by 2050.

[39] http://www.ens.dk/en/supply/heat-supply-denmark/heat-supply-goals-means-years/public-heat-planning-1970s-1980s

[40] http://www.kl.dk/ImageVaultFiles/id_41857/cf_202/Opl-g_om_strategisk_energiplanl-gning.PDF

The Danish Energy Agency supports local government in the endeavour to make strategic energy planning through recommendations, tools and public funds available subject to an approved application.[41]

Critics object that the voluntary character of strategic energy planning is a serious problem because the needed changes to make the energy system truly flexible and energy efficient cannot be dealt with at city-level or only with regard to one's closest neighbours. According to this perspective, there is a need for a renewed Master Plan at nation-level – and one that sets specific goals and articulate clear expectations to the role and responsibility of local government and the energy sector.

The recent direction in strategic energy planning echoes core principles in the Copenhagen Climate Plan, and is anchored in the Climate Team, responsible for CPH 2025 – whose goals for the energy sector, integrated energy planning and energy consumption amounts to the City's strategic energy planning.

But to be sure, cities today work closely together with stakeholders whom they need to respond to and implement long-term ambitions at the same time as stakeholders must make the system work on daily basis. Figure 10 shows the geographical scope and key stakeholders of the district heating system for Greater Copenhagen.

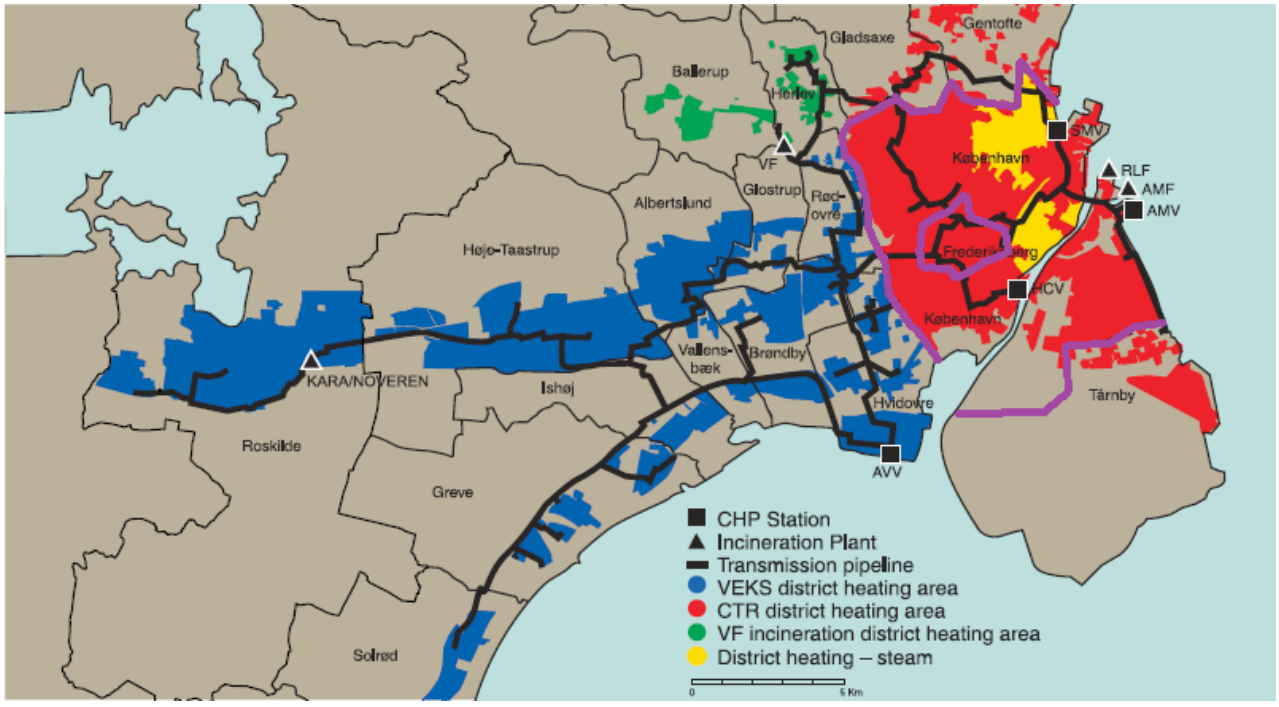

Figure 10:
Illustration of the district heating system around Copenhagen. Purple lines indicate the municipal borders of the City of Copenhagen. The municipality of Frederiksberg is located 'inside' Copenhagen. VEKS and CTR are TSOs for district heating. VF, KARA and AMF are waste incineration plants while RLF is a waste water treatment plant.

[41] http://www.ens.dk/undergrund-forsyning/el-naturgas-varmeforsyning/strategisk-energiplanlaegning-kommunerne

It is obvious that for a large, interconnected energy system to be operative and, ideally, at the forefront of future challenges through the suggestion of potential solutions, various methods must be used. At least three can be singled out in the case of the district heating system:

- Ensure that all stakeholders are part of the processes that define daily operations or planning for the future.

- Ensure coordination among stakeholders on daily operations (e.g. including a large number of municipalities, TSOs and DSOs and district heat producers).

- Set up a forum that will develop and discuss scenarios for the future energy supply, that is, considering the energy system in its totality in the Nordic context (more details will be given in Part B that describes challenges).

All three methods are effective in Greater Copenhagen. The following sections will briefly describe this.

***Varmelast.dk*: Daily operations and planning of heat production**
A central office, *Varmelast.dk* ('heating load'.dk) plans the daily heat production for 17 muncipalities in Greater Copenhagen.[42]

***Varmeplan Hovedstaden*: Scenarios and long-term planning for district heating**
A primary framework for the development of district heating is anchored in the so-called '*Varmeplan Hovedstaden*' ('Greater Copenhagen Heat Plan'). This project rests on collaboration among the municipality-owned utility company HOFOR and the two Transmission System Operators (TSOs) for district heating in Greater Copenhagen, CTR and VEKS. The third *Varmeplan Hovedstaden* was released October 2014.

The purpose of *Varmeplan Hovedstaden* is to envisage and plan for the future supply of heat in the capital region. Both national level developments such as, e.g., the national goal of a RES-based energy sector by 2035, and EU framework conditions figure in the scenarios building.

HOFOR, *Hovedstadsområdets Forsyningsselskab* (Greater Copenhagen Utility) is a a merger, as of January 2013, of the former utility company *Københavns Energi* (Copenhagen Energy) and the water utility companies in seven municipalities South and West to Copenhagen. But it is only the water-section that is co-owned by more cities, the rest of the company is owned by the City of Copenhagen only.

Københavns Energi used to be an integral part of the City Administration. The (former) electricity section was sold off in 2000 in response to the EU's request for liberalisation, and the remaining organisation was separated from the City Administration in 2005 – to enhance

[42] http://www.varmelast.dk/da

efficiency and a stronger focus on the core business (then: primarily to run the operation of CHP plants for district heating).

Today, HOFOR handles waste water and delivers clean water, district heating, city-gas and districting cooling to customers. HOFOR also invests in climate adaptation initiatives and installs wind power. In all areas, wind power excluded, HOFOR is the biggest utility company in Denmark. As of 2014, HOFOR owns the CHP plant *Amagerværket*. HOFOR is a non-profit company, and the supply subject to regulation by law. HOFOR has around 1,000 employees, and the annual turnover is approximately 5.5. billion DKK (€0.74 million).[43]

CTR, *Centralkommunernes Transmissionsselskab I/S* (Metropolitan Copenhagen Transmission Company) is a partnership, dating back to 1984, among the five municipalities of Copenhagen, Frederiksberg, Gentofte, Gladsaxe and Tårnby.[44] The purpose of CTR is to supply the municipalities and local heat supply companiens with district heat, primarily based on surplus heat from waste incineration or CHP plants. In total, CTR supplies heat to about 275,000 households, equalling approximately 10% of the total Danish heating supply.[45]

VEKS, *Vestegnens Kraftvarmeselskab I/S* ('Western District Combined Heat and Power') similar to CTR, and serving similar purposes, was established in 1984 and represents 12 municipalities geographically located on the stretch from Copenhagen towards Roskilde in West and Køge in South.[46] VEKS supplies heat and water to the equivalent of 150,000 households.

Almost ten production sites deliver base load district heating, including both politically prioritised and capacity-induced players, while more than 30 small production sites function as peak load reserves (e.g. in case of base load fall-out during winter).

Politically prioritised production:
Waste-incineration plant *Amager Ressource Center* (ARC)
Waste-incineration plant *Vestforbrændingen*
Waste-incineration plant *KARA/Noveren*
Waste water cleaning plant *Lynetten*
Geothermal demonstration plant on Amager.

Base load :
The politically prioritised production
CHP plant *Amagerværket* (owned by HOFOR)
CHP plant *Avedøreværket* (owned by DONG Energy)
CHP plant *H.C. Ørstedværket* (owned by DONG Energy)

Peak load and peak load reserves:

[43] http://www.hofor.dk/om-os/om-os/
[44] http://www.ctr.dk/en/about-ctr/articles-of-association.aspx
[45] http://www.ctr.dk/en/about-ctr.aspx
[46] http://www.veks.dk/~/media/VEKS/Files/EN-%20Publications/Engelske%20vedtaegter%202011.ashx

Approximately 30 smaller peak load reserves (owned by HOFOR, CTR and VEKS)
4 larger peak load and peak load reserves at *H.C. Ørstedværket* and *Svanemølleværket* (both owned by DONG Energy) contribute both to peak load when demand is particularly high and in the case of base load fall-out.

3.3 Energy transition Financial /fiscal Framework

There are two primary dimensions in the financial framework for CPH 2025. One distinguishes types of *economic calculations* that lie behind the definition of the level of expenses as identified in the Climate Plan. Here three kinds of calculations matter: the City's expenses to each initiative in CPH 2025, the level of tariffs (this is particularly important in the area of waste), and socie-economic calculations that show the overall value and cost of CPH 2025. The socio-economic calculation primarily serve communicative and legitimising puposes: Only a positive socio-economic value can guard CPH 2025 from becoming an easy target for criticisms and drawbacks in economic dire times.

The second dimension of the financial framework for CPH 2025 distinguishes types of *investment* that are necessary to implement the plan. Three types of funding matter: Public finance, direct, and indirect energy and climate finance – and the picture is clear. CPH 2025 can only be implemented if considerable amounts of direct and indirect, private investments are mobilised too.

Direct energy and climate finance is the one that directly has to do with, for instance, the production site for energy or waste handling. *Indirect* energy and climate finance, in contrast, stems from private actors whose primary interest is not necessarily energy or climate per se, but for instance the quality or level of expenses of their building or car fleet.

Another set of primary differences is that there are few and well-known actors contributing *direct* energy and climate investments. Moreover these actors are mostly companies under public ownership, but run as private companies. In contrast, there are a lot, and a very heterogenous group of private actors providing *indirect* finance – ranging from institutional investors to developers, associate housing companies and individual housing or car (fleet) owners.

In absolute figures, CPH 2025 requires 2.7 billion DKK (€363 million) from the City of Copenhagen, approximately 20 to 25 billion DKK (€2.7 – 3.4 billion) direct energy and climate investments (e.g investments in district heating and wind turbines etc.), and from 200 to 250 billion DKK (€27.9 – 33.6 billion) private, indirect energy and climate investments.

The relative shares of these three types of finance is approximately 1 : 9 : 85. This means that for the balance to add up, the City will invest 1 DKK while actors contributing direct energy and climate funding must invest 9 DKK, and private actors' indirect funding must reach 85 DKK.

Public investments – City of Copenhagen
As of mid-2014, 700 million DKK (€94 million) out of the required total 2.7 billion DKK (€363 million) were allocated in Budgets 2013 and 2014.

For example, among the major public investments are, infrastructure for bicycles, enery saving street lightning and energy investments in the City's own buildings (new-built and retrofit projects).

A critical condition for funding through the annual City Budgets is a continued political interest and focus on the challenges that necessitated CPH 2025 and its implementation in the first place. But it is well-known that political agendas are dynamic, not a static factor.

A key condition for funding via the Budgets is consequently the Climate Secretariat's ability, during the annual negotiations of the Budget, to find support across the Administration and raise political interest for initiatives that contribute to the implementation of CPH 2025.

In terms of the both the direct and indirect private investments, the City has few or limited means to influence decision-making and monitor progress in the level of investment.

Private, direct energy and climate investments
In the case of the City-owned HOFOR, the alignment of goals and investements in support of 2025 enable a considerable level of influence on investments and monitoring. For instance, the introduction of wind power as a new business area in HOFOR results from the City Council voting for this solution, and the Finance Administration of the City of Copenhagen following up on the request, vis-à-vis HOFOR to make it happen.

The primary direct energy investments concern investments in distric heating and wind power.

HOFOR finances most of its investments in its non-profit companies (e.g. district heating) through the national financing institution *Kommunekredit* ('the municipal credit system'). The actual loan conditions of *Kommunekredit* are 3% for a 25 years loan (covering 100% of the investment) due to a municipal guarantee. For commercial activities (e.g. district cooling) HOFOR typically obtains bank loans with an interest rate around 5-8% and a 5 year maturity. All loans are paid back through consumer tariffs.

In other cases, such as ARC, CTR, VEKS and DONG Energy, different approaches and negotiation strategies are necessary. In the case of ensuring CO2-neutral heat, the City of Copenhagen (along with the other local governments co-owning CTR and VEKS) requested of the two district heating TSOs, CTR and VEKS, that they ensure the supply of CO2-neutral heat by 2025. CTR and VEKS in turn then had to, and did, request of district heating producers – such as, in particular, DONG Energy, the owner of *Avedøreværket*, Vattenfall, the former owner of *Amagerværket* (as of 2014 owned by HOFOR) and ARC – that they produce and deliver CO2-neutral heat.

Private, indirect investments in energy and climate
The big question of how to influence the private, indirect investments in energy and climate can only be summed up as a matter of dialogue, persuasion – and pilot projects that allow for tests of new ways to unleash the capital in the service of energy efficiency or more flexible energy consumption.

These investments are those that private companies do, such as, investments in retrofit of privately owned buildings.

Only market-based surveys of investment levels allow for some kind of overall impression of investment levels

National influences on urban planning and building standards
National Government can help, or impede, the implementation of CPH 2025. For instance, national subsidies that incentivise the retrofit of buildings may accelerate the implementation of energy efficiency goals in CPH 2025.

On the negative side, it requires mentioning that CPH 2025 rested on the premise that national Government introduce a congestion charge for Greater Copenhagen. But the Government coming into power in 2011 failed to do so, and this produced a 70,000 tonnes CO2 deficit in CPH 2025 that must be dealt with differently (e.g. installing more wind power, additional initiatives in the transport or building sectors) – and funded.

Also, on the negative side, national government decided in May 2014 to diminish local government's right to make demands on new built's energy class through local plans. Henceforth, energy classes can only be regulated via *Bygningsreglementet*, the at any time current, national building regulation.[47]

The building regulation is revised on the initiative of the national Danish Energy Agency that hosts the building regulation.[48] Smaller *ad hoc* amendments can be added to an existing framework. Now and then, every two to five to 15 years, the building regulation is subject to a major revision process, involving stakeholders and formal consultation processes.[49] It requires mentioning that building regulations must be respected in both new built and renovation, and regardless whether there is a demand to apply for permission at the local government or not to build or renovate.[50]

While not *directly* a matter of investments, local plans are nevertheless decisive for how developers build – and thus whether they invest in business as usual solutions, or in solutions that provide, for instance, greater levels of energy efficiency or enable flexible energy

[47] http://www.ugebreveta4.dk/89-vaekstforslag-faa-overblik-paa-lidt-over-fem-minut_19620.aspx
[48] http://bygningsreglementet.dk/
[49] http://bygningsreglementet.dk/tidligerebygreg/0/40
[50] http://www.danskbyggeri.dk/for+medlemmer/teknik+-c12-+processer/byggekrav+og+processer/bygningsreglement

consumption. When local government can no longer make particular demands on energy classes through local plans, they loose a formal tool to strengthen demands and will have to work harder to reach the same goals through dialogue, persuasion and negotiation.

In stead of focusing efforts on urban planning in the city through local plans, it is henceforth necessary also to lobby the Danish Energy Agency with new requests, on the one hand, and developers, on the other – because the time frame for revisions of the building regulation is far too long for real life building processes.

Another change that impacts on local plans, but in as of yet uncertain ways as regards energy levels of buildings, concerns local government's ability to decide the share of social housing in green and brown field areas. By late November 2014, political pressure since years from left-wing city politicians resulted in national government deciding to change the national framework for land use (*Planloven*). Amongst others this framework rules the kind of demands that local government can make through local plans.

Henceforth, local government may reserve up to 25% of green and brown field areas to social housing. In combination with better conditions for loans for social housing associations, the newly acquired right to demand up to 25% social housing in local plans endows cities with a strong tool to balance housing needs socially. The expectation is that the two measures in combination will result in more affordable housing (up to around 6,600 new apartments before 2025) in areas with land prices that would otherwise prevent social housing from being developed there. This will reduce the trend to rich ghettos in urban development areas with expensive land prices.

Whether this will also lead to an increase in *energy* optimised buildings, however, is yet to be seen. The likelihood that it will lead to a greater share of highly energy efficient new built is probably low, given the need to respect maximum prices per square meter for social housing and in spite of the more favourable opportunities for financing new built for social housing.

This open question about the energy profile of social housing in areas with high land prices begs another question, namely that of the role of the City – as facilitator of finance to support politically backed priorities.

3.4 Actor mapping and related competencies (governance)

The principle of 1 : 9 : 85 of public, and private direct or indirect finance to make the implementation of CPH 2025 possible directly vehicles the message that the City cannot go it alone. But in addition to the question of finance, a whole series of other resources, competences, know-how and decision-making powers outside of the City are required on-board too. In other words, the implementation of CPH 2025 depends largely on the City's ability to mobilise, build alliances with and, if need be, gently nudge actors to move in the desired direction.

How well connected is the City of Copenhagen to its key stakeholders? This section provides at a glance a picture of the stakeholders that the City, now and in the future, must interact with to succeed in becoming carbon neutral. It is outside the scope of this section to offer a thorough analysis of the question of how complete the actor networks are that the City needs, has already, or should build.

The mapping exercise within the TRANSFORM project, undertaken by AIT from September through November resulted in the following picture of the situation, see figure 11, pointing out a range of stakeholders as key, and among them potential change agents for CPH 2025 in the future.

Staff dedicated to advancing the Climate Secretariat's collaboration with key stakeholders locally, nationalle and vis-à-vis international society will eventually assess the quality of the stakeholder relationships: Which ones to build? Which ones to strengthen? And how to do it?

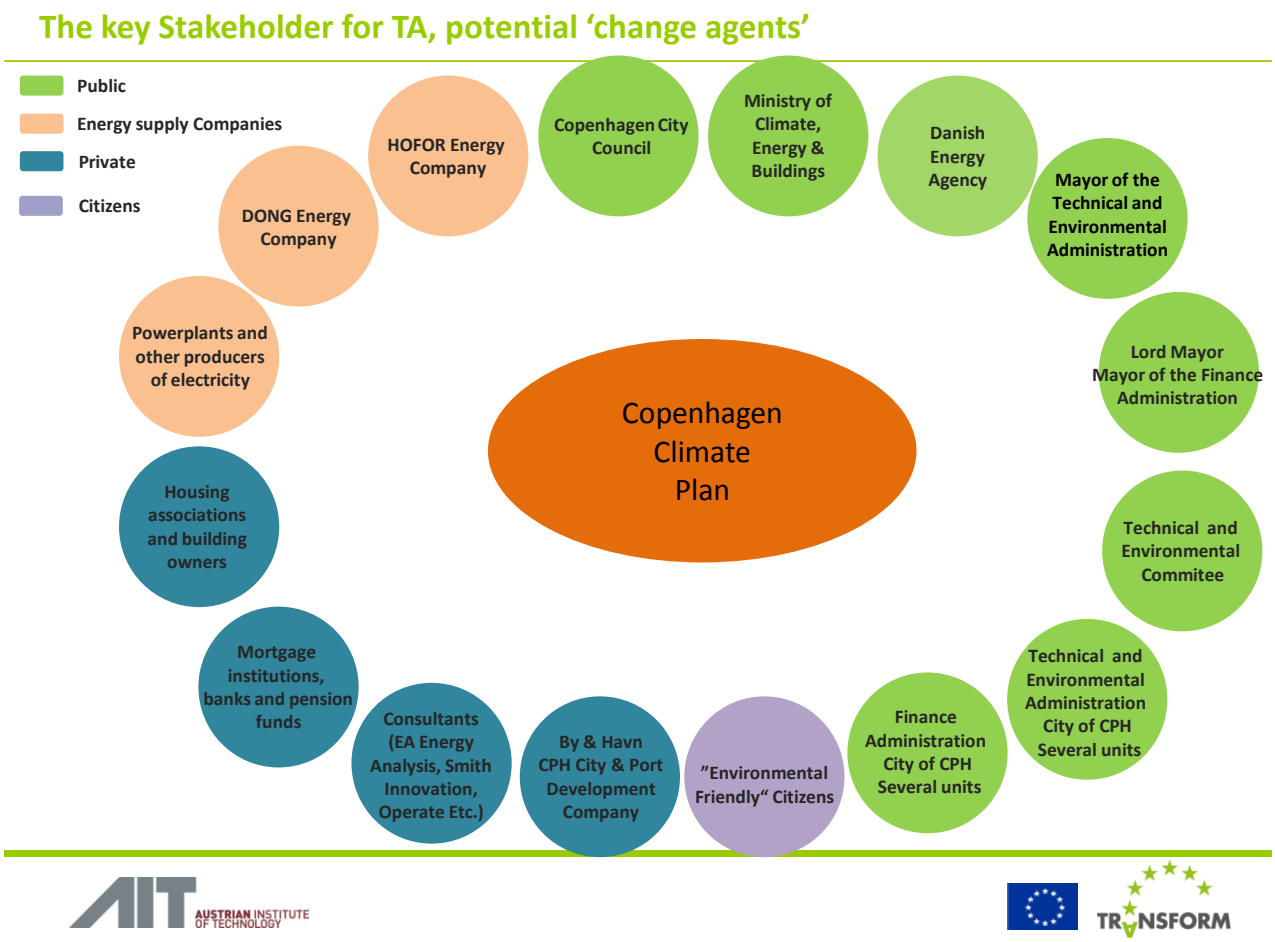

Figure 11:
Stakeholder-mapping, Copenhagen: Key actors and potential change agents. 'TA' is TRANSFORM-language for Transformation Agenda.

Part B - Evaluation of CPH 2025

This section assesses the concept of CPH2025, and singles out challenges that, if met, improve the implementation scale or speed of the climate plan.

In terms of the TRANSFORM definition of the Smart Energy City (cf. definition in the smart city introduction), Copenhagen is doing well – in particular in so far as the concept is a highly integrated concept, with a long-term perspective, an already politically adopted goal, with agreed funding, and some 65 specific initiatives described in the roadmap for CPH 2025 that, moreover, works in tandem with a whole series of plans and strategies on environmental issues, the use of data in new ways, partnerships with private actors and the ambition to offer Copenhagen as a test lab for innovative approaches.

Yet, while overall, CPH 2025 is on track, it is far from *well* on track on *all* accounts – whether measured in its own terms as sufficient and fast progress on all initiatives, or in terms of the TRANSFORM project as a whole (cf. the score on Key Performance Indicators (KPIs) in WP1, with some lacking behind, or the ability to work with data in WP3). But the impression of a deficient performance level also applies when it comes to certain fundamental dimensions of the set-up of CPH 2025.

This section progresses from an overall strategic point of view towards the more particular, although no less *general* difficulty in cities: How to work with data & ICT *and* succeed in levering energy efficiency potentials effectively through this particular set of means (e.g. in buildings)? Or how to create greater levels of flexibility in the energy system, including through contributions from buildings.

1 City concept assessment – strategic level

The objective of this first section is to assess CPH 2025 as a concept, using various sources.

Based on the analysis by the City of Hamburg of all cities in the TRANSFORM project and the degree of strategic value of, in the case of Copenhagen, CPH 2025 – the overall picture in Copenhagen is that CPH 2025 is a fairly strong concept. In 8 out of 11 categories, the answer is A (good) instead of B (less good).

In three cases, CPH 2025 is strategically seen as a less strong concept:

1) CPH 2025 is mostly a stand-alone plan that does not concern or link formally to other themes of politics/governance.
2) CPH 2025 has no explicit offer for participation, aimed at citizens.
3) CPH 2025 is subject to open financing and depends on recurring negotiation processes.

The full questionnaire with all Copenhagen answers can be found in the Annexes (Annex 2).

The rating calls for a few reflections, complemented by other sources of evaluation of CPH 2025, strategically seen.

A stand-alone plan with little or no formal links across City Administrations
Although holistic in terms of its handling of energy questions, CPH 2025 could be a lot stronger in terms of its integration with other strategies and goals – for instance vis-à-vis other units working on retrofit, but also with regard to schools, education and the integration of good practice or knowledge about climate change in curricula.

How are we to change anything in the long run if colleagues and their projects, on the one hand, and children, on the other, are not taught the idea of that which must change, such as the city they live in? The projects they work on? Or their own life style and habits?

At the end of the day, change hinges on mindsets and habits that carry and sustain change over time. This applies in all cases across the City's many units and Administrations.

When not coordinated across City Administrations, CPH 2025 runs the risk of reduced effects at any time and a too slow shift of mind-sets generally over time.

The place of citizens
At first, it comes across as striking that people, or citizens, are generally absent from the CPH 2025 strategy to reach goals. The primary reason is that CPH 2025 concentrates efforts on institutionalised and market actors. This focus stems from the strategy to gain 74% of the CO2-reduction from the energy production sector, and which is, moreover, publicly owned. Thus a great deal of the change – including changes that will directly affect citizens in their everyday life – depends on structural change (e.g. a new model to finance or bundle retrofit projects) or improved systems (e.g. investments in district heating to make it CO2-neutral, or investments in infrastructure for bicycles). Also, the City's plans for increased levels of renewable energy through wind power happens when the City so to speak acts through HOFOR that invests in, and erects wind turbin parks, mostly outside of the City or off-shore – and here too, the question of local citizen support is less directly critical (as opposed to local on-shore wind turbine parks).

However, even some structural projects depend on citizens supporting or using the outcome of that which changed. For instance, what is the use of a huge net of bicycle lanes if nobody uses them? And it is worth keeping in mind that the difficult change is not the least the one that affects citizens' habits of everyday life. This is exactly the the case when it comes to the challenges of reducing energy consumption from transport and buildings. Active citizen participation or investments are required for changes to happen. Yet there is no systematic approach in CPH 2025 that targets citizens and their necessary contributions.

In sum, the risk that the lacking strategy to involve citizens entail is that of no or less effect of strategies, including in the case of structural solutions that partly depend on whether and how people use the solutions.

The focus on institutionalised and market actors would in part seem to reflect the chosen CO2-calculation method that prioritises activities and sources within the geographical city (Scope 1 in the GPC framework), and the opportunity to get compensation from investments in wind power outside the City. This focus in turn reflects the assumption that the City stands both too poor chances of influencing consumption patterns of citizens and businesses in a global market and, moreover, lacks the methodogy to report the resulting CO2-emissions (Scope 3, GPC framework).

A more ambitious approach with sufficient resources at hand would do both and also develop approaches to involve citizens more in CPH 2025. The Agenda 21 plan of Copenhagen does explore opportunities and barriers to make 'green' choices a priority for citizens but very few people within the City Administration work on this issue with virtually no budgets and no strong linkages to CPH 2025.[51]

The Agenda 21 plan should be better integrated with the work in the Climate Secretariat, and/or CPH 2025 develop a convincing citizen approach. This latter suggestion, however, begs the question of how well the CPH 2025 story is told to citizens.

Can politicians articulate a vision that will convince citizens to become part of the process? To help the City turn Copenhagen into the world's first CO2-neutral capital by 2025 (i.e. the goal of the City) is probably too abstract and too far from the ordinary citizen's perspective. To act on this, the City Aministration and politicians would have to come up with stories, benefits or necessary changes of habits that are tangible and desirable for citizens to identify with and act on. Then, the City would be able to engage citizens – and might in turn itself benefit from improvements that citizens could bring to the process of implementing CPH 2025.

The open finance question

The question of conditions for obtaining finance was already briefly discussed in the section 'Energy transition Financial/fiscal Framework'. The overall issue is that although the total required City budget, amounting to 2.7 billion DKK was, in principle, agreed once and for all, it was only agreed that this amount of public money will be granted *at some point* throughout the life time of the plan.

Needless to say, this situation makes it difficult for the Climate Secretariat to make long-term planning for the implementation. Their plans are likely to change fundamentally at least once a year when the result of the Budget negotiation is done, that is, if the outcome is far from the desired level.

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51 http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment/GreenEverydayLife.aspx

If no or much less money than requested is granted, the Climate Secretariat has to think of other ways to finance or implement the imagined initiative – either by finding money elsewhere, re-applying for public finance the following year, or by re-thinking the way the implementation must happen. Ever changing budgets are a barrier to efficient planning and implementation.

While it would make no sense with the entire funding of 2.7 billion DKK (€363 million) granted at once upfront, it would allow for much more efficient planning and implementation processes, if the required basic funding for the roadmap for each four years' period be granted ahead of each four year period. This would allow for better planning, and less resources would be spent on annual re-planning.

The current funding set-up creates a risk of delay in the implementation of initiatives.

In addition to the basic funding, however, external funding must be found, such as through EU projects, to cover all costs of planned projects in the plan.

The current status as regards the overall granted finance to CPH 2025 is that approximately 700 million DKK (€94 million) out of 2.7 billion DKK (€363 million) were allocated so far. This is about one fourth. On average, to reach the 2.7 billion DKK – although this is clearly not how the Budget process works – the Climate Secretariat should be granted 200 million DKK (€27 million) p.a. from 2015 through 2025. In the process for Budget15, they got 20 million DKK (€2.7 million), primarly to cover the staffing of the Climate Secretariet, confronted with the situation of several staff on a contract ending their contracts by the turn of the year.

Stable organisation vs. risk of loss of competences due to frequent staff-turnover

In prolongation of the just mentioned importance of stable framework conditions, it is worth mentioning another strategic dimension that was pointed out in the report by the TRANSFORM project's Advisory Board, namely the importance of a stable organisation, or unit, within the Administration. This organisation should have enough and updated competences to manage, implement and keep abreast of developments in required fields of knowledge to implement the climate plan. The argument in the Advisory Board report goes, that a competent and stable organisation is at least, if not even more important than political goals.

It may be discussed whether it is more appropriate to see the two as equally important: political goals and a stable organisation. Either way, as spelled out in the Advisory Board's analysis, the value of a stable organisation is indeed that of ensuring knowledge-transfer within the organisation, competent participation in collaborative settings with stakeholders, and, generally, keeping up the stamina in approach over time.

While it is positive that Budget15 in the City of Copenhagen granted money to sustain the Climate Secretariat, the recruitment strategy with staff on a contract remains a challenge that creates instability, and implies a risk of loss of essential knowledge owing to frequent staff-turnover.

The remainder of this chapter first considers a series of other assessments of CPH 2025 before going into more detail with two particular sets of challenges of either great importance in terms of energy consumption (e.g. buildings), or of cross-cutting relevance (e.g. data and how to unleash their potential as an asset in driving CO2-figures down and energy efficiency or flexibility in consumption up).

2 CPH 2025 in light of assessment workshops and processes

A number of sources assessed progress and barriers in the implementation of the CPH 2025 Plan, including the recurrent Copenhagen Green Accounts, the Climate Secretariat's own current status, and the TRANSFORM project's 'Intake Workshop' process. In the first two cases, the assessment is entirely internal and build on existing staff's hand-on knowledge of the state of affairs. With regard to the TRANSFORM 'Intake Workshop' process, City staff and stakeholders (business and research institutions) were involved in discussing and evaluating barriers and opportunities. See Annex 3 for a list of participants to the 'Intake Workshop'.

CPH 2025 – progress according to the City's reporting in the Green Accounts
The latest Copenhagen Green Accounts (2013) notes that already in 2011, the City reached its mid-term goal of reducing carbon emissions by at least 20% in 2015, relative to 2005. This result is primarily due to changes in the pillar of Energy Production, most importantly the shift from coal to biomass at CHP plants. A small increase in city-installed wind power production (mostly outside of Copenhagen) contributed to the result too.

What is not singled out in the Green Accounts is that this means that HOFOR delivered, and carried the investments, of the bulk of the CO2-results of Copenhagen, so far.

Progress must in years to come also be created in the three other pillars in CPH 2025, that is, through Energy Consumption, Green Mobility and the City Administration's own climate initiatives. The initiatives within these three pillars, however, are *smaller* in terms of their CO2-reducing potentials, taken individually and as a whole (i.e. a total of 26% relative to the impact of RES-based CHP and wind power that account for the majority of the 74% planned CO2-reductions), but *bigger* in terms of both the number and complexity of the actors that must be approached and motivated to become part of the process.

In other words, the action plan for CPH 2025 attempted the low-hanging fruits first but in years to come will have to try the more difficult ones.

Moreover, if achieving the goal of carbon neutrality by 2025 seemed enough in terms of ambition, try reaching the goal with a population gone up by one fifth. This is the challenge that follows from the growth estimates of the Copenhagen population. Roughly 1,000 inhabitants arrive – to stay – every month, and the result is expectedly 100,000 more Copenhageners by 2025.

The growth of the city population is considered a proof of the attractiveness of the city. But it necessarily calls for new, more efficient ways of delivering city services and engaging users of the city in habits that contribute to the creation of more resource-efficient lifestyles.

To reach the goal of becoming carbon neutral, a much greater degree of decoupling of population growth and energy consumption is needed. And especially one that results from the *City's* initiatives because the national trends, while so far dominant in the declining carbon figures for Copenhagen, will deliver their results far too late (by 2035) for their impact to suffice to make Copenhagen carbon neutral by 2025.

The pillars of Energy Consumption (expected to deliver 7% of the planned CO2-reduction) and Green Mobility (set to deliver 11% CO2-reduction) depend much more on citizen or end user choices than the pillar of Energy Production (– the only pillar so far on track). This fact does not sit too well with the lack of a convincing approach in CPH 2025 to mobilise and incentivise citizens.

These strategic choices in CPH 2025 compare as follows to trends in the 110 cities that reported their carbon footprint to the Carbon Disclosure Project (CDP)'s annual report[52]: It is noteworthy that while 60% of the cities target transport activities to reduce CO2, 56% energy demand in buildings, 42% waste and 39% urban land use, the question of energy supply (corresponding to Energy production in CPH 2025) ranks fifth with 38% of the cities addressing this sector. To be sure, the number of CO2-reducing *activities* say little, if anything about the impact in terms of tonnes CO2 saved. Yet, it would seem that CPH 2025 could benefit from a greater share of citizen – and other stakeholder – involving approaches to reach set goals in the three pillars other than that of Energy Production.

CPH 2025 – room for improvement according to the Climate Secretariat

The Climate Secretariat regularly monitors progress of CPH 2025. Over the summer 2014, a preliminary, internal evaluation of CPH 2025 pointed out the majority of the following list of challenges that the City was seen as handling in a wanting fashion. The evaluation process which the Climate Secretariat carried out from November 2014 through March 2015 added a few more elements, systematised the observations and proposed a series of solutions – but most importantly, this second evaluation process identified a gap measured in tonnes CO2 missing in 2025 if nothing be done to adjust the implementation power of CPH 2025. This evaluation serves the purpose of briefing the Technical and Environmental Committe ahead of the formal, external evaluation to be carried out in 2015 and early 2016

<u>Energy consumption from buildings</u>:

- Retrofitting of existing, including the City's own buildings + new built of higher standard: How to drive the market, incentivise investors, building, owners and developers? And how to co-develop retrofit initiatives with other benefits that could

[52] https://www.cdp.net/CDPResults/CDP-Cities-2013-usage-summary.pdf

prove more efficient drivers for change, such as upgrading whole communities or improving the indoor climate?
- Bundling of energy savings/retrofitting: Is bundling – presenting investors with a greater volume of tasks, and expected relatively lower prices for the services due to the scale of tasks – the way forward? A concept presented during negotiations for Budget2015 did not get funded. How to progress after all? Postpone till next year?
- Data/HOFOR – the City's Action Plan for retrofitting: Attempts for a year to get data from HOFOR testify to the real difficulties in sharing data. How to remove barriers and speed up progress? A more modest approach to exchanging data for a more limited number of buildings was launched autumn 2014.

Energy production, including the handling of waste:
- Waste, recycling, remove plastic, more fractions, incl. organic waste: How to implement new ways of handling waste?
- Need for additional wind power to close CO2-gap in 2025 (e.g. off-setting transport CO2-emissions)

Mobility:
- Public and bus transport: How to get more travellers? And more integrated services?
- New fuels – EVs, hydrogen and new synthetic fuels: How to spur innovation and improve performance?

Involvement of citizens and stakeholders:
- Greater levels of involvement of citizens and stakeholders: How?
- Partnerships – there is still room for improvement.

The City's own initiatives or cross-cutting strategies:
- Public procurement – greener: How to ensure that the City 'walks the talk'?
- Copenhagen as 'Smart City' – what does this mean? What should it help the City do better? How well coordinated across the City Administrations is it?

As seen, a considerable part of the listed items have to do with buildings. Data, although only implicitly, cuts across several of the items. Before diving deeper into the challenges the City face with regard to buildings and data, the following sections describe some of the challenges that were identified during various workshops and meetings of informal working groups in the TRANSFORM project.

CPH 2025 – challenges according to TRANSFORM

Within TRANSFORM, challenges for CPH 2025 were identified in various working groups throughout the project. But certain challenges, originally identified within the City, were also discussed during two workshops with local stakeholders and project partners from TRANSFORM in autumn 2013 and spring 2014. Following sections briefly describe each set of challenges.

Challenges that CPH 2025 produce or reveal
While the goals of CPH 2025 represent, if solved, a way out of the dependency on fossil fuels (transport excluded), they come with new challenges attached that need attention and call for not yet found solutions. At least four such challenges spring to mind:

Effect on buildings in Copenhagen of energy savings obligation: CPH 2025 too optimistic
Energy consumption in buildings in the old part of the city is high but retrofitting very difficult and/or (too) expensive in terms of the return on investment (ROI) of energy savings. However, the City's expectations to the general effect of the energy savings obligation, as stated in CPH 2025, appear far too optimistic. There is both a need to agree on ways to monitor the energy savings, among the City and utility companies, and a need to discuss what is required for utility companies to speed up their actitivities in the city at large – so far, Copenhagen is, from an energy utility company perspective, far from representing the best business case for the creation of energy savings under the energy savings obligation.

To give an example, and as will be further discussed in Part C, a way to address the challenge of CPH 2025 being too optimistic as to the effect of, e.g. the energy efficiency obligations, the City can decide to endow its own, larger buildings with 'intelligent service', as offered by for instance HOFOR or other energy consulting companies. The effect is typically reduced malfunctions and improper energy management, thereby saving about 10% of heating demands.

Clarity of goals
CPH 2025 has a target of 20% reductions in heat consumption in 2025 compared to 2010. The goal might sound clear, but there are a number of issues: First, these savings are given in actual numbers. This is unusual for reduction goals for heat consumption in buildings. Typically the consumption is degree-day corrected. When using this method, it is possible to compare heat consumption for each year on an equal basis, while taking the relative impact of cold or warm years into account.

Second, the year 2010 was a cold year. This means that the chosen reference year for consumption in CPH 2025 is unusually high. Using actual consumption figures without degree-day correction thus makes part of the savings easier to achieve. But only on paper. In reality, the actual relative savings on a degree-day basis will be smaller.

The same problem arises for the year of 2025: Depending on whether 2025 will be a cold or hot year, the heat reduction goals could be reached or not. Another issue regarding what the heat reduction goal refers to has to do with the number of new buildings and citizens in the city. It is not specified whether the expected heat savings concerns the building mass as of 2010, or whether it will have to apply to the ever-growing city. A clarification of these questions would allow for clearer goal for the reductions in heat consumption.

Long time-frame for the identification of new fuels for future distric heating
Fuels or heat sources for future district heating production must be selected and their introduction planned for long time before realization.

Yet, this is challenging because of the difficulty of predicting which alternative fuel is the better choice for a moment in time that lies far ahead. Both technological development and price changes in the future may influence the business case or desirability of one fuel vs. another.

Moreover, several actors are likely to be influenced and should be involved in the decision-making process, properly starting with analyses, scenarios and estimates.

Wind, a solution with strings attached
Although the City 'solves' the carbon problem in transport, off-setting transport-induced CO2 through a surplus production of RES, a new challenge arises. The City and HOFOR agreed that HOFOR installs 120 to 130 large wind turbines (360 MW in total by 2025). While this is obviously good in terms of added RES, wind power is, by nature, an inflexible energy form. To help balance the impact of more wind power in the energy system, the City ought to put more emphasis and efforts into the development of increased levels of flexible energy consumption and/or production. Part C suggests a number of ways that this can be done.

CPH 2025 challenges – raised in TRANSFORM workshops and processes
Internal process in the City of Copenhagen resulted by mid-2013 in a long-list of approximately 20 themes, reduced to six prior to the 'Intake Workshop' on 31 October to 1 November 2013, WP2, in Copenhagen.[53] Upon the workshop, three themes were selected for further work within TRANSFORM: Dialogue with Developers, Flexible Energy Buildings[54] and the Flexible Energy System. During an internal workshop in February 2014, and a three-days' workshop in April 2014, the 'Intensive Lab Session' (ILS), WP4, new dimensions of the themes were explored.[55] The theme Dialogue with Developers is discussed in more detail in the Implementation Plan for Nordhavn, WP4.

The three selected themes are far from covering all relevant themes important for the Copenhagen Transformation Agenda and CPH 2025. The three themes were chosen as some of the most important themes, however, that moreover had so far not been particularly developed in CPH 2025. Part C describes a series of specific measures in reply to the challenges described in this chapter.

[53] The 'Intake Workshop' was on the first day structured around a SWOT-analysis, and on the second according to the roadmap method. The method to perform the SWOT analysis (Strength, Weakness, Opportunities and Threats) was described in the WP1 report D1.3. It introduces two new elements in the WP1 and WP2 work: the Intake Workshop and the PESTLEGS analysis (Political involvement, Economics (financial feasibility market development), Social (stakeholder engagement and acceptance), Technological enablers, Legislation, Environment, Governance and Spatial opportunities). In this way, it bridges the work in WP1 to WP2 (i.e. delivering in put to the thematic focus in the Transformation Agenda). In the 'Intake Workshop' the findings from the State of the Art city report and the established level of 'Smart City'ness' went through a structured process with the aim to focus on the most important and applicable energy related themes for the city.
[54] It should be noted that originally, the term 'Smart Energy Buildings' prevailed during workshops, internal papers and TRANSFORM draft deliveries. Upon reflection, it became clear that the issue that the Transformation Agenda could handle was more preceisely that of *Flexible* Energy Buildings – both to add value relative to the vast literature on sustainable, green or climate-friendly buildings, and to delimit its focus.
[55] See Implementation Plan for Nordhavn, WP4 for further details.

Theme 1: Dialogue with Developers

While the two themes of Flexible Energy Buildings and the Flexible Energy System are interconnected, on the ground, that of Flexible Energy Buildings hinges not the least on the acceptance by developers to integrate the solutions in their building projects. In other words, the implementation speed, scale and ease of the Flexible Energy Building partly depends on the willingness among developers and land owners (e.g. negotiating conditions for new built) to integrate the suggested solutions at the right time in the building process. In building processes, timing is of the essence. And at the same time, the outcome of the Dialogue with Developers depends on the latest knowledge about how to make buildings more flexible.

This poses a series of challenges, both in terms of having the dialogue with developers in the first place, and with regard to the kind of prioritised items discussed with developers, during such dialogue – who decides what to prioritise? And how to have the dialogue?

The challenge, in terms of having the dialogue in the first place, is that the City is not the landowner (brown and green field areas), and disposes of no formal urban planning tools that allow for a tightening of environmental or sustainability standards relative to demands in the current Building regulation. So how to get the desired high level of sustainbility in buildings that the City wants? In particular in Nordhavn that, accordring to City visions, is supposed to showcase the best, most sustainable and state-of-the-art solutions that the future needs.

The idea is that the ongoing project within the City of Copenhagen, hosted by the Climate Secretariat, to improve the dialogue with developers prior to construction in brown and green field areas, draws on experiences from the City of Malmö, invites developers, experts in city development and finance to co-develop a better way of having the dialogue.

The key is to achieve more sustainable urban development through, first, a more focused process, hinging not the least on a much better coordinated effort within the City itself (this is ongoing as of today), and second, through voluntary agreement with stakeholders (this is yet to be seen). Third, the expectation, based on experiences in Malmö, is that an improved dialogue in itself may lead to more sustainable building and urban development than would otherwise be the case.

The second challenge, that of the prioritisation of items during the dialogue, raises the following questions: Who defines the dialogue and prioritises items to be discussed? So far, the idea seems to be to build on and upgrade an existing, fairly open 'sustainability tool' that the City developed on an earlier occasion, but also to put the stakes on DGNB-certification as a tool and method to increase the level of sustainability. To this end, a group of City employees begun a training in the DGNB-method.

While this is certainly worth-while and bound to have an effect – if the trend for demands for DGNB-certified buildings increases to critical scale – the question remains to what extent a focus on DGNB will result in 'future-proof' buildings if by such buildings we understand buildings that are suited for the future necessarily more flexible energy system?

While DGNB requires thorough use of data to provide measuring and monitoring of buildings, DGNB does *not* pay any particular attention to the integration of buildings with the grid such as through an advanced use of data or services to underpin the connection. The DGNB certification process will hardly lead to a greater share of Flexible Energy Buildings.

Finally, it seems that within the ongoing project on the improved concept for the dialogue with developers, there is too little focus on the need for a business case to accelerate the transition towards building with higher energy performance than ensured through the current Building Code. This is a serious problem, considering the critical importance of the business case to convince developers to do something else than business as usual.

Several studies, even those starting from a rather technical point of departure, conclude that some of the most important barriers to the implemention of new, more advanced building solutions have to do with cooperation, organisation, incentives, business models, finance and stakeholder management – rather than, e.g. lack of technologies.[56] The key is better coordinated efforts. Following this, it is worth considering if the improved concept for Dialogue with Developers is in fact far too narrow in scope and focus. There could be a need for a more comprehensive approach to the way in which the City, and the Climate Secretariat, works with stakeholders generally.

Theme 2: Flexible Energy Buildings

Buildings, the existing building stock in particular, account for a considerable amount of energy consumption, approx. 40%. What are the measures that can 1) help us bring this figure down and, 2) in the future, enable a more flexible consumption of energy in buildings? The latter in response to balancing needs of the energy system once the, by nature, more volatile RES make up a greater share of the energy mix. As seen, the two themes of Flexible Energy Buildings and the Flexible Energy System overlap – not only in theory but certainly also in reality.

The challenge is, first, to understand or define what exactly Flexible Energy Buildings is, including an assessment of the desired contribution to driving down CO2 whilst ensuring a reduction in energy demand and, ideally, favoring the use of energy from renewable sources. Second, the challenge is to be able to make buildings do all this.

The theme of Flexible Energy Buildings bridges a series of interests across the City Administration to 1) use data *more*, and also to use them more *intelligently*, 2) improve the City's own building and maintenance practices, and 3) reduce use of energy and resources from buildings in the city at large.

TRANSFORM workshop processes identified a series of things to do:

- Define what 'Flexible Energy Buildings' means in a Copenhagen context.

[56] Svendsen, Peter & Amanda Borup Pedersen (2014): *Smart Energy Buildings – Nordhavn Udfordringer og veje frem*, København: Copenhagen Cleantech Cluster, p. 18. *Smart City Wien*, pp. 75-83.

- Develop a set of criteria that the City and others can use as a check-list to assess how smart their buildings are (e.g. construction, maintenance, and use – seen in the context of the wider energy system and avoiding the pitfalls of suboptimised practice in isolated buildings).
- Consultation process with private companies, research institutions and utility companies would be required too, to ensure both broader ownership to the agenda, and a strategy for Flexible Energy Building actually fitting, or fuelling, the level of technological innovation and solutions.
- Remove barriers to the development, such as:
    - Trade-offs between the energy savings obligation and an enhanced use of shared or open data;
    - Lack of a business case, convincing to both actors within the City of Copenhagen, experts and private companies.

Ideally, the process should yield material and insigthts for both existing and new buildings.

Theme 3: The Flexible Energy System
The Danish energy system is rapidly (by historical and international comparison) changing to intermittent RES, in particular wind turbines, but also photovoltaics. This development, together with a growing need for energy efficiency and an increase in electrification level, emphasizes the need for a more flexible energy system.

The challenge is to define, in organisational and technical detail how the energy system should be made more flexible.

A key precondition for the creation of a more flexible energy system is a greater degree of collaboration among the stakeholders who plan and operate the different elements in the energy system. Antoher key issue is to ensure increased 'translation' between energy resources and secondary energy forms (i.e. electricity and heat) of the various utilities.

However, different stakeholders have different objectives. This leads to the obvious question of how to ensure a solution that serves the public good best while contributing to continued growth and operating opportunities for the stakeholders? More than just a need for collaboration among stakeholders, there could be a need for facilitation, lest the challenge get stuck in power games, and dead-ends if no solutions are found. But who should lead the process? And how? Who has the mandate? These questions are not only interesting, but also necessary to answer.

In support of this, a series of technical and economic questions require addressing too, including:

- Which technical solutions can be used, and in which combinations?
- What is the business cases for different solutions?
- How to use data, including how to share or publish them on open platforms, and yet ensure data security, respect for data privacy, and solutions to cover the costs of increased work on data?

Finally, the main challenge in the Danish context is to move from pilots and experiments to large-scale demonstration and market up-take of ways to increase the flexibility of the energy system.

The roles of the City
Urban energy policy is getting increasingly important. The options for a city to act and increase the energy transformation is limited compared to the options that a country has (Keirstead & Schulz, 2010). Policy options that the City of Copenhagen can use, and use already today, are land use planning and the national building regulations (mainly through the municipal long-term plans, issued every four year, and local plan), awareness raising through information campaigns and advisory services, innovation projects in cooperation with private partners and pilot projects for new technologies.

Which policy option that should be preferred depends on purpose and objectives, e.g. investing in hydrogen cars and hydrogen fuel stations might not give the highest immediate CO2 savings, but could provide other benefits such as increased competitiveness for local innovation companies and an improved environmental profile of the city that attracts new citizens or capital. Cost-efficient ways to reduce CO2 emissions usually exist in the building sector through options that spur demand-side energy reduction.

The following sections discuss the roles of the city with regard to first buildings and second data.

Buildings – and the roles of the City
This section maps the issue of buildings using different distinctions, and pointing out the roles and powers of the City which will differ greatly, depending on the situation.

<u>Existing vs. new-built buildings</u>
The existing building stock and the old, historic city in particular represent both the greatest challenge and potential (in terms of volume) for energy savings. Annually, new-built only add approx. 1% to the building mass. Moreover, new building codes making greater demands on energy performance reduce the potential for extra energy savings in new-built. However, new-built may more easily be equipped with devices to enable a more flexible energy consumption, provided investors and developers be persuaded of the idea and mobilised to integrate equipment in early phases of a construction project.

Regarding new-built, the City has a role through urban planning processes to strike up more dialogue, or improving the timing of dialogue with developers.

Regarding existing buildings, the City has a role as provider of updated information about technical solutions or funding schemes; as active part in urban reneweal programmes with local actors; as the driver in the test of new models, such as bundled retrofit programmes that are more appealing to investors/business owing to the greater volume of total tasks, and at

the same time, better for building owners/users due to the, expected, relatively lower prices for the services.

Essentially, the *new* role urban planners of the City could adopt is that of creating win-win solutions, that is, taking a pro-active role in initiating and steering communication processes rather than *reacting* to requests from citizens, business or housing associations – or doing nothing, or only 'passive' communication (i.e. upload of information to homepages).

Use of data in the service of energy savings or CO2-reductions

The Member States of the European Union have to implement smart metering if an economic assessment, through a cost-benefit analysis, has a positive outcome. Denmark presented an assessment in March 2013[57] stating that the nationwide socio-economic value would be around 10 million DKK (€1.34 million) yearly.

The Danish Parliament decided that the implementation of smart metering in Denmark should continue from 1,85 million installed and planned meters to a total of 3,23 million meters by the end of 2020.[58]

The Danish cost-benefit analysis assumes energy savings of 2% and peak load shifting of 8.4%. These savings, however, are dependent on the introduction of dynamic tariffs. The cost-benefit analysis includes costs for providing feedback to consumers. For comparison, a case study of smart meters with feedback provided to households in Austria, resulted in electricity savings averaging 4.5% (Schleich, Klobasa, Gölz, & Brunner, 2013).

[57] http://www.ens.dk/sites/ens.dk/files/undergrund-forsyning/el-naturgas-varmeforsyning/Smart-grid/samfundsoekonomisk_analyse_udrulning_fjernaflaeste_elmaalere_19032013.pdf

[58] http://www.ens.dk/undergrund-forsyning/el-naturgas-varmeforsyning/elforsyning/smart-grid-fremtidens-intelligente

Table 20 CBA Scenarios: Member States rolling out electricity-only smart metering by 2020 [78]

Member States rolling out smart metering	Metering points in the Country	Roll-out period Start Date	Roll-out period End Date	Penetration rate by 2020 (%)	Smart metering lifetime (years)
Austria	5700000	2012	2019	95%	15
Denmark	3280000	2014	2020	100%	10
Estonia	709000	2013	2017	100%	15
France	35000000	2014	2020	95%	20
Greece	7000000	2014	2020	80%	15
Luxembourg	260000	2015	2018	95%	20
Malta	260000	2009	2014	100%	11
Poland	16500000	2012	2022	80%	8
Romania	9000000	2013	2022	80%	20
Spain	27768258	2011	2018	100%	15

Member States rolling out smart metering	Investment (CAPEX + OPEX, € mn)	Total Benefit (€ mn)	Consumers' benefit (%)	Energy savings (%)	Peak Load shifting (%)	Discount rate used (%)
Austria	3195	3539	78.5%	3.5%	2.5%	4.2%
Denmark	310	322	NA	2.0%	8.4%	5.0%
Estonia	110	191	NA	NA	NA	6.7%
France	4500	NA	NA	NA	NA	NA
Greece	1733	2443	80.7%	5.0%	5.0%	8.0%
Luxembourg	35	40	17.0%	3.6%	5.0%	8.5%
Malta	20	NA	NA	5.0%	NA	NA
Poland	2200	2330	NA	1.0%	1.0%	NA
Romania	712	552	NA	3.8%	NA	7.5%
Spain	NA	NA	NA	NA	NA	NA

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0189&from=EN

The City's own vs. other buildings

Another distinction has to do with ownership and differing decision-making processes and funding schemes for retrofitting or upgraded energy performances of new-built. The City, while the second largest property portfolio manager in Denmark, owns about 5% of the entire building mass in Copenhagen, administered by '*Københavns Ejendomme*' (KEjd).

How to mobilise building-owners in the city at large? And, in terms of the agenda-setting role of the City and credibility of the City's request of others to save energy, how to mobilise decision-makers within the City Administration and the City Council to reap the City's own energy savings potentials?

Introducing KEjd, the Copenhagen building portfolio manager

KEjd, the City of Copenhagen's building portfolio manager, is the administrative manager for all of the municipality's buildings, owned and leased. The portfolio administration areas of responsibility includes; managing building and renovation projects, purchasing, lease and sale of property, maintenance and repair as well as initiating building innovation, energy savings initiatives and climate change adaptation whilst adhering to and promoting standards and regulations.

KEjd is the second largest property portfolio management firm in Denmark and is responsible for some 750 properties comprising roughly 2.6 million m^2. These properties range through offices, schools, child care centres, old age homes, bunkers, swimming pools, cultural buildings and so forth.

The ambitions KEjd has are those of the City and can in a great sense be seen to be an extension through which the City develops its 2025 CO^2 neutrality and works towards a better building profile. With this longer term plan there are many buildings that need to have their environmental and energy efficiency profiles enhanced. In addition KEjd's data infrastructure still needs to mature to allow intelligent control.

KEjd sets a strong focus on energy efficiency and its climate change responsibilities. All newly built buildings, such as schools, offices and kindergartens meet at a minimum the energy climate change requirements standards adopted by the City. KEjd requires adherence to buildings minimum energy 'plan 2015' and is ready (pending political ratification) to require developers adhere to 'plan 2020' effective January 2015.[59]

Regarding the City's own – existing – buildings, it appears questionable if the coordination of different Administrations' stakes in energy efficiency happen in a way that puts the purpose of energy efficiency above other interests. How would one otherwise explain that KEjd's proposals to implement annual energy savings worth approx. 20 million DKK (€2.7 million) at a ROI of 6 years were rejected in Budget negotiation processes year after year? To be sure, there could be good or bad reasons for this situation. If bad, they must be addressed, and barriers removed. If good, they may still be addressed and an overall better solution put in place.

Regarding the City's own – new-built – buildings, the role of the City is, ideally, that of driving the market towards innovating and bringing better solutions to the market. This can only happen through intelligent and long-term procuring processes (whether in the form of tenders or Public Private Innovation partnerships (PPI), that is, making functional tenders rather than tenders too focused on 'price here and now'. In reality, short-term or tight budgets can jeopardize market-driving opportunities through procurement by the City.

[59] More details about KEjd's own building innovation programme may be found in the Annexes (Annex 4).

Regarding other buildings, the role of the City resembles the roles mentioned under the title of 'existing vs. new-built buildings': Information provider, facilitator, showing the way through pilots.

Owner-renter dilemma

A fundamental barrier for energy savings is typically referred to as the owner-renter (or: landlord/tenant) dilemma. If the owner must invest in retrofitting but the renter of a buliding or apartment gets the benefit through cheaper energy bills, the investment is less likely or even completely unlikely to take place. How to solve this dilemma?

The role of the City can be that of requesting that (in-house or commissioned) desk research be undertaken to collect ideas and experiences, publish these, and lobby national Government if needed. Or the City could team up with interest and knowledge partners to make a competition for the best models & results, and award the winning project(s) a prize to raise awareness generally and recognise progressive actors for their contribution.

Types of challenges: Technical, financial and organisational

Different types of challenges require different competences, collaboration with different stakeholders, and responses. For instance, it requires *technical* insight to identify and prioritise among energy savings alternatives, fit data to desired modelling ends, or make systems work. However, the challenge of implementing technical solutions, once identified, may be *financial*, *organisational* or both. And these two latter types of challenges will differ in nature and with regard to effective solutions, depending on the kind of building-owner/user (e.g. public, private; individual or collective; owner or renter).

The role of the City is to understand, whether in its own (partly divided) house or in the city at large, what the primary challenge is in a given situation (technical, financial or organisational), or in which sequence or types of packages the challenges should ideally be dealt with. This requires thorough understanding of complex situations and connections across sectors and actor types. The City is probably more likely to succeed if this role is shared with interested knowledge partners.

Roles of the City

A case study by Bale, Foxon, Hannon, & Gale (2012) performed in Leeds highlights the potential of a 'strategic energy body' and the services such a body could deliver. A city could assist private actors in finding opportunities, facilitate investments and support contract processes to lower the barrier of a high initial investment.

One possibility for Copenhagen could be to take a more active role in the energy saving obligation scheme introduced in Denmark, where energy production and distribution companies have to initiate annual demand-side energy savings. The City of Copenhagen has a guide on their homepage for citizens to find out where they could get financial support for energy efficiency investments. This guide could be improved by calculating a couple of examples of typical energy saving potentials and displaying how the financial support given by energy companies lowers the payback time.

Many renovation activities that are performed do not require a planning permission, e.g. changing windows or replacing circulator pumps. For those activities that do require a planning permission, the City can – and do to some extent today – inform the applicant about the possibility to get financial support for energy renovations.

Targetting instead more institutionalised players, the City could initiate groups or clubs that convene to address structural or potential large scale challenges, exchange experiences or even engage in collaborative efforts to create new solutions.

More options that the City of Copenhagen could consider strengthening:

- Invest in measures targeting infrastructure and buildings that are owned by the city.
- Introduce some kind of smart energy city criteria in public procurement, e.g. for office equipment and street lighting (Borg et al., 2006).
- Set building energy standards tougher than the building regulations. The City of Copenhagen could try to sharpen building regulations in areas highly attractive for new developments. A criterion on power demand flexibility could also be tested.
- Act as a facilitator. Inform, educate, raise awareness, bring stakeholders together and support consensus building.[60]

Data – and roles for the City

Data is the new black – according to some. Others take a more tempered approach. Either way, and though tricky to define exactly the added value of the use of data, the question is: How can we use data to speed up action on the City's goals? In the case of buildings, the question goes whether data about energy consumption, can help us drive up energy efficiency, or enable more flexible consumption of energy?

A key precondition for extracting real value of data bases, data-mining exercises or modelling is that data match the exercise in terms of format, quality and compatibility with the model. Put simply, a model will never deliver better quality answers than the data you put in.

Since the cost of making data ready for modelling may be considerable and very time-consuming – it is far from just a question of 'pressing a button' – it takes a sober cost-benefit analysis to assess in which cases advanced data-driven solutions are better, or hardly worth the hassle than less data-dependent, or alternatively, less advanced data approaches.

With these few observations in mind, the point of departure here is the hypothesis that data can, and must, help us solve many of the City's challenges, meaning that the right data, used in the right manner can be useful as a basis for decision making, for better operation of the city, and for the people using, living or working in the city.

[60] Cf. Immendoerfer, Winkelmann, & Stelzer, 2014. Further options for cities to improve their energy transition has been identified by the CONCERTO initiative (Immendoerfer et al., 2014, p.120).

The City of Copenhagen launched a series of projects and initiatives to work more and better with data. Some of them include:

- Open data portal
  - Hosting as of yet approximately 70 City of Copenhagen data sets[61];
- KK and Københavner Kortet
  - GIS-based maps for internal planning and external, that is, open use[62];
- ITS – Intelligent Traffic Control
  - To ease flow, parking and crowd management;
- Street lightning
  - Saving 50% energy and allowing for the use of light posts as 'data hubs';
- Digital infrastructure for the entire city through 'Copenhagen Connecting'
  - To leverage services across sectors through use of sensors, RFID-tags etc.[63]
- Collaboration with Cisco about the 'internet of everything';
- Public tender, with the Capital Region of Copenhagen, for a Big Data Infrastructure
  - The goal is a model for an economically sustainable (i.e. not subsidised) platform for not only public but also qualified private data[64];
- Launch of the Copenhagen Solutions Lab, as of 1 November 2014
  - To facilitate action across City administrations, sectors and through partnerships with other actors. The goal is to spur innovative ways of handling the City's challenges better; not the least through new ways of using data.[65]

Most of these initiatives are organised under the auspices of the Smart City Project Council, established following decisions in Budget14. The data-ambitions are currently (as of winter 2014) in the process of being better integrated with various data-projects in other City Administrations than the Technical and Environmental Administration.

The following sections, first, introduce some of the context for the City of Copenhagen wanting to work with data, using the case of buildings, and second, describe challenges in work with data in the service of energy savings or flexible energy consumption in buildings.

The Annexes give a thorough description of the attempts within TRANSFORM, WP3 to work on data in Copenhagen (cf. Annex 5). Only lessons learned from this exercise will be briefly touched upon in following sections.

Case: Mapping building mass in the entire city to drive market for energy services
The City, through the Climate Secretariat, and HOFOR have for quite some time discussed ways for HOFOR to deliver data to the City in support of CPH 2025, and more specifically the ambitions to drive energy reductions and retrofit actions in the city at large.

[61] Cf. http://data.kk.dk/
[62] Cf. http://kbhkort.kk.dk/cbkort
[63] Cf. http://copenhagenconnecting.com/_include/img/work/full/TM82B2_-_praesentation_CC.pdf
[64] Cf. http://cleancluster.dk/projekter/big-data-infrastruktur-innovativ-udbudsproces/?pid=3901
[65] Cf. http://cphsolutionslab.dk/

The ambition, as seen from the City's perspective is to differentiate among building types, year of construction and owners to develop the most adequate communication or other initiatives towards the different types.

For instance, it makes a big difference with regard to decision-making whether a building is owned by a company or investor, or whether a building is part of a housing cooperative, thus co-owned and subject to a democratic decision-making process primarily based on the annual general assembly and a series of formal procedures to tap into at the right time, lest ideas to be acted on collectively be postponed until the following year.

On the basis of a first overview of the building mass in Copenhagen in 2013, the City gained insight into the most important actors and building types to address. The majority of buildings are multi-storey buildings, for housing or office uses. Most of those buildings date from the period 1890-1930, and second-most from 1931-1950. With regard to ownership structure among the buildings for housing, most are housing cooperatives, second most are privately owned apartments, then comes social housing and fourth in rang, appartments for rent. Moreover, the distribution of building types can be mapped according to neighbourhoods.

While the described mapping can be made solely on the basis of information in existing and available data bases, two crucial elements are missing to further finetune campaigns and the identification of most relevant initiatives: Access to energy labels for all buildings, and, second, current, actual energy consumption levels in the buildings.

The greatest difficulty regarding electricity is to *get access* to consumption data, hosted at the DSO for electricity, in the case of Copenhagen: DONG Energy Distribution. The challenge with regard to heat data is the *quality* of data. While some data are available from BBR (the national data base for buildings), they are organised according to the *cadastre* (that is, the information about land ownership and other interests, collected and contained through the services of the land registry) which may or may not coincide with a building. And moreover, these data may be accurate or not.

To address the issue of the quality of heat data, the City at first requested all heat data from HOFOR. From the point of view of HOFOR, this request came with a series of challenges: Who would pay for that rather big request? How to solve data quality issues, such as the current practice of data being organised, at HOFOR, on the basis of *main metres* and which data are by BBR being converted into data for the *cadastre*, but the City is requesting data for *buildings*? Moreover, a series of other issues made the City's request difficult to handle, including: Data privacy obligations that HOFOR is bound by law to respect, commcerial interests in certain data, and lacking clarity in the communication between the City and HOFOR as to the purpose of the data collection.

At pilot basis, the City and HOFOR agreed to a different approach. The City will deliver a list of particularly important cases from select areas in the city, that is, types of buildings with the greatest energy reduction potentials, based on the described ways of differentiating among

buildings in the city at large and including the BBR-data on heat. HOFOR will screen the data on heat, double check in cases that look 'weird', and add actual heat consumption data.

Data related challenges
The ambition and challenges to work more with data apply to a range of sectors within the city such as transportation, energy, shopping, buildings, climate etc. The following list while far from exhaustive and listing challenges in random order, gives an impression in the case of buildings:

- **Lack of City executives strategy as to the *purpose* of more work with data:**
  - Which are the challenges that the City imagines (better) solved through enhanced use of data?
- **Lack of executive decision-making in the City of Copenhagen and HOFOR**
  - Align objectives
  - Allocate sufficient resources to handle more requests for data mining or more sophisticated ways of working with data
- **Lack of mutual understanding of barriers to the sharing/open publishing of data**
  - Lack of communication on, e.g., different goals and challenges in meeting goals**.**
- **The quality of data**
  - The degree of match between buildings and meters is too poor, and in only about 25% of the cases do meters and buildings correspond correctly.
- **There is no obvious model for the use of data at scale**
  - There is no business case for systematic work with data among key actors (e.g. cities, developers, utility companies, commercial/service providers, data owners).
  - No platform for open data on a commercially sustainable platform
  - No clarity on standards for data formats
  - No clarity on how to handle privacy issues, no clarity on how to asses, let alone deal with risks of hacking and data security generally.
  - Insufficient clarity as to the interplay of the energy savings obligation (on utility companies) and shared/open data – or whether the two are at odds.
  - No clarity on the degree of automatisation vs. dependency of end-users' collaboration on enhanced use of data.

The solutions for several of these challenges are out of hand for local stakeholders, including the City and utility companies, that is, some of the questions and challenges must be clarified by guidelines or legislation on national or even EU level. With a clearer overall data framework it will be easier to meet the local data challenges.

One key question is that of establishing an overview over existing data – such as in terms of their legal ownership, location (where are the data hosted), format, the purpose of the data sets (why have they been generated in the first place), their typical use, and whether the City of Copenhagen has access to the data. Until recently, there was no particular need for anyone to have that overview.

Concentrating on energy, a first impression of the range of data was established autumn 2014 by DTU. The picture is that of a vast system of data, and lack of a coordinated effort to bring them into play in one coherent aproach. The full list is provided in the Annexes (Annex 7).

Challenges in TRANSFORM, WP3 exercise on 20 of the City's own buildings
This section summarises challenges during the TRANSFORM WP3 objective to develop a 'decision support environment' consisting in an online tool that, depending on input data and output assumptions, can calculate effects of given measures. For a fuller description of the WP3-exercise, see the Annexes (Annex 5).

There were various challenges at different point of times during the tool exercise. Some had mostly to do with communication or the mobilising of interest that is a precondition for the allocation of resources. Others were more technical in nature. Overall, it turned out to be a very time consuming exercise that leaves a general impression of lack of overview, including within the City: What data are available? What can they be used for? How to create synergies among all available data sets?

Communication, purpose of tool

- The first challenge was to understand what the tool was all about, and how it could add value compared to existing tools for energy and urban planning in Copenhagen. It is very difficult to mobilise interest for a tool-development if professionals feel (whether rightly or wrongly) that they already have either better or good enough tools at their disposal.
- The second challenge was to understand the target group. The tool throughout at the same time appeared too complicated for non-experts and too simple for planning experts.

Organisation of knowledge

- Lack of overview within the City on all available data and its usefulness.

Technical challenges

- The excel files from KEjd and other Administrations within the City of Copenhagen are not consistent with each other, i.e. different data sets has different information on energy consumption, area and address.
- Errors in the energy consumption data cannot be ruled out.
- Changing meter identity and missing data makes it hard to track changes in energy consumption over several years.
- Information on which meter that is related to a specific room or area is not provided.
- Techniques on organising and matching large databases are needed.

The roles of the City
In all cases, the primary role of the City is that of mapping and analysing energy reduction potentials. This, however, is no simple task and requires a great level of competences in number crunching internally and the ability to negotiate with various 'data actors' to get access to required data for the City to be able to deliver reliable analyses of the potentials.

Part C
Improving abilities to implement: selected themes and strategic city working groups

This chapter aims to suggest ways in which the City can increase its ability to act on the identified challenges discussed in Part B. Throughout this chapter, it should be kept in mind that the proposed ways to address identified challenges make no claims to represent exhaustive answers or solutions.

Moreover, as will be seen, in several cases, the role of the City is relatively weak, that is, for instance, the City has limited powers or depends to great extent on other actors. This situation begs the question of political commitment that must – for these actions to be implemented – not only be strong but also, politicians and staff must be in it for the long haul. To the extent that implementation hinges on stakeholders taking action, the City needs a comprehensive and proactive approach to stakeholders, competences to lobby national Goverment, and a stronger capacity to build alliances.

1 City strategic working groups

At strategic level, the four identified primary challenges should be dealt with to strengthen the organisation and implementation power of the climate plan. To remind, the four challenges are: First, CPH 2025 suffers from 'open financing', that is, short, annual Budget processes. Second, the Climate Secretariat is organised according to a recruitment policy with staff on a contract. Third, a low degree of participation results from the lacking strategy to ensure non-market or non-institutionalised involvement. This approach eclipses citizens from the picture, that is, the voters, otherwise expected to deliver ongoing support to the climate policy of the City, and also people are indispensable as actual users of certain measures. Finally, within the City Administration, CPH 2025 functions primarily as a stand-alone plan with little or no formal links to other areas of policy or governance.

Examples of solutions are:

1. Request long-term budgets covering required funding for each four-year road map period, e.g. to enable more efficient planning, and thus following the advice from the IPCC scientific community that action *now* is better and cheaper than postponed actions;
2. Offer permanent positions to key staff with specialised competences required to implement CPH 2025;
3. Develop and fund initiatives to involve citizens in actions required to implement or even improve CPH 2025;
4. Strive to make CPH 2025 mainstream and broaden the ownership of the project across City Administrations, for instance targeting schools and pre-school institutions or any unit working on retrofit.

The primary strategic forum for taking up these challenges is the Climate Secretariat that can address the challenges and propose solutions in the Steering Group. This applies to all four issues. The Climate Secretariat can also approach politicians in the Technical and Environmental Committee to sensitize them to the challenges.

Further to these four overarching issues, the Climate Secretariat is also the key forum to assess the specific measures proposed in connection with the three themes that are dealt with in more detail in the remainder of this chapter.

2 Action plans, theme by theme

Based on the three themes and related challenges described in Part B, the remainder of this chapter addresses how the City's ability to implement on the themes may be improved and proposes Action Plans for selected solutions.

In terms of methodology, it should be noted that the authors of the report found it useful to use the SWOT- and PESTLEGS-tools[66] to support the discussions about the themes at early stages in the drafting process, and implicitly used insights from these exercises in the action plan tables that summarise the proposed new initiatives in support of CPH 2025.

Some of the suggested measures in the sections '*Theme 2 – Flexible Energy Buildings'* and '*Theme 3 - The Flexible Energy System'* are similar. In Theme 2 these measures are seen from the perspective of the building, whereas in Theme 3 they are considered from the vantage of the total energy system.

Before going into detail with the themes of Flexible Energy Buildings and the Flexible Energy System, the following section first touches upon the theme: Dialogue with Developers (described and discussed in more detail in the Implementation Plan, WP4). This theme is dealt with in the Transformation Agenda especially to the extent that it plays a role as a precondition for the other two themes to fully succeed, or succeed faster or at scale as opposed to in a piecemeal fashion.

3 Theme 1: Dialogue with Developers

Through an improved way of having the dialogue with developers, the City aspires to get more sustainability than would otherwise be the case. This is in essence the purpose of the ongoing project to develop and implement a new concept for the City's dialogue with developers.

[66] 1) Map and analyse a situation or initiative, using the matrix of the SWOT: Strengths, Weaknesses, Opportunities, Threats. 2) Analyse responses to the mapped situation or project to assess whether they cover all required dimensions, using the filter of the PESTLEGS: Political, Economic, Social, Technological, Legal, Environmental, Governance, Spatial.

The fundamental challenge is that the City cannot, through local plans or other formal instruments, do a great deal to make demands on developers. But dialogue, inspiration, and voluntary agreements with developers may have some effect in terms of pushing the market to built in ways that introduce a higher environmental standard.

Two issues, however, must be solved for the City to succeed, that is, a part from improving *internal* processes in the City Administration and the *timing* of the soliciting of developers (these two dimensions are described in the Implementation Plan and given prime attention in the currently ongoing project to improve the City's concept for dialogue with developers).

The two additional issues, currently *not* dealt with in the ongoing project to improve the concept, are first, the question of the lacking business case for Flexible Energy Buildings – or more broadly, for buildings built or renovated to optimise their energy and resource profile. And second, an extended use of data through shared or open data platforms to underpin in particular the energy performance of buildings.

Business case for Flexible Energy Buildings
The lack of a business case is a critical lacuna because as long as the business case lacks, the majority of developers will at best be friendly in tone but firm in rejecting any ideas of going out of their way to build in ways that perform better than the current Building Code demands. They have a legitimate *raison d'être* to build for profit. If the City wants business as usual to become more sustainable, resource or energy efficient than required in the Building Code, it is the responsibility of the City to take action to ensure that a business case be made – and which, to be sure, must be sufficiently convincing in commercial terms for developers to change their habits. The action plan for the development of the business case for Flexible Energy Buildings, draws on the design for the business case that was developed for the somewhat broader theme of Smart Energy Buildings during the ILS in April 2014, and provided in full detail in the Annexes (Annex 8).

Another, more modest, way of dealing with the need for a business case is to address the need for *evidence* for effects of initiatives or measures that are implemented to drive down CO2-figures. As of winter 2014, the City is in the process of revising the City framework for environmental standards and demands to the City's own buildings, City-subsidised social housing and urban renovation projects, and, finally, the City's construction sites (*Miljø i Byggeri og Anlæg (MBA)*). This process, pending political approval of its final proposal, scheduled to spring 2015, may lead to the development of evidence-based calculations as a tool to visualise total economic and environmental impacts of measures to increase the energy profile of a building.

To this end, CLEAN contributed, as a sub contractor to the City of Copenhagen during TRANSFORM, a case study of six cases regarding both City-subsidised and City-owned buildings, with some buildings having been retrofitted, and some being new built. The aim of the study was to give input to the MBA-revision process. The study ran from October 2014 through March 2015. Lessons learned are summarised in Part D.

1.1 Business case for Flexible Energy Buildings

Theme 1*: Dialogue with Developers*	Priority: **High**
Business case for Flexible Energy Buildings	
Purpose and description of measure	If the City wants a better fit between the growing share of the less flexible energy production of RES, on the one hand, and energy consumption, on the other, the latter must be made more flexible. This can be ensured by buildings that can use energy in ways and at times that support the overall energy system. There are currently no economic incentives for developers and investors to build or renovate in ways that allow the buildings to support the overall energy system. There might also be an insufficient level of shared understandings of the challenges in the energy system that must be solved, and how buildings may contribute.
Challenges, incl. Finance / business case	Who will lead the process of developing the business case? How could it be financed?
Next steps, solutions	The MBA-revision may deliver some data and insights that suggest the extent to which high energy performance in buildings pay off, not only in terms of environmental impact or better indoor climate, but also with regard to the economics. Building owners, residents, developers and energy companies must all clarify (or contribute to showing) costs and benefits from increased building flexibility. A pilot project, *EnergyLab Nordhavn* in Copenhagen aims to collect information on the technical, economic and environmental potentials of building flexibility. Based on the results, a business cases can be developed, and, if feasible, the concepts may then be applied at scale. The project starts in April 2015.
Impacts	The City will, if endowed with a business case for Flexible Energy Buildings, strengthen its ability to push the market for high energy performance in buildings.
Achievements so far	Collection of data for MBA-revision in process (as of winter 2014). Funding for the pilot project *EnergyLab Nordhavn* was granted through the national funding programme EUDP.
Role of the City	The City plays a key role, first, in requesting the business case be made, second in faciliting a set-up that ensures its finance. The City can identify appropriate buildings, including its own, as a basis for the business case, and contribute to initiating dialogue to establish common understandings of the challenges and solutions.

Stakeholders	Building developers/investors and owners, as well as district heating and electricity grid owners, - operaters, - traders and energy solution companies (both technological and services).

Data – an asset to create energy savings and services

The second issue that the City must contribute to solving is that of data and their growing status as an asset to create energy savings, more flexible energy consumption, or other services that third parties may develop on the basis of open data. However, a series of challenges makes it difficult to unleash the data-based potential.

Until recently, one key issue was the trade-off between the national energy savings obligation and increasing demands for open or shared data. Because it costs resources for energy companies to deliver open or shared data, the companies would want something in return for the effort. And until recently, that expectation was not met.

Energy companies in Denmark are by law obliged to ensure a certain amount of energy savings every year. Energy companies can either make initiatives that will result in energy savings, or they can buy the savings from others. For the energy savings to be valid and hence creditable according to the national framework for the energy savings obligation, the energy company must document the kind of measures they have implemented (or bought), and the resulting amount of energy savings. Energy savings that are achieved when equipment is replaced by newer, and more efficient equipment, can typically be linked directly to investments in the new equipment – and hence documented. In contrast, energy savings that result from behavioural changes caused by the energy company's delivery of data are much harder to document.

It must be kept in mind that energy savings represent an economic value (they can be bought/sold). But energy savings that will be credited through the national framework for the energy savings obligation are far more likely to happen at scale. And because energy companies have to invest resources in generating open or shared data, they look for something in return for the effort.

This particular challenge was resolved through the Danish Energy Authority's amendment by autumn 2014 to the framework for the energy savings obligation. Henceforth, energy companies get credits for delivering detailed consumption data to consumers. This is an important step towards a more dynamic use and flow of energy data, and it is a precondition for a market for shared or open data to, potentially, take off.

If also the remaining data-issues were solved – such as those over data security, privacy, costs and resources – it would be easier to implement Flexible Energy Buildings (and other data-dependent initiatives or services). Some of these challenges are dealt with in the measures discussed under the title of *Flexible Energy Buildings* (following immediately below).

It might, however, be argued that the City ought to develop a data strategy, covering all challenges in a comprehensive manner, that is, across all Administrations.

4 Theme 2: Flexible Energy Buildings

What is a Flexible Energy Building?

While no consensus, technically or otherwise, exists, this section roughly delimits Flexible Energy Buildings from other energy optimising efforts, it gives a preliminary definition, and suggests specific solutions that could lead to more Flexible Energy Building being built, or existing buildings being upgraded to become more flexible.

Generally, energy savings in buildings may be achieved by three different means: 1) Improved building envelope (e.g. better insulation and windows), 2) upgrading the energy consuming equipment in the building, and 3) improved energy management. This theme on 'Flexible Energy Buildings' is about the latter, intelligent energy management or, in short, intelligent service.

In terms of reducing CO2 emissions from buildings, this might not be the measure with the highest impact. However, it will indirectly enable CO2 reductions because it will allow for more RES in the energy system. For this reason and to counterbalance some of the imbalances in the energy system that greater shares of wind power will lead to, this theme includes, together with *Theme 3: The Flexible Energy System*, important measures for the development and improvement of the energy system.

Thus the added value of the Flexible Energy Building, relative to existing concepts (sustainable buildings, green buildings or energy efficient buildings) is that it highlights the particular element of its connection to, and active collaboration with the overall energy system.

But how to define in more detail what a Flexible Energy Building is?

A Flexible Energy Building is a building of high quality materials that facilitate energy management through a high number of measurements, communication networks, efficient appliances and demand side energy activities such as smart meters and local electricity production with e.g. solar cells. The benefits are higher comfort, reduced energy demand and increased demand flexibility. A power grid with more flexibility can enable a higher penetration of intermittent renewable energy. This would together with energy savings allow for lower environmental impact.

The matrix (see below) provides an overview of suggested measures that can help making buildings more flexible. The measures, which are described in more detail in later sections, have been prioritized (high/medium/low) according to their perceived environmental impact (in particular greenhouse gasses) and economic feasibility, and also according to their

flexibility potentials. Low priority does not mean that a measure is not prioritized, only lower than medium.

The time frame suggests estimates for when a given measure is likely to be mature for implementation.

The high priority measures and some of the medium priority measures are described as detailed action plans (in schemes), while the remaining measures are described in brief narratives.

Theme 2: Flexible Energy Building measures									
Measure		**Priority**	**Benefits**	**Obstacles**	**Important actions**	**Key driver(s)**	**Start**		
							2015 - 2017	**2018 - 2020**	**2019 - 2022**
2.1	**Intelligent service**	H	Energy savings in buildings through better management of the internal heating systems, enabled by remote metering and analysis.	The economic feasibility needs be better communicated to building owners.	Dedicated campaigns targeted at specific building segments. The City should commit their own buildings.	HOFOR and City Administration	x		
2.2	**Flexible heat load**	M	Cheaper operation of the total system, which results in reductions in heat expenses for the consumers.	Current heat tariffs are fixed at annual basis and do not encourage flexible use.	Tests of new tariff schemes and dynamic, in-house heat storage tanks.	DH company, Danish Energy Regulatory Authority		x	
2.3	**Flexible use of electricity**	M	Using electricity when the prices are low the consumers could get the same level of comfort at a lower cost.	Price incentives are too low to change consumption patterns, and virtually no household equipment supports flexible energy consumption.	Electricity price signals must be made more dynamic.	Danish Energy Agency, electricity companies		x	
2.4	**New services for consumers**	M	Extended service and user friendliness for building owners and users	Privacy and economic issues. Data platform presently not available.	Development of a national strategy for data collection and use	Utility companies, service companies, and building developers	x		
2.5	Electricity generation from the building	L	Consumers will benefit from lower energy expenses and less consumption from the electricity grid.	The subsidy schemes for e.g. solar cells must encourage self-generation of electricity	Revision of the subsidy schemes	Danish Energy Agency	x		

2.6	Heat generation from the building	L	Heat from e.g. solar collectors or cooling equipment could be used in the house, saving money and energy from the energy systems.	Space requirements for the equipment could be an issue. Economic benefits as of yet unclear.	Demonstration projects are necessary to show both the technical feasibility and economic benefits.	Danish Energy Agency	x		

2.1 Intelligent service

Theme 2*: Flexible Energy Buildings*	Priority: **High**
Intelligent service	
Purpose and description of measure	A remotely read heat meter offers an opportunity to share detailed data between HOFOR 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 enable HOFOR 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.
Finance / business case	The meters and the data management system will be financed by HOFOR, while the building owners will pay a fee for the services rendered.
Next steps, solutions	HOFOR is now offering intelligent service to all its customers with remotely read meters, essentially all large buildings. Next steps would be dedicated campaigns targeted at specific building segments, e.g. municipal owned office buildings, other municipal owned buildings, other office buildings built 1950-75, other office buildings built 1975-2014, new buildings (e.g. in Nordhavn), commercial buildings, and apartment buildings (according to ownership models and ages). The goal for HOFOR is to reach 200 service agreements in 2014, and a total of 600 service agreements by the end of 2015. HOFOR will promote this service through events and communication with heat consumers.
Impacts	CPH 2025 sets a goal of 20% reduced heat demand in buildings, roughly 800 GWh/year. If half of the existing building stock employs intelligent energy service, thus saving in average 10% heat, a total reduction of 200 GWh/year will be achieved, equivalent to one fourth of the overall 20%-target. When intelligent energy service is implemented, an accurate understanding of the building's energy performance becomes possible. This enables approved economic assessment of further energy savings, such as by improving the building envelope. In addition, intelligent energy service also allows for easier and more accurate monitoring and documentation. Use of actual energy data for energy labeling of buildings can replace the current system based on theoretical calculations.
Achievements so far	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.
Role of the City	The City of Copenhagen should commit all their own buildings to the program. They should make the results public to motivate other building owners in the city to follow suit and participate in

	the dedicated campaigns mentioned above. KEjD has received financing to commit in such programs. Additionally they should promote smart meters and carry out campaigns, teaching people how to use the new information on their energy consumption.
Stakeholders	HOFOR, Copenhagen Municipality, building owners and developers.

2.2 Flexible heat load

Theme 2*: Flexible Energy Buildings*	Priority: **Medium**
Flexible heat load	
Purpose and description of measure	Introducing flexible heat loads will primarily benefit the energy supply companies, cf. measure 'Interruptible heat consumers' under Theme 3. However, to become effective consumers must benefit too. Dynamic charging of hot water storage tanks, for instance, could reduce loads in peak hours and thus reduce the total energy system costs. Changes in the district heating tariffs are required to give consumers economic incentives. A similar concept for space heating may require a heat buffer tank installed in the buildings. An equivalent solution may be applied for cooling solutions.
Challenges, incl. Finance / business case	Current heat prices are fixed throughout the year. Thus consumers have no economic incentives to change heat consumption habits or invest in "flexible heat" equipment such as heat storage tanks within the buildings.
Next steps, solutions	Test of new heat tariffs, methods for temporary increase/decrease in household consumption and test of equipment suitable for this, e.g. hot water stores at the consumers. This requires approval by the national Energy Regulatory Agency. The business case should be calculated and tested.
Impacts	The system would become more flexible, allowing a higher share of renewable energy sources. This would reduce the expensive and polluting peak load. For the consumers this should, ideally and for the measure to work, result in economic savings.
Achievements so far	Monthly tariffs are being introduced in 2015. This will later be expanded to daily tariffs or three-step tariffs (night / weekend, day time and peak consumption), particularly in an area such as Nordhavn, where hot water consumption may eclipse space heating.
Role of the City	The key element, tariffs, is regulated by the Danish Energy Regulatory Authority. The City can support local test projects, e.g.

	by identifying appropriate buildings, and lobby the authorities.
Stakeholders	District heating and power utilities. City Heat and power producers Consumers

2.3 Flexible use of electricity

Theme 2*: Flexible Energy Buildings*	Priority: **Medium**
Flexible use of electricity	
Purpose and description of measure	Equipment such as dish washers and washing machines may might be timed to operate depending on the electricity price, preferably run when electricity prices are low. Equipment such as refrigerators and freezers, with thermal capacity, might be turned off shortly to reduce electricity consumption at peak hours or use energy, when prices are low.
Challenges, incl. Finance / business case	There is currently no economic incentive for the consumer.
Next steps, solutions	A few pilot projects will be implemented in new buildings in Nordhavn. Pilot projects in existing buildings must be identified and implemented.
Impacts	Lower electricity peak load and possibly a slight drop in comfort for consumers. The potential loss of comfort needs be compensated economically.
Achievements so far	Not yet started.
Role of the City	The City may assist in identifying appropriate buildings, including its own, and in disseminating the experiences in order to inform and involve more consumers. Furthermore the City should engage electricity trading companies and lobby for an amendment to the electricity price signals to promote a more flexible use of electricity.
Stakeholders	Building developers, owners, and users, the electricity grid owner, electricity trading companies

2.4 New services for consumers

Theme 2: *Flexible Energy Buildings*	Priority: **Medium**
New services for consumers	
Purpose and description of measure	A large number of data may become available from building equipment such as energy meters etc. There is a huge potential for using such data for improving the service level of the house. This is the case for both existing and new build buildings. Indoor comfort control may be achieved by measurements of CO_2 content, temperature, humidity and activity in the house. Likewise the lighting in buildings could automatically turn off, when there is nobody in the rooms, or turn on or when it gets dark and if somebody moves in a room. Also, a higher degree of natural ventilation, natural lighting, natural heating and cooling (avoidance of extra heating) could be achieved by the use of energy-saving windows and automatic shadings. The control of these will be highly dependent on data. Other possible services are: • Sensitize users on reducing their consumption by giving them easy access to information about their actual consumption. • Enable consumers to manage their heat systems from their computers, telephones, and tablets. This enables them to turn off the relevant energy supplies, when going on vacation, and turn it on again in due time before returning, etc. • Detect unexpected consumption as a broken water pipe. • Using the measurements, the system could be used as burglary alarm, monitoring unusual consumption. These services would all require installation of new equipment to get the right data (cf. measure 'Data management and sharing' under Theme 3). This will require data collection and a central ICT system in the building to control all connected equipment within the building.
Challenges, incl. Finance / business case	The data must be collected in one data system for the building. Such a system is presently not available. Having one central database with all the house data poses challenges in data protection and privacy issues. The consumers will have to accept a change in the building systems which might reduce their own control of the building operation. However, this is expected to be accepted by economic savings.

Next steps, solutions	Pilot projects with real-time data must be made for both old and new buildings to understand actual benefits, make system assessments and identify legal and other barriers. Also cost-benefit analysis and assessment of potential for different types of buildings must be made (e.g. year of construction, use of building, type of owner)
Impacts	
Achievements so far	Small projects have been conducted, but a comprehensive approach is still missing.
Role of the City	The city shall facilitate pilot projects for demonstration of the benefits from using data as well as require a well defined framework on privacy issues and data confidentiality on a national level, e.g. in Nordhavn for new buildings and Sydhavn for existing buildings.
Stakeholders	Danish Energy Agency and the Danish Data Protection Agency Service providers City administration Utility companies Citizens

2.5 Electricity generation from the building

Integration of photovoltaic for local electricity generation.
The implementation is mainly driven by economic incentives for the building owners or by requirements in the Building Regulations. The economic feasibility depends on subsidies and taxes.

2.6 Heat generation from the building

Local heat generation from a building can be achieved through solar heating or heat pumps. The heat pumps can use the ground as heat source or waste heat from e.g. cooling equipment. The produced heat can be used within the building, supplied to adjacent buildings or to a low temperature district heating network, depending on the needs. The same principle could be applied for cooling production.

There are, however, a number of legal barriers against using heat pumps in central CHP areas like Copenhagen and there are both economical and legal barriers against private consumers delivering heat to the district heating network.

5 Theme 3: The Flexible Energy System

Denmark is to become independent of fossil fuels by 2050, and Copenhagen to become carbon neutral by 2025. The Danish energy system will become dominated by intermittent RES, and electricity will be the dominating energy carrier. In this situation, the energy system needs to be developed towards an optimised and multi-carrier energy infrastructure (e.g. electricity, heat, cooling, gas, transport), which through flexible interactions, horizontal integration and optimization at system as well as local level can accommodate the integration of fluctuating RES.

Integrated designs and operating approaches are needed to ensure an optimized future energy system. Use of new and extensions of existing smart energy design and dimensioning methods can lead to substantial savings and reduction of tied-up capital through the right investment decisions and development of the most optimal solutions.

Theme 3 focuses mainly on how the district heating system may support the development of more flexibility in the overall energy system. The simple reason for the focus on district heat, and not electricity is that in Copenhagen the district heating company (HOFOR) participates in the TRANSFORM project, not electricity companies.

The below matrix provides an overview of measures that may increase flexibility. Like for theme 2, the suggested measures for the theme Flexible Energy Systems have been prioritized according to their perceived . environmental impact (in particular greenhouse gasses) and economic feasibility. The time frame suggests estimates for when a given measure is likely to be mature for implementation.

Theme 3: The flexible energy system									
Measure		**Priority**	**Benefits**	**Obstacles**	**Important actions**	**Key driver(s)**	**Start**		
							2015 - 2017	**2018 - 2020**	**2019 - 2022**
3.1	**Large heat accumulators**	H	Allows for more flexible heat production, e.g. the CHP plants can produce depending on the electricity price.	The stores are large and must be located near the DH grid, i.e. in the city. It is difficult to find suitable locations.	The City must prioritize the measure and reserve space in urban planning processes.	City & district heating companies	x		
3.2	**Large electric boilers and heat pumps**	H	When electricity generation is high, electric boilers and heat pumps can operate and produce heat.	Electric boilers and large heat pumps are not allowed in central DH areas. Also the economic feasibility of this measure is questionable.	Test projects with both electric boilers and heat pumps. May require changes in the electricity price signals to make it economically feasible.	District heating producers, Danish Energy Agency and electricity transmission and system operator	x		
3.3	**Interruptible heat customers**	H	The district heating companies can reduce the use of expensive and polluting peak load production by shortly shutting off heat for certain consumers.	Unclear what the benefits for the district heating system are. Unclear business case for the district heating company. The acceptable times of heat interruption are unknown.	Test the solution in pilot projects with consumers.	HOFOR	x		
3.4	**Data management and sharing**	H	Improved planning and decision making. New technologies and applications to improve use of energy.	Privacy and commercial constraints. Economic value may not match the costs.	Improve data quality. Create viable business model.	Municipality & district heating companies	x		

3.5	**Smart Charging of EVs**	H	Reduce need for grid investments. Allow a higher share of fluctuating renewable energy in the electricity grid.	Current electricity costs do not give incentives to charge EVs in a system supporting way.	Installation of more smart chargers and changed electricity price incentives.	Building/EV owners, City of Copenhagen, electric grid company, electricity traders		x	
3.6	Dynamic electricity consumption	H	Reduced electricity peak loads.	Current price incentives are insufficient.	Pumps for district heating, water and sewage may be regulated according to electricity prices	HOFOR		x	
3.7	Bypass steam	H	Allows decoupling of electricity production and heat production in CHP plants and allows less electricity and more heat to be produced.	Not all CHP plants are technically able to bypass steam. Requires reconstruction of the plants. Business case might not be good.	Business cases must be made and, if this shows economic feasibility, the plants should be rebuild	CHP plant owners		x	
3.8	Prosumers	M	Extra heat from buildings can be sold through the grid.	Currently consumers cannot deliver heat to the grid. Heat tariff system would have to be changed. This would require low temperature district heating.	Demonstration projects.	Building owners, energy distribution companies		x	
3.9	Integrated district cooling and district heating	M	E.g. a sea water heat pump can be used for cooling during summer and heating during winter, thus increasing its use and feasibility.	Unclear business case.	Business cases must be developed.	District heating & district cooling companies	x		

3.10	Upgrading of biogas by flexible use of electricity	M	The city gas grid may receive a larger share of biogas than today.	Upgrading technologies need be more market-proven and cheap	Follow demonstration projects and commercial developments	HOFOR		x	
3.11	Storing heat in the distribution network	L	Increased temperature in the district heating grid increases the storage capacity.	Would require a coordinated temperature increase of all the heat producers simultaneously.	Technical and economical feasibility must be analyzed.	District heating companies		x	
3.12	Fuel shift	L	Energy using appliances may shift between different energy carriers, e.g. heat and electricity, to offer flexibility.	Dynamic tariffs need be introduced	Implement and evaluate demonstration projects	Building owners, energy distribution companies			x
3.13	Sale of comfort rather than hot water in pipes	L	The offered good is closer to what consumers actually want	A revolutionary concept	Studies and seminars to assess the feasibility	Municipality & HOFOR			x

The potential flexibility measures have been grouped in 5 categories. It is worth noting that several of the measures may contribute substantially to flexibility, without them depending on advanced use of data or IT.

3.1. Large heat accumulators.

Theme 3*: The Flexible Energy System*	Priority: **High**
Large heat accumulators	
Purpose and description of measure	The existing hot-water stores may be operated more intelligently, maximizing the benefits for the integrated heat and electricity system. Also, with the increasing generation from intermittent RES, there is a strong need to expand the amount of stores. Today, three heat accumulators (pressurized hot water) are located at the main power plant sites. They are operated for three purposes: 1) As buffer for errors in the forecasting of heat demand; 2) As buffer in case of heat generation breakdown; and 3) for the benefit of electricity generation, i.e. the stores are filled when the electricity market favours a larger generation than the heat market can consume. The economic value of heat stores may be increased if their ability to operate in the two separate but interlinked markets for electricity and heat is better exploited. Also, with increasing generation from intermittent RES, electricity prices will become more volatile. Thus the need for heat storage will increase, as much of the generation in Copenhagen area is combined heat and power. A recent analysis indicates a need for up to 7 times more storage capacity by 2050 in the Greater Copenhagen system.
Challenges, incl. Finance / business case	A business case for how to gain more benefits from operating the current heat storages needs be developed. Business cases for new stores must be developed. Some heat storages will be owned and financed by the power utilities, others by the district heating companies. Heat storages are typically high-rise buildings, and it is thus difficult to find appropriate sites for new heat stores (e.g. they disturb the view from neighbouring buildings and partly eclipse the sun). Another option is to store heat in former ship-yard dry docks. This may contradict recreational or other harbour development purposes.
Next steps, solutions	The business case for improving the operation of existing storages will be developed by HOFOR, the heat transmission companies (CTR and VEKS), the Greater Copenhagen Heat Dispatch Centre, and the owners of the power plants in Greater Copenhagen.

	Expected start: 2015. The business cases for new heat stores located within the city of Copenhagen will be developed by HOFOR in cooperation with the heat transmission companies. Expected start: 2015.
Impacts	The electricity system will benefit from a more flexible energy system, paving the way for optimized integration of intermittent renewable energy generators. This will lead to environmental and economic benefits in addition to increased security of supply. District heating will benefit from reduced generation costs. District heating being a non-profit business, all economic gains will benefit heat consumers.
Achievements so far	Decades of experience with operating hot-water storages. No achievements yet as to a fully optimized operation of the stores.
Role of the City	The City must take a lead in discussing the location challenges, cf. above, with all relevant partners, and ensure that urban planning processes, not the least local plans, take the need for more space to heat stores into account.
Stakeholders	District heating and power utilities. City administration. Neighbours to potential new heat stores.

3.2. Large electric boilers and heat pumps.

Theme 3*: The Flexible Energy System*	Priority: **High**
Large electric boilers and heat pumps	
Purpose and description of measure	Electric boilers and heat pumps may consume electricity, when this is cheap, and generate heat. Such an operation mode may be used as a flexibility instrument for the electricity system, while reducing costs of district heating. Electric boilers and heat pumps may also improve security of supply in Copenhagen's district heating system, that would otherwise become entirely dependent on biomass and waste incineration.
Challenges, incl. Finance / business case	Heat pumps have rather high investment costs and should therefore have many operational hours, similar to base load operation to become financially feasible. This contradicts the objective of being operated primarily when electricity is cheap. It is therefore essential that large heat pumps become more market mature, get higher efficiencies, lower investment costs, and lower operational costs. Meanwhile electric boilers would often be the most favourable solution in terms of enabling flexibility. Another part of the solution is to have access to sufficient heat storage capacity, cf. above measure.

Next steps, solutions	HOFOR is preparing to establish a couple of 5 MJ/s heat pumps as a demonstration project, expected to start operation in 2016. This is in preparation of installing an expected total capacity of 200-300 MJ/s before 2035, most of them using sea water as heat source. At least one of the demo heat pumps will to some extent be regulated by fluctuations in electricity prices.
Impacts	A more flexible energy system, paving the way for optimized integration of intermittent renewable energy generators. This will lead to environmental and economic benefits in addition to increased security of supply.
Achievements so far	A design project for the demonstration heat pumps is on-going, and a comprehensive plan for the future development is being finalized. When the long-term heat plan has been approved by the district heating companies of Greater Copenhagen (expected November 2014), appropriate sites for the first large-scale heat pumps shall be identified.
Role of the City	Proper access to sea water may conflict other interests of using harbour and sea areas. The City has a crucial role in avoiding and reducing such conflicts of interests.The City must take the initiative to facilitate dialogue with all relevant partners. Moreover, the City must ensure that urban planning processes, not the least local plans, reserve harbor areas and make the necessary preparations to allow the placement of heat exchangers on the bottom of the sea. Also, it is important to ensure smooth processing of environmental assessments and any other required permissions.
Stakeholders	Landowners, Copenhagen City and Port Development, Biofos (Copenhagen wastewater treatment company), sea authorities.

3.3. Interruptible heat customers.

Theme 3*: The Flexible Energy System*	Priority: **High**
Interruptible heat consumers	
Purpose and description of measure	The current district heat load that goes into the grid occurs today simultaneously with the actual consumption in buildings. This means that the heat must be supplied exactly at the time of consumption, except the heat that goes through the heat accumulators. If the consumption of heat from the DH grid becomes more flexible, the total energy system can become more flexible because this would change the time of the production relative to consumption. As the heat and electricity grids are interconnected, and will be even more so in the future, this is of great importance for the future system. This would allow higher amounts of wind, solar etc. in the power system. The aim of this action is to manage critical supply situations and minimize expensive peak load generation, but interruptible customers may also be used for flexibility purposes. Building envelopes have an enormous heat capacity, which can be better exploited e.g. through temporary interruptible heat consumers. Buildings with a significant hot-water demand may also increase their heat storage capacity if equipped with larger hot-water tanks.
Challenges, incl. Finance / business case	New contractual agreements must be developed to ensure sufficient economic incentives for building owners and users. Health risks if the temperature of hot tap water gets too low.
Next steps, solutions	This measure will develop business models and make agreements with a number of interruptible heat consumers, some using the building envelope as storage, others using hot-water tanks. Next steps are a pilot project (2016-17) implementing a limited number of consumer agreements, and a large-scale demonstration project (2017-18).
Impacts	Interruptible heat consumers may be activated, when expensive and environmentally unfriendly peak load generation, e.g. from oil fired boilers, is needed. Involved consumers should be given economic compensation. Thus the focus would be to reduce heating costs and mitigate CO_2 emissions.
Achievements so far	HOFOR will carry out an analysis to identify economic and environmental perspectives (2015).
Role of the City	The city should commit some of their own buildings in the planned tests. Also, owners of existing buildings and building developers should

	be informed about the perspectives in becoming interruptible heat consumers, and learn more about the ways in which their buildings can be adapted to better suit the purpose.
Stakeholders	HOFOR, building owners and developers, architects, engineers.

3.4. Data management and sharing

Similar to some of the measures in Theme 2, this also concerns data. Here, the focus is open data sharing at city and energy distribution company level.

Theme 3*: The Flexible Energy System*	Priority: **High**
Data management and sharing	
Purpose and description of measure	The primary objective is to improve the basis for municipal energy planning, decision making and monitoring of progress in reducing energy consumption in buildings. The quest for establishing open or semi-open data platforms raises several issues, which need be addressed: 1. Ways to enhance collaboration between energy utilities and data consumers. 2. Strengthen the organisation of buildings data management within the City of Copenhagen, in particular across administrations 3. Find new and efficient business models concerning: • Sharing data (enabling consultants to analyse data and suggest feasible energy savings) • Extracting value from data • Ensuring that data sharing costs shall not be covered through consumer tariffs (scheme for data payment) • Share experiences on data management and advanced modelling (through networks and courses). 4. Address reluctance of end-users to reveal energy data to third parties, e.g. by using standard values for such buildings. 5. Address reluctance of end-users to smart metering and smart tools that are perceived as surveillance, e.g. by informing them of the potential for achieving energy reductions at low cost, facilitating competition and a sense of proudness by becoming more energy efficient.
Challenges, incl. Finance / business case	Energy consumption data are not of uniform quality, making proper analyses difficult. This may be improved by intelligent energy service (cf. action box 2.1), heat labelling, uniform reporting formats, and cooperation agreements between the City Administration and building owners. Some data may not be shared due to privacy issues (primarily data which can be referred to legal persons). Other data may not be shared for commercial reasons. Collating and delivering data have expenses, and the data receiver may not be willing or able to cover the costs. At the same time, building owners and utilities have no economic incentive to share data.

Next steps, solutions	Generally, more dialogue. HOFOR will continue to improve the quality of end-user data to allow cross-cutting analyses within consumer segments. The data quality improvement process will be linked to dedicated campaigns that target specific building segments of the measure 'Intelligent energy service' (cf. the theme Flexible Energy Buildings, action box 2.1). Thus end-users will be actively involved, and expectedly result in more data sharing with the City Administration.
Impacts	Building data constitutes a huge potential for reducing energy consumption and operational costs of a building. Data access may help creative minds in developing new technologies and applications to increase energy efficiencies, reduce losses, and improve consumer services.
Achievements so far	Dialogues between the Municipality and the energy supply companies have been going on for a couple of years.
Role of the City	The City must support test projects to demonstrate benefits from using data as well as require a well defined framework on privacy issues and data confidentiality at national level. In particular, the City shall pave the way by introducing intelligent energy service in its own buildings. The City may facilitate the creation of platforms for sharing data delivered by the utilities and others and attract finance to cover the costs.
Stakeholders	Data owners, primarily the City and energy supply companies.

3.5. Smart charging of electric vehicles

Theme 3*: The Flexible Energy System*	Priority: **Medium**
Smart Charging of EVs	
Purpose and description of measure	Today, the charging of EVs is not made in a dynamic way that supports the electricity system. By charging at the right periods, e.g. during night when the electricity consumption is low and there is a high production of wind power the total electricity system could be better supported. This might reduce system investments and at the same time, consumers would benefit from their EVs charging at times with low cost electricity. For the electricity system, this will ease the integration of fluctuating energy sources and reduce the peak load production.
Challenges, incl. Finance / business case	Current electricity costs do not give incentives to charge EVs in a system-supporting way. For this to happen, electricity payment must become more dynamic.
Next steps, solutions	Installation of more smart chargers and a change in the electricity payment incl. tariffs and taxes are needed.
Impacts	The use of dynamic charging of EVs will help the electricity system become more flexible which might reduce the need for grid investment. This would also allow for a higher share of fluctuating RES in the system. At times with a high power need the EVs could shortly feed power to the grid. Increased use of EVs that replaces traditional vehicles in the city will result in better air quality, and less noise.
Achievements so far	Charging stations are being installed in the city. Work is being conducted to change the electricity market, which is a step towards dynamic electricity prices. The work is carried out on a national level but is delayed until late 2015.
Role of the City	The City is responsible for support to the grid companies in their application for grid construction. The City shall install dynamic EV chargers in connection with their own buildings and in public places, and thus support the charging infrastructure. A system for paying for the use of these chargers is necessary. The City shall also lobby for an amendment to the electricity cost system to promote smart charging of EVs.
Stakeholders	Building/EV owners City of Copenhagen Electricity grid companies Electricity traders

3.6. Dynamic electricity consumption.

Similar to 'Flexible use of electricity' in buildings (Theme 2) and smart charging of electric vehicles (cf. above) use of electricity can be made more flexible. HOFOR has a large consumption of electricity for pumps for district heating, water and sewage. Such pumps may be operated according to electricity prices, for example by filling water towers, when the price is low, thus reducing peak loads.

3.7. Bypass steam.

CHP can reduce electricity production and increase heat production by passing steam around the turbines. Principally, i.e. from a system's point-of-view, steam bypass is equivalent to electric boilers.
This is already possible at one unit at Amager Power Plant. However, steam bypass may be introduced for other power plant units.

3.8. Prosumers.

Improved coordination between the energy company and prosumers (customers both consuming and producing energy, such as buildings with heat pumps or solar heaters).

3.9. Integrated district cooling and district heating

Theme 3: *The Flexible Energy System*	Priority: **Medium**
Integrated district cooling and district heating	
Purpose and description of measure	The heating and cooling businesses are separated, meaning that each business must have their own equipment. Both systems could use a heat pumps, but in different time of the year, district heating in the winter and district cooling in the summer. This would increase the number of operational time and thereby increase the economic feasibility. The purpose of this measure is to find a way for the two businesses to co-invest in heat pumps.
Challenges, incl. Finance / business case	One of the big challenges is that district heating is a non-profit business and district cooling is operated on market conditions. The equipment sharing between these twotypes of companies requires new business models.
Next steps, solutions	A pilot project is under consideration, using one of the present district cooling terminals for heat production during winter, when cooling can be provided from free cooling by sea water.
Impacts	The measure could reduce the costs for district cooling which could replace a number of the building based cooling units. As district cooling is much more efficient and less polluting, this would have both economic and environmental effects.
Achievements so far	The legislation has recently been changed and therefore not much has meen achieved so far.

Role of the City	The city must support projects and give permissions to test projects as well as ensure sufficient space near the water for heating/cooling units.
Stakeholders	District heating and district cooling companies Danish Energy Authority Danish Energy Regulatory Authority

3.10. Upgrading of biogas.

The use of hydrogen (produced during periods of low electricity prices) for methanizing the CO_2 content in biogas is an interesting opportunity for the ongoing conversion of town gas to green gas, at the same providing flexibility to the electricity system.

3.11. Storing heat in the distribution network.

Heat may be stored in the pipes by increasing the forward temperature. A particular advantage of storage in the district heating system is that it can absorb large amounts of electricity production over several days, even weeks – in contrast to e.g. electric vehicles and flexible consumption of electric appliances (refrigerators, freezers, etc.).
The primary concern is technical challenges, and hence economical. For this reason the measure needs be demonstrated at small scale to be better understood.

3.12. Fuel shift.

For example, dishwashers and washing machines could be water heated by district heating. Back-up electricity, possibly with an option for delayed start, will increase flexibility in relation to electricity and heat markets.
All measures will be implemented by HOFOR or consumers. HOFOR will finance its activities through consumer tariffs. Thus, business cases need be elaborated to identify how the measures can become win-win – for consumers and HOFOR.

3.13. Sale of comfort rather than hot water in the pipes.

Intelligent electricity and heat will open up a new product, climate packages, focusing on offering indoor comfort rather than hot water in pipes. Acceptable indoor comfort can be boiled down to three parameters: Temperature, relative humidity and CO_2 content. To this end, there must be an agreement between the heating company and building owner / user of these three parameters. The heating company shall then deliver comfort, whether through district or local heating.

Part D
Status so far and impact on existing energy strategy

By way of conclusion:
Recommendations to improve the City of Copenhagen's ability to accelerate smart city development within the CPH 2025 target both the overall, strategic level and specific themes. While the strategic recommendations are not prioritised, the recommendations on the specific themes are. As said earlier, the recommendations shold be seen as *supplementary* to the City's, and in particular the CPH 2025 Plan's existing strategies, roadmaps and initiatives.

Strategic recommendations include, *inter alia*, the following ones:

- Request long-term budgets that cover required funding for each four-year roadmap period to enable more efficient planning (– and thus follow the advice from the IPCC scientific community that action *now* is better and cheaper than postponed actions);
- Offer permament positions to key staff with specialised competences required to implement CPH 2025;
- Develop and fund initiatives to involve citizens in actions required to implement or even improve CPH 2025;
- Strive to make CPH 2025 mainstream and broaden the ownership of the project across the City's Administrations, for instance targeting schools and pre-school institutions, or any unit working on retrofit.

With regard to the specific themes, recommended actions are listed here:

Theme 1: Dialogue with Developers
- Develop business cases for Flexible Energy Buildings;
- Coherent and cross-departmental strategy for the City's use of data;
- Find alternatives to the DGNB Certification that ignores whether an *advanced* use of data takes places or not in building management or urban development projects.

Theme 2: Flexible Energy Buildings:
Generally, progress will require that the City:
- Prioritise Flexible Energy Building initiatives;
- Lobby national Government;
- Rally support and team up with 'play mates' to test ideas, learn more and scale up initiatives.

In more technical detail, the following prioritised list of actions could yield progress in the field of Flexible Energy Buildings:
- Intelligent service
- Flexible heat load
- Flexible use of electricity

- New services for consumers
- Electricity generation from the building
- Heat generation from the building

The introduction of suggested solutions in *new built* depends to some extent on the City's ability to strengthen its Dialogue with Developers (not the least through business cases, that ought to be developed too). With regard to *existing* buildings it is important to reach out to building owners and raise awareness of both options and benefits (this will also require business cases).

Theme 3: Flexible Energy System:
Generally, progress will require that the City:

- Create the required coordination (between, for instance, the City's urban planners and utility companies);
- Engage stakeholders and proactively facilitate collaborative efforts;
- Lobby national authorities (on, e.g., tariffs, taxes or counter-productive regulation).

In more technical detail, the following prioritised list of actions could yield progress in the field of the Flexible Energy System:

- Large heat accumulators
- Large electric boilers and heat pumps
- Interruptible heat customers
- Data management and sharing
- Smart charging of EVs
- Dynamic electricity consumption
- Bypass steam
- Prosumers
- Integrated district cooling and district heating
- Upgrading of biogassby flexible use of electricity
- Storing heat in the distribution network
- Fuel shift
- Sale of comfort rather than hot water in the pipes.

Progress of the recommendations to bring about a more Flexible Energy System hinges on increased efforts from many stakeholders, including energy producers, utility companies, the City of Copenhagen as well as the National Government.

This observation would seem to apply in general, in all three cases: The immediate role of the City is weak – but then again, this only points to the City's need to lobby (national Government), and strengthen dialogue with stakeholders. To do so, the City needs to prioritise the dialogue and lobby activities, to ensure the right skillset among staff, and to build the networks that will accelerate the desired change.

1 What has been achieved so far?

Due to the short time in between the drafting of the Transformation Agenda and the development of the proposed actions, there is not a great deal of progress of actions to report.

There is agreement at project level that the next step is to initiate processes within the City Administration, in a collaborative effort with the Climate Secretariat in particular, and vis-à-vis stakeholders to assess the robustness of recommendations. Upon this, a process to further refine selected ideas should follow, as well as funding and adequate organisational support.

Theme 1: Dialogue with Developers:
The first meeting with developers, to test the refined concept for the City's dialogue with Developers, will take place during spring/summer 2015. Based on this, an evalution will allow for futher adjustments and lessons learned.

With regard to the question of business cases for Flexible Energy Buildings, some steps were taken through the work on six business cases for City-subsidised and City-owned buildings, both retrofit and new built: One school, one sports facility and four multi-storey buildings (both new built and retrofit cases). The aim was to to collect evidence, based on energy data, to inform the on-going MBA-revision process. The case study was carried out October 2014 through March 2015 by CLEAN, as a sub contracter to the City of Copenhagen in TRANSFORM. The case study collected and described the six cases in qualitative terms, but it proved impossible to develop proper business cases (e.g. getting data on energy consumption and the economics such as investment levels, operational costs before and after retrofit etc.).

Five lessons learned from the case study include four lessons from the building owners' experiences with energy investments in retrofitting/new built, and one lesson about the case study itself, that is, the difficulty of doing business cases:

- Include energy investments/sustainability goals in retrofit and new built projects from the very start;
- A pilot will allow you to test solutions, materials and methods, thus, to make better decisions about the full-scale project;
- Carry out retrofit projects in phases. This ensures that buildings are not left empty, and also allows for adjustments throughout the project;
- Involve the users of the buildings to enhance their understanding of new technological solutions – alternatively, the users get a chance to contribute with their needs and ideas, or object to certain solutions (e.g. noisy ventilation systems);
- You need sufficient resources to do the business case: It takes a lot of time, access to a number of people from each building project, and the building of trust to get to the information you need. Also, you need convincing 'value propositions' (i.e. good answers to the question why they should spend time for free, helping the City build

a business case). And, needless to say, it requires a great deal of number crunching and key figures drawn from numerous contexts, documents and excel sheets (that are often difficult to find, confident or no longer existing) if the goal is to end up with the full picture of not only random case descriptions (i.e. differing amounts of information, case by case), or primarily figures on energy consumption as opposed to key figures about the economics too. All this must be in place for the information to be compiled in a format that allows for comparison across cases.

Theme 2: Flexible Energy Buildings:
Lobby actions from actors in the energy sector led to the Danish Energy Agency's amendment by autumn 2014 to the framework for energy saving credits for the sharing of data through the national energy savings obligation. While this was not the result of TRANSFORM initiatives, it corresponded with recommendations of a working group discussing how to remove barriers to more open and shared data.

Similarly, recommendations in TRANSFORM working groups on the development of a business case for flexible energy buildings point out the need for consumption data and information about cost, investments and expected benefits in terms of e.g. reduced operation costs of the buildings. To some extent, TRANSFORM members at HOFOR contributed to ensuring that the EUDP-supported project *EnergyLab Nordhavn*, starting in April 2015, can be expected to deliver input about this.

Theme 3: Flexible Energy System:
At present, no action to report – but the proposed measures deserve to be properly assessed and considered as candidates for elements of the future, necessarily more flexible energy system in and around Copenhagen.

2 Impact of Transformation Agenda on energy strategy and policies

The entire process of working on TRANSFORM – from the very early stages of deciding to reply to the EU call throughout the actual work on TRANSFORM – contributed substantially to A) putting smart city on the agenda among executives and in the City Administration and B) kickstarted other smart city initiatives that, meanwhile, got their own life such as the Smart City Project Council.

The smart city agenda gained traction during the time when TRANSFORM, and it would moreover seem that the impact of the Transformation Agenda contributed to an initial pushing at the limits of the borders of reflection on what 'smart city' means in Copenhagen, and how best to work with the concept. An initial narrow approach has from early 2014 to 2015 broadened to include more Administrations and their ways of working with the concept. This resulted not *only*, but nevertheless *also*, due to input from TRANSFORM project team members and project deliveries.

The effort to interview and collect key staff's knowledge about the preconditions for the emergence of the Climate Plan, in the first instance, and requirements for its sustained support over time, provided an overview (Parts A and B) which may potentially serve as an introduction to new staff, as a reminder, or input for applications (for funding, prices etc.).

Whether the more technical recommendations in the Transformation Agenda will have any impact is yet to be seen. As already suggested, whether the technical recommendations will be implemented hinges less on the technology, and rather on the City's ability to work for them through processes, dialogue and lobbying.

What does seem clear, though, is that the Transformation Agenda functioned as a *pilot* that allowed both the City of Copenhagen and HOFOR to try out, draft and refine their thinking – which will be tried out in yet other processes and contexts, immediately following TRANSFORM in time, such as the EUDP project EnergyLab Nordhavn, or in pilots between the Climate Secretariat and HOFOR to map buildings through new, enhanced use of data, and potentially leading to analyses that allow for better targeting of initiatives, tailor-made to different types of buildings with different potentials for energy optimisation. And certainly, the work on TRANSFORM, had the City realise that working on and with data is challenging and demands a lot of resources.

The six cases from CLEAN's case study will be used in both the MBA-revision process and in the Climate Secretariat's continued efforts to increase the speed in and scope of the retrofit of buildings and higher energy standards in new built.

ANNEXES

ANNEX 1

Roadmap, Copenhagen Climate Plan, CPH 2025 (politically adopted in 2012)
This is an excerpt only, pages 16 through 19, of the Climate Plan CPH 2025. For the full version, cf. http://kk.sites.itera.dk/apps/kk_pub2/pdf/983_jkP0ekKMyD.pdf. Please note, that the excerpt reads from the left to the right *across two pages*.

ROADMAP >

MAIN AREAS	GOALS FOR 2025	MAIN INITIATIVES UP TO 2025
ENERGY CONSUMPTION	• 20% REDUCTION IN HEAT CONSUMPTION COMPARED TO 2010 • 20% REDUCTION IN ELECTRICITY CONSUMPTION OF COMMERCIAL AND SERVICE COMPANIES COMPARED TO 2010 • 10% REDUCTION IN ELECTRICITY CONSUMPTION HOUSEHOLDS COMPARED TO 2010 • INSTALLATION OF SOLAR CELLS CORRESPONDING TO 1% OF TOTAL CONSUMPTION	Framework improvements for construction sector Energy efficient buildings in copenhagen Proliferation of solar cells Innovation and profiling The smart city
ENERGY PRODUCTION	• DISTRICT HEATING IN CPH IS CARBON NEUTRAL • POWER GENERATION BASED ON WIND AND BIOMASS AND EXCEEDS TOTAL CPH REQUIREMENTS • SEPARATION OF PLASTIC - DOMESTIC AND COMMERCIAL • BIOGASIFICATION OF ORGANIC WASTE	Land wind turbines -within city of copenhagen Wind turbines - other municipalities Offshore wind turbines Bidding partnership for state wind turbine projects Biomass in combined heat and power plants New heat generation units in copenhagen Conversion of peak production to carbon neutral fuels New waste treatment centre Treatment of organic waste Separation of plastic from waste

	INITIATIVES UP TO AND INCL. 2016	2013-2016
	Develop strategy for energy consumption in construction sector	
	Develop and test funding model for realisation of energy savings	
	Work to change legislation to facilitate more energy efficiency	
	Establish method and guidelines and target funds for increasing climate retrofitting	
	Establish method and framework to ensure coherence between projected and actual energy consumption	
	Promote development of technology and solutions to secure low-energy new build	
	Adequate regulation of heat and domestic water supplies	
	Develop, test and implement model for realising energy savings in commercial and service companies	
	Motivate and support proliferation of solar cells	
	Knowledge building and experience sharing	
	Establish partnerships for setting up private lighthouse projects	
	Establish digital infrastructure for public data	
	Support an increased flexible energy consumption	
	Disseminate concept of smart house solutions	
	Local hydrogen production	
	Improve framework for use of onshore electricity on cruise liners	
	Identification of 4 sites in Copenhagen with room for 14 wind turbines	
	Planning process for a total of 7 wind turbines expected to be concluded in 2013	
	Negotiations with land owners on possible sites	
	Encourage the Government to lay down favourable settlement model for offshore wind turbines	
	Installation of offshore wind turbines on 2 predetermined sites	
	Examine possibilities for establishing tendering partnerships in relation to offshore wind turbine projects	
	Draft decision-making basis regarding the establishment of wood-fired combined heat and power plant	
	Negotiations on the conversion to biomass on Amager and Avedøre combined heat and power plants	
	Draft decision-making basis regarding the establishment of geothermal plant	
	Draft decision-making and time line for the establishment of renewable heat production units incl. heat pump, heat storage and solar heating	
	Analyse possibilities for converting peak load production	
	Draft decision-making basis regarding the establishment of new waste incineration plant	
	Assessment of REnescience plant and other treatment technologies for biogasification of organic waste	
	Examination of various methods of organic waste collection	
	Set up arrangement for collecting for hard plastic	
	Clarify methods for prevention, separation and reuse of plastic	

> ROADMAP

THEME	GOALS FOR 2025	MAIN INITIATIVES UP TO 2025
GREEN MOBILITY	• 75% OF JOURNEYS IN COPENHAGEN ARE DONE ON FOOT, BY BIKE OR BY PUBLIC TRANSPORT • 50% OF ALL JOURNEYS TO WORK OR EDUCATION IN COPENHAGEN ARE DONE BY BIKE • 20% MORE PASSENGERS USING PUBLIC TRANSPORT COMPARED TO 2009 • PUBLIC TRANSPORT IS CARBON NEUTRAL • 20-30% OF ALL LIGHT VEHICLES USE NEW FUELS • 30-40% OF ALL HEAVY VEHICLES USE NEW FUELS	City of Cyclists
		New fuels in transport sector (power, hydrogen, biofuels)
		Public transport
		Intelligent Traffic Systems
		Mobility planning
CITY ADMINISTRATION INITIATIVES	• REDUCE ENERGY CONSUMPTION IN CITY ADMINISTRATION BUILDINGS BY 40% COMPARED TO 2010 • MUNICIPAL NEW BUILD UP TO 2015 TO MEET REQUIREMENTS OF 2015 CLASSIFICATION AND NEW BUILD UP TO 2020 TO MEET REQUIREMENTS OF 2020 CLASSIFICATION • ALL CITY ADMINISTRATION VEHICLES RUN ON ELECTRICITY, HYDROGEN OR BIOFUELS • ENERGY CONSUMPTION FOR STREET LIGHTING IN COPENHAGEN IS HALVED COMPARED TO 2010 • A TOTAL OF 60,000 SQM OF SOLAR CELL PANELS ON EXISTING MUNICIPAL BUILDINGS AND NEW BUILD HAVE BEEN INSTALLED	Systematic consumption mapping and energy management
		Energy efficient buildings
		Solar cells installed on City of Copenhagen properties
		Switching of car fleet to new fuels
		Procurement
		Behaviour and training
		Energy-efficient street lighting

	INITIATIVES UP TO AND INCL. 2016	2013-2016
	Develop cycle connections to and from Copenhagen	
	Develop partnerships and green growth for cycling	
	Establish partnerships with 300 - 600 companies about using electric cycles	
	Develop concept of improved conditions for cycling with the aim of promoting cycling in 600 - 1,000 private companies	
	Develop and start demonstration projects using new fuels for light and heavy transport	
	Establish infrastructure for vehicles using new fuels	
	Initiate collaboration and joint ventures with relevant players	
	Work to ensure that the Government secures a long-term charging structure favouring cars using new fuels	
	Develop and start demonstration projects using new fuels for busses	
	Improve public infrastructure by implementing CityNet 2018	
	Energy efficient operation of Metro and S-train	
	Establish a plan for monitoring traffic management leading to improved traffic flow	
	Establish a system for joint traffic management leading to improved traffic information	
	Optimisation of signalling installations to facilitate better traffic flow and improved passability for buses	
	Increase of ecodriving by offering courses	
	Establish mobility programme to alter transport conduct	
	Long-term 'attitude training'	
	Establish remote meter reading and systems to register energy consumption	
	Establish organisation to assess development of consumption	
	Secure energy management and energy efficient operations as a permanent and integrated part of operations	
	Continue the Municipal Energy Savings Fund	
	Implement all energy saving initiatives with a short payback time	
	Climate retrofitting of all City of Copenhagen properties	
	New buildings to be constructed with climate adaptations and low energy use	
	Secure energy efficiency in private rented accommodation and other non-municipal properties by consumption regulations	
	Create lighthouse projects within climate retrofitting and climate-adapted new build	
	Establish solar cells on City of Copenhagen properties	
	Develop and implement a transition plan	
	Implement management system	
	Establish infrastructure for electric charging stations	
	Establish pilot and demonstartion projects for fuel technologies for heavy vehicles	
	Determine regulations for the use of new fuels for external driving	
	Implement procurement strategies with focus on transport, energy consuming products and the construction sector	
	Secure climate-friendly conduct by City employees in the areas of consumption, transport and purchasing by means of courses and info meetings	
	Replace street lighting	

ANNEX 2

City assessment categories – Copenhagen answers, 11 February 2014

1. **Definition of objective(s): How is the (main) objective/aim of the city plan defined?**

   a) Well defined components of the city plan (e.g. CO_2-reduction, energy demand reduction, increase of renewable energy production or energy efficiency), using a clear quantitative and qualitative set of categories?

   b) Qualitative objectives only, which allow for different interpretations of how they can be reached best; or rather no explicit objectives – i.e. "the path is the way".

Answer: A

The overall target of the Copenhagen Climate Plan 2025 (CPH 2025) is to turn Copenhagen into the world's first carbon neutral capital by 2025. The plan is structured around a set of categories, four in total: energy production, energy consumption, green mobility and City Administration initiatives. Each category comes with a series of specific initiatives (65 in total) and set, quantitative goals.

Cf. attachment CPH 2025, roadmaps, pp. 16-19.

2. **What is the underlying "philosophy" of the plan?**
   a) Holistic and integrative approach, considering the interrelations between different components of the transformation agenda (e.g. the energy chain with respect to production, distribution and consumption).
   b) Segregated, additive approach. (Accentuation of individual sectors without consideration for interdependencies.

Answer: A

The core logic of CPH 2025 is to achieve holistic planning (as reflected in the aforementioned four categories). This means that CPH 2025 describes how the ambitions for carbon neutrality should be used as leverage for better quality of life, innovation, job creation and investment in green technologies. Also, CPH 2025 describes how the goal of carbon neutrality can (only) be reached in close cooperation among public authorities, business, knowledge institutions and Copenhageners.

3. **Does the plan provide a specific timeline?**

   a) Cleary defined milestones for short-term, mid-term and long-term targets as well as for the implementation of measures.
   b) Flexible and open timeline.

Answer: A

The overarching goal for CPH 2025 is that by the year of 2025 Copenhagen must be carbon neutral. The process of implementing CPH 2025 is split into three periods: 2013-2016,

2017-2020 and 2021-2025. This means that in addition to the overarching milestone a series of specific sub-targets must be reached within set time-lines to pave the way for yet other targets and/or feed into the overall goal of CPH 2025.

4. Is the achievement of objectives monitored?

a) A system of monitoring is in place which observes the transformation process and provides regular progress reports – with possible adjustments
b) The process is designed to an open and flexible program. Specific objectives are negotiated on an ongoing basis.

Answer: A

CPH 2025 is being monitored on yearly basis. This includes a status on all initiatives qualitatively speaking to assess whether progress takes place. Two major evaluations of CPH 2025 will take place in 2016 and 2020 respectively. Moreover, the idea is to publish annual reports on the progress and to arrange a yearly conference. These two elements are yet to be fully implemented.

Quantitatively, the so-called Green Accounts evaluate among other things CO2-emissions of a range of activities in the city.

5. Is technical and social innovation (e.g. new energy producing technologies, changing consumer behavior) taken into consideration as an accelerator/catalyst for the city concept?

a) The plan outlines the significance and possible directions of innovation as well as the ability to influence it.
b) The plan does not reflect the potential impact of innovation. It does not attempt to stimulate and govern innovation.

Answer: A

CPH 2025 has identified innovative needs in the four categories, and set a series of both processes and projects in motion with stakeholders. However, consumer-involving processes have so far not been fully integrated in the approach and processes of CPH 2025.

6. Does the plan reflect the spatial differentiation in terms of city scales (eg. building-, quarter-, district- or area-scale)?

a) High level of differentiation with an integrative view on different city scales.
b) City considered as homogeneous space.

Answer: A

This question is a little unclear to us – but we think our answer is A if you ask us whether we work at all levels (both regional, city-wide, city-district and building level). However, we think our answer may be B, if you ask us whether our overall means of achieving our

goal targets the city as a whole (which it does: the absolutely major source of CO2-reductions is energy production and specifically combined heat and power plants (CHP)) or not.

7. Does the city plan concern other themes of politics/governance?

a) Integrated in other political concepts (multilevel governance)
b) "Stand alone" plan

Answer: A and B

CPH 2025 is a 'stand-alone' plan in the sense that the focus and governing principle for identifying and prioritizing initiatives are effects in terms of CO2, energy and climate.

However, there is no doubt that CPH 2015 at the same time leverages a number of other things, including growth (e.g. more retrofit projects = more business for the 'clean tech sector'), quality of life and better health (e.g. more people using their bikes = better health, less pollution) – to mention but a few.

8. What is the role of Stakeholders?

a) Systematical, continuous participation in developing and implementation of the city concept (e.g. theme and agenda setting, part of governance)
b) Selective, isolated participation, mainly priority for administrative acting

Answer: A

Stakeholders are involved in both agenda setting and to secure finance.

Prior to the adoption of the first Climate Plan in 2009, the City of Copenhagen demanded a series of consultancy reports to establish, first, *if* it were possible to reach the political goal of a carbon-neutral capital by 2025, and, second, *how* to reach the goal.

During the preparations for the second Climate Plan (adopted in 2012), aimed at making a more detailed action plan for CPH 2025 with clear prioritizing of initiatives and required funding, 200+ stakeholders were invited to four major 'dialogue meetings'. The meetings took place during the winter 2011 and spring 2012, and stakeholders influenced the planning process and development of the roadmaps.

Throughout, and as a *condition sine qua non* of the entire plan, stakeholders are involved to ensure that required investments take place. The relative share of public, semi-public and private money respectively is 1:9:85. This means that the City Administration will invest 1,- DKK (e.g. a new street lighting system), various utility companies (partly owned by the City, and responsible for e.g. wind turbines, geothermal pilot project, metro) must provide 9 ,- DKK, and 'truly' private investments must account for 85,- DKK (through e.g. retrofitting, new buildings, vehicles).

9. Which other participative elements are included in the plan?

a) A wide offer of options for participation, priority of action planning and experimental approaches;
b) No explicit offer of options for participation

Answer: B

CPH 2025 lacks a clear concept and plan for how to involve citizens and consumers in achieving the goals. The city has an Agenda 21 Plan that supports the overall goal of CPH 2025. A process to integrate the two plans better is being considered.

10. Does the plan ensure a coordinated action within the administration?

a) Comprehensive tasks are explicitly named and considered in the organizational processes;
b) No coordinated action between different administrative areas.

Answer: A

The CPH 2025 steering group is set up with representatives across the City Administration, and the entire group of seven executives co-govern the overall decision-making process ('7-DIR').

11. How well is the plan integrated in and secured by medium-term budget plans?

a) The plan is secured, all measures are examined with regard to their financial dimensions and designed accordingly;
b) Open financing depending on recurring negotiations

Answer: Mostly B

With regard to the majority of the required funding (cf. 1:9:85), the City Administration can influence, inspire but not control especially the '85' out of the 1:9:85.

With regard to the '1', the CPH 2025 is during the annual budget processes subject to the usual recurring processes of negotiation. Budgets run for four years. Within each period of four years, measures are examined with regard to their financial dimension and designed accordingly.

12. Which energy themes are included in the city concept? Please, specify and list the energy themes.

Please, see answer to the first question – or CPH 2025, Roadmap, pp. 16-19.

ANNEX 3: Participants in the Copenhagen 'Intake Workshop', 31 Oct.-1. Nov. 2013

Themes / Contact persons in bold

Dialogue with Developers

Contact person	CMI, City of Copenhagen	**Annette Egetoft**
	CBG, City of Copenhagen	Kai Stefan Kanafani
	CBG, City of Copenhagen	Anni Møller
	CMI, City of Copenhagen	Tina Hjøllund
	CMI, City of Copenhagen	Thomas Chapelle
	Malmø Stad	Kerstin Torseke Hulthen
	Skanska	Elo Alsing
	HOFOR	Jørgen Boldt

Flexibility in Energy System

Contact person	CMI, City of Copenhagen	**Anders Brix Thomsen**
	HOFOR	Jannik Kappel
	DTU	Per Bromand Nørgaard
	DONG Energy, Distribution	Peder Cajar
	Spirae	Peter Keller-Larsen
	Balslev	Benny Andersen
	Dansk Energi	Christian Dahl Winther
	DTU	Sara Benn Amer
	Enel	Filippo Gasparin
	Accenture	Alex Cramwinkel

Vacuum waste system

Contact person	CAG, City of Copenhagen	**Mette Skovgaard**
	CAG, City of Copenhagen	Mette Jørgensen
	CMI, City of Copenhagen	Sara Winding
	Envac	Thomas Rovsing Nielsen
	Dansk Skraldesug	Frank Frederiksen
	Dansk Skraldesug	Jan Bruun
	MariMatic	Palle Stevn

Plastic out of waste

Contact person	CAG, City of Copenhagen	**Mette Skovgaard**
	CAG, City of Copenhagen	Marianne Bigum

	ØKF, City of Copenhagen	Jesper Svensson
	CMI, City of Copenhagen	Hans Christian Christiansen
	CMI, City of Copenhagen	Hanne Coco Arildsen
	Vestforbrænding	Yvonne Amsgaard

Smart Energy – Buildings

Contact person	KEjd, City of Copenhagen	**Jesper Samson**
	ØKF, City of Copenhagen	Søren Nørgaard-Madsen
	CRS, City of Copenhagen	Rolf Foxby
	KEjd, City of Copenhagen	Sten Erik Drønen
	CBG, City of Copenhagen	Winn Nielsen
	CBG, City of Copenhagen	Niels-Aage Kirketerp
	HOFOR	Sannah Grüner
	DTU	Peder Bacher
	DTU Byg	Fred Heller
	NineConsult	Søren Peter Nielsen
	Siemens	Kurt Othendal Nielsen
	IBM	Bente Tørring Koefoed

EVs

Contact persons	CMI, City of Copenhagen	**Lone Pedersen**
	CMI, City of Copenhagen	Greta Nedergaard
	CTR, City of Copenhagen	Annette Kayser
	CPK, City of Copenhagen	Stine Helms
	Copenhagen Electric, Region H	Kåre Albrechtsen
	Danske Delebiler	Knud Henrik Strømming
	Hertz Delebiler	Helle Friborg
	DTU	Sara Benn Amer
	DTU	Per Sieverts Nielsen
	Let's Go	Bjarke Fonnesbech

Other participants

Facilitator	Accenture	Trygve Skjøtskift
Facilitator	Accenture	Kristoffer Hvidsteen
Head of unit	CMI, City of Copenhagen	Charlotte Korsgaard
Head of unit	CMI, City of Copenhagen	Ole Vissing
Senior adviser	CMI, City of Copenhagen	**Else Kloppenborg (workshop responsible)**
Business development manager	Copenhagen Cleantech Cluster	Peter Bjørn Larsen

ANNEX 4

City of Copenhagen: KEjd's own building innovation programme
With regard to existing buildings there are several programmes and strategic adoptions that KEjd (the City of Copenhagen's building portfolio manager) employs to lift the profile of the City's buildings. These can be broken down to building renovation, space utility innovation, building energy efficiency and climate change improvement.

Through building energy efficiency and climate change improvement there are several programmes that form the basis for KEjd's direct investment in this regard: '*Helhedsrenovering*' (holistic renovation), space utility innovation, ESCO – Energy Service Company, and '*energirenovering*' (energy renovation).

***Helhedsrenovering*,** is a part of KEjd's portfolio management activity wherein buildings are identified for holistic renovation. Buildings are shortlisted through several means including aesthetic appeal, poor inner climate, political focus, community investment, poor performance and potential for efficiency or fiscal savings. Renovation work is holistic in scope and not secluded to the buildings' renovation identifier. It is thus a good vehicle for how KEjd lifts its energy performance and climate change profile.

Building renovation, though not part of the holistic renovation effort, does grab the opportunity within allowances to make energy and climate change enhancements. Buildings may be earmarked for renovation based on its undesirability to be leased, or as part of other initiatives such as bridging span between two buildings. These renovations often align with energy efficiency and climate change adaption, or through little extra funding can ensure that the renovation activity lifts the building's profile.

Space utility innovation is a new project wherein the property portfolio usage in its entirety is to be continually reviewed. The premise of this analysis is based on observation of poor fit through overcrowding, inefficient floor space allocation, or spatially distributed workforce. Aside from this leading to inefficient work environment, it is a poor usage of an expensive asset: building space. The focus of this programme is to improve and innovate on usage through identifying sharable office space usage (i.e. mixed departmental offices), relocation to best fit buildings (we have several museums being merged into one larger and more attractive location), identifying potential after hour usage options (school halls being made available to public usage in a structured manner), etc.

***Energirenovering*,** with its funding pool of 130 million DKK prioritises the worst offend targeted (typically schools and swimming pools) buildings. The nominated buildings are determined through statistical analysis of their performance and potential for efficiency, or fiscal savings benefits are identified. But buildings identification can also be driven by political visibility. The identified buildings are ranked and the annual priority is based on a balance benefits realisation. To date targeted buildings have been by type (of building), schools and swimming pools. This is now changing to being area focused and, it is hoped that this will align with other area targeted works and hopefully achieve some benefits this

synergy. Following this round of investment and an analysis will determine if there are benefits to be gained through one model or the other.

A special initiative has also been set to target swimming pools with a funding pool of 10 million DKK. Swimming pools have a large public profile and are typically high energy offenders. In this initiative 8 pools have been identified with roughly half as of mid-2014 already renovated. Work has included new or improved ventilation, renovation of main pool plants, installation of roofs and insulation in windows, walls and roof in addition to pool coverings, heat recovery, controlled recirculation and solar panels in the roofs. Fiscal savings answers to between 3 pct -72 pct and CO2 reductions of 323,000 kg / year.

Energy Service Company project (**ESCO**) provides a broad range of energy solutions including designs and implementation of energy saving, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and supply, and risk management. Following a recent tender process KEjd has entered a 5 year ESCO partnership with Schneider Electric Danmark. Schneider Electric will implement energy conservation measures with clear ROI in a number of properties as a single project with a guarantee for years (5-10 years) on agreed energy savings. Extra saving and some building management will be for Schneider Electric benefits.

There are 35 ESCO project properties in KEjd that otherwise were not covered by '*helhedsrenovering*' (holistic renovation) or '*energirenovering*' (energy renovation) and are considered to have great energy savings potential.

Smart Buildings
Beyond just innovations in building energy efficiency, KEjd set a target for an integrated information system that once complete will integrate near-real time data feed on building observation (such as energy usage and alarms) through to building part audit and maintenance plans, as well as access to contracts and events schedules.

KEjd is in the current process of preparing a tender for an integrated Facility Management system that will target primarily lease management, space management, utility usage, call centre response to repair, and planed building maintenance with tight integration to economy systems.

There are many benefits through this programme that along with enhancing KEjd's ability to manage its portfolio of buildings will also form the platform via which the community at large can be kept informed. Through an information portal giving direct access to full information on a building, and web services the idea is to enable community innovation and smart city access.

KEjd is also actively engaged in promoting public utility companies in installing smart utility meters that along with remote usage reading on minute basis also allows for remote access to these meters. The ambition is to ensure a higher degree of building maintenance.

ANNEX 5

WP3, the 'DSE tool', buildings and data from KEJD – a pilot exercise in TRANSFORM
The challenges that will be described in this section are largely, but not exclusively based on experiences to co-develop an online tool, the co-called 'decision support environment' (DSE), under WP3 in TRANSFORM. This work was based on efforts to collect data on 20 buildings administrered by the City of Copenhagen's building portfolio manager (KEjd) – and turn them into input for the tool that would in turn allow for tests regarding three retrofit measures for buildings : Optimisation of district heating substation ; replacement of circular pumps ; installation of solar cells. While 20 is a relatively small number of buildings, the assumption is that lessons learned may prove useful for a better understanding of more general problems.

The WP3 'decision-support-environment' tool for energy retrofitting
WP3 sought on a co-development basis among Accenture, AIT and each of the six the cities in TRANSFORM to design an online tool for decision-making – a key element in the 'decision support environment' – and prioritising among alternative solutions to a given CO2 or energy challenge.

The idea was that the tool suggest a number of scenarios or options on the basis of data and input from the cities. For instance, if a city wanted to know which neighborhoods to target, or how to prioritise among measures in retrofit programmes, the tool should, ideally, be able to suggest answers (e.g. which neighbourhoods, costs of measures, which measures in which neighbourhoods, impact in terms of energy savings or CO2-reductions).

As indicated, the WP3 tool should ideally be developed for the entire city to allow for indications of big-scale, optimum directions. This, however, would require data for the entire city on energy consumption at building level (or aggregating buildings at the level of e.g. no more than 5 to 20 buildings, depending on chosen security levels for data privacy).

With no ability to get access to this amount of data (from e.g. HOFOR (heat data) DONG Energy (electricity data)), the City proposed to work on 20 buildings owned by the City of Copenhagen and managed by city-owned 'Københavns Ejendomme' (KEjd), using primarily the City's own data.

The trouble is that while in a legal sense, utility data belong to the end-user, utility companies are trusted to handle them subject to data privacy. Data represent knowledge about the market and utilities consider them part of their business case. Data are aggregated but can be retrieved on non-aggregated levels too. The challenge of developing a model for more data-sharing with utility companies reaches far beyond the scope of TRANSFORM and the WP3 tool exercise. This is why, in the the tool exercise, focus shifted from city-scope to a pilot of 20 buildings.

Copenhagen experiences with data and buildings in WP3
The aim of the re-focused tool exercise was to find ways of working with data, which reflect potential energy reductions in specific buildings. The expected task was, first, to gain

experience in assessing what archives or data bases are best suited to reflect potential improvements of a building and, second, how to manage data handling including technical, administrative, legal and economic challenges.

Method
As the idea of the tool is to suggest scenarios or optimum solutions, based on input and data about context and alternative solutions, information about both general conditions (e.g. fuel prices, marginal emission factors to calculate carbon emission reduction potentials from energy savings) and various solutions to reach set goals (e.g. measures) must be fed into the tool.

In the Copenhagen case, three retrofit measures for buildings were defined as potential solutions: Optimisation of district heating substation ; replacement of circular pumps ; installation of solar cells. For a full description of conditions for selection of buildings, the method for estimating saving potential, electricity production and cost as well as general assumptions and description of the chosen measures, cf. Annex 6.

The exercise then consisted in providing various data for the 20 buildings (e.g. heat, electricity, building-ID and address) to allow for upload in the tool, prior to tests of the tool's ability to propose and prioritise cleverly among retrofit measures.

Among the available data, we decided to use the following three archives and data bases:

1. BBR ('*Bygnings- og Boligregistret*' (Building and Housing Register) by the Ministry of Housing, Urban and Rural Affairs), the nation-wide obligatory register of building data. Datasets are public and free if single buildings are accessed individually, whereas larger data sets must be purchased. We used BBR to get the building's basic data in order to ensure a clear identification of each building. Generally, however, it is well-known that BBR is not up-to-date, and although an obligation exist to upload data (e.g. heat data), it does not happen and no sanctions appear in place.
2. KEjd's own database with heating energy consumption. Consumption data of the 20 cases from the last 5 years were delivered in structured form and could be used without limits. This data included identifiers that enabled linking to BBR data.
3. KEjd's own database with energy label reports. Based on expert exmination, this data includes proposals for improvements. Some of these proposals are directly used as potential improvements. Energy Labels are mandatory for municipal buildings, and in case of real estate sales. This data included identifiers enabling linking to BBR data. Energy labels are also publically accessible via BBR. We decided using KEjd's energy labels, however, because their data were already re-organised in structured form. The potential of the new digital energy label database (by the Danish Energy Agency) has not been investigated.

Energy label reports are a high quality source for a building's energy retrofitting demand. However, not all buildings have up-to-date energy labels. Here, heating energy consumption can give a hint regarding the building's energy-related condition when compared to other, similar buildings. Since all 20 cases have current energy labels, a comparison of this kind has not been tested in the tool experiment.

Results, experiences, transferability
While manageable, the exercise on 20 buildings proved far from easy, and far too time-consuming, considering the low number of buildings dealt with. Fundamental problems must be solved before scaled up work on data is possible whether the idea be to work on the basis of the City's own data sets or other data sources.

Among the used data in the tool exercise, energy labelling was most reliable and showed best, how buildings can be energy retrofitted. During the tool exercise, data was manually linked to the individual building cases from one database to another (time consuming; not possible at city-scale). However, it is possible to purchase dynamic BBR-data including energy labels.

Buildings without up-to-date labels cannot be assessed for specific means of energy retrofitting using available data – i.e. energy consumption, function and date of completion – only. The energy saving potential can only be estimated statistically by comparing energy consumption with similar buildings, i.e. using existing research studies (not taken into account in the tool exercise).

ANNEX 6

WP3, the 'DSE' tool: Conditions for selection of building – in more technical detail
Buildings for the TRANSFORM project were selected from a list of city-owned buildings administrated by Københavns Ejendomme (KEjd) (file name 'agenda2100 forbrug 140220.xlsx') fulfilling the following conditions:

- One electricity and one heat consumption meter per building-ID
- Electricity and heat consumption data available throughout the years 2009-2013
- Identical meter-ID throughout the years 2009-2013
- Building addresses are included in both databases: 'Engelsk_Soldata_Kbh_bygninger.xls' and 'agenda2100 forbrug 140220.xlsx'

Method for estimating saving potential, electricity production and cost

Measure 1: 'Optimisation of district heating substation'
Every building has a heating substation that transfers the heat from the main network to the heating system of a building. The measure is a set of improvements in the heating system that are bundled together, e.g. replacement of heat exchanger and adjustment of settings. The heat saving potential and the cost of the measure called 'Optimisation of district heating substation' was found by sorting the sheet 'Renset hovedark EBF' in 'Energimærker_Energibesparende forslag_stamdataSAR.XLS' based on column T ' Energibesparende tiltag' set to 'Styring og indregulering, VVS' and eliminating rows containing electricity savings or lacking information about floor area size. The average heat saving per m^2 and the average cost per m^2 (calculated from column AH 'Just invest ekskl. moms') were taken as the heat saving potential and the cost respectively.
The heat saving potential is estimated to 4% of the total heat consumption. This measure cannot be applied to buildings with energy label B or better. These buildings are assumed to have a rather optimised system. The investment cost is estimated to 1.5 €/m^2.

Measure 2: 'Replacement of circulator pumps'
New circulator pumps are more efficient and consume less electricity. The electricity saving potential and cost of the measure called 'Replacement of circulator pumps' was found by sorting the sheet 'Renset hovedark EBF' in 'Energimærker_Energibesparende forslag_stamdataSAR.XLS' based on column T 'Energibesparende tiltag' set to 'Udskiftning af pumper' and eliminating rows containing heat savings or lacking information about floor area size. The average electricity saving per m^2 and the average cost per m^2 (calculated from column AH 'Just invest ekskl. moms') were taken as the electricity saving potential and the cost respectively.
The electricity saving potential is estimated to 1.1 kWh/m2 of the total electricity consumption. This measure cannot be applied to buildings with energy label A or better. These buildings are assumed to have circulator pumps of higher standard. The investment cost is estimated to 2.1 €/kWh.

Measure 3: 'Installation of solar cells'
The potential for electricity produced from roof-mounted solar cells was calculated from data in 'Engelsk_Soldata_Kbh_bygninger.xls', where the roof area for three categories of annual average solar irradiation (1000 kWh/m^2, 900 kWh/m^2 and 800 kWh/m^2) was specified. Roofs on top of listed buildings were assumed to have no potential for solar cells. The annual electricity potential for each building was found after multiplying the roof area in each categories with its irradiation and with the conversion efficiency (set to 15%) and accounting for losses in inverters and cables (set to 15%, thus multiplying with 0.85).
Cost data for a solar cell system with installation provided by Accenture for Amsterdam was multiplied with 1.25 to reflect the higher price level in Denmark (27% higher in April 2014 according to OECD statistics).

General assumptions
Carbon emission reduction potentials can be calculated by multiplying the energy saving potentials with marginal emission factors for Copenhagen[67] at 0.879 kg/kWh for electricity and 0.09 kg/kWh for heat.

Prices for Copenhagen are specified without VAT of 25% since all buildings belong to the municipality.

Fuel prices used in calculations are 0.24 €/kWh for electricity (average unweighted price for public companies) and 0.08 €/kWh for heat (marginal price for public companies).
Share of renewable energy per energy carrier used in calculations are 43.1% for electricity and 46% for heat.

[67] Ea Energianalyse, 2012, El- og fjernvarmeforsyningens fremtidige CO2-emission, accessed 15/05/2014, http://www.ea-energianalyse.dk/reports/1176_el_fjernvarmeforsyningens_fremtidige_CO2-emission.pdf

ANNEX 7

Energy consumption and data in a city (Copenhagen)
DTU, November 2014

Energy has not until recently been seen as a common theme in a city. With the focus on reducing CO2 emissions and hence identifying fossil fuel use, it has become a common theme. However, a city uses energy for so many purposes. Historically the City may have received one single heating bill and one single electricity bill for their own heat and electricity use. But, these aggregate bills may cover many buildings and/or many purposes.

In the table (cf. next page) an attempt has been made to sum up the many different ways in which energy is used in Copenhagen. The hope is also to provide an idea of how it is measured and/or monitored, and who owns the data. For instance if the City does not know how much electricity is used for traffic lights it is difficult to measure and monitor any progress made in this context. In the Copenhagen case the City gets a bundled electricity bill from DONG Energy 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. Just to get the specific value on that particular use is difficult – even on a monthly basis. Imagine how difficult it is to get hourly data about the use of electricity for traffic lights in Copenhagen. It is just an example, but it 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 be able to measure, monitor, and analyse the data.

The City controls a minor part of energy in the city. It controls public buildings and some infrastructure but otherwise it is owned by other parties including the citizens of the city. Therefore the City also only have some 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 have ownership of the corresponding 5% of the data, that is, its own energy use data. In that case, the City has no ownership of or access to the remaining 95% data. The City of Copenhagen does not directly own energy infrastructure, but then again, it does through the self operating companies, which the City owns.

The list in the table can be more specific in the deail, but it highlights how diverse the energy issue is for a city, and how spread out the responsibility is across administrations. However, the table also highlights that it is not difficult to make significant progress on this, although the data collection has to be centralised in some form to make it operational for the City. This applies in particular if the goal is a common energy data platform for the City.

Heat and electricity are 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. But transport data it is own beast as long as electrification of the transport sector has not happened. Therefore there is a bit of a challenge in which type of data we are looking for.

We want to know more about energy consumption, but it is only through understanding the behavior behind the energy consumption that we get a chance to understand the data.

Energy consumption and data in Copenhagen

Name of data set or tool	Purpose and development year	What information does it provide	Who does it and ownership	Which type of data is available for CC.
Energy consumption in CC owned Buildings (including CC own administration buildings)	Determine heating, cooling and electricity use. Data his collected in a spreadsheet on monthly basis to be able to pay the energy bills.	Use of heating, cooling and electricity on a monthly basis.	The data is collected by Copenhagen Properties (Københavns Ejendomme, Keyd) - a company owned by CC.	Data collected on a monthly basis from HOFOR (heat) and DONG (electricity). Electricity and heat metering are not consistent or comparable on property level. Some properties may have a number of sub-meters.
Installation of solar PV and/or solar thermal of individuals or businesses	Determine consumption and production of heat and electricity from solar. No database.	How many own solar PV and its production capacity? As the energy is not traded it is not possible to know how much is produced.	Solar PV (or solar thermal) systems are owned by the building owner. Any production data owned by building owner.	Everyone who installs a solar PV or a solar thermal system will have to apply for a building permit with CC. Data on how many systems have been installed and its total capacity is therefore available in the building permit system, but not collected in a central database.
Installation of geothermal heating systems of individuals or businesses (including air to air heat pumps)	Determine consumption and production of heat. No database.	How many own geothermal systems on a private basis its production capacity? As the energy is not traded it is not possible to know how much is produced.	Geothermal systems are owned by the building owner. Any production data owned by building owner.	Everyone who installs a geothermal system will have to apply for a building permit with CC. Data on how many systems have been installed and its total capacity is therefore available in the building permit system, but not collected in a central database.
Solar PV, solar thermal potential on roofs in CC.	Determine the potential for solar PV and Solar thermal on roof in CC.	It provides data for CC on possible investments into solar PV and solar thermal. However, due to the use of district heating in Copenhagen installation of thermal systems will not be feasible.	Solar PV (or solar thermal) systems owned by the building owner. In case of CC buildings - owned by Keyd.	On a city scale (at a title level) the data is open for the public in GIS format.
Geothermal potential in CC (including air to air heat pumps).	Determine the potential for heat production using geothermal sources.	It provides data for CC on possible investments on individual geothermal systems. However, due to the use of district heating in Copenhagen such installations will not be feasible.	Geothermal systems owned by the building owner. In case of CC buildings - owned by Keyd.	On a city scale (at a title level) the data could be developed and be open for the public in GIS format – as for solar systems.
Electricity use in buildings	Determine electricity use in buildings, residential as well as commercial	Determine electricity use in buildings, residential as well as commercial	The specific data is in principle owned by the private owner, but in practice by the utility. In the CC case that means DONG.	The standard customer gets a monthly or quarterly bill, unless he/she ask for a more detailed bill. Only when smart meters are introduced in CC will it be possible to have real time data.
Heat use in buildings	Determine heat use in buildings, residential as well as commercial	Determine heat use in buildings, residential as well as commercial	The specific data is in principle owned by the private owner, but in practice by the utility. In the CC case	The standard customer gets a monthly or quarterly bill, unless he/she ask for a more detailed bill. Only when smart meters

			that means HOFOR.	are introduced in CC will it be possible to have real time data.
Use of Metro trains	Determine how many use the Metro. The Metro was established in 1998.	Data on how many use the metro. Data on public use of metro is provided by the "Transport og Vejdirektoratet" once a year.	The specific data on public use is owned by Metroselskabet, co-owned by CC and the Danish state. "Transport og Vejdirektoratet" makes annual surveys.	"Transport og Vejdirektoratet" makes annual surveys. Dont know in which format the data is delivered.
Use of S-trains	Determine how many use the S-trains.50+ years	How many use the S-trains? Data on public use of S-trains is provided by the "Transport og Vejdirektoratet" once a year. Use of electricity?	The specific data on public use is owned by DSB, fully owned by the Danish state. "Transport og Vejdirektoratet" makes annual surveys. DSB does not provide data on use of electricity and diesel.	"Transport og Vejdirektoratet" makes annual surveys. Dont know in which format the data is delivered.
Use of Regional trains through CC	Determine how many use the regional-trains, which passes through CC. 50+ years.	How many use the trains? Data on public use of regional trains is provided by the "Transport og Vejdirektoratet" once a year. Use of electricity and diesel?	Trains owned by DSB. Does DSB provides data for CC? Does DSB provide data on use of diesel and electricity? However, "Transport og Vejdirektoratet" makes annual surveys	"Transport og Vejdirektoratet" makes annual surveys. Dont know in which format the data is delivered.
Use of city Buses	Determine how many use the buses, which passes through CC. 50+ years.	How many use the buses? Data on public use of the buses is provided by the "Transport og Vejdirektoratet" once a year. Use of electricity and diesel?	The specific data on public use of buses owned by Movia, owned by the Greater Copenhagen municipalities. "Transport og Vejdirektoratet" makes annual surveys. Movia does not provide data on use of diesel and electricity.	"Transport og Vejdirektoratet" makes annual surveys. Dont know in which format the data is delivered.
Use of bikes, use of cycle ways	Determine how any use bikes to and from work and using bikes for getting around in Copenhagen	Determines how many use the bike to and from work in CC.	People own their own bikes. CC owned the data they collect when using coils and/or using permanent monitoring.	The coil is used on specific roads to calculate traffic but able to determine which type of vehicle passes. Some cycleways have permanent monitoring – and the data showed on displays. The data is collected in a database.
Use of private cars	Determine how much fuel is used by private cars in CC.	Determines how many use the car to and from work in CC. It is also not possible to know how many passengers there are in each car and what the purpose of the trip is.	People own their own cars. CC owned the data they collect when using coils. May be included in the annual surveys. From Transport og Vejdirektoratet".	The coil is used on specific roads to calculate traffic but able to determine which type of vehicle passes. "Transport og Vejdirektoratet" makes annual surveys. Dont know in which format the data is delivered. No-one is probably is monitoring the total sale of petrol and diesel.
Goods transport	Determine how much fuel is used in CC for transporting goods.	How many trucks drives in Copenhagen?	Trucks are owned by private companies. May be included in the annual surveys. From Transport og Vejdirektoratet".	There are probably no specific counts on trucks. No-one is probably is monitoring the total sale of petrol and diesel.

Traffic lights	Determine electricity use	Use of electricity	CC owns the traffic lights	DONG as the electricity provider collects the data and is bundled in the monthly electricity bill to CC. DONG is a private utility company. To know the specific use the electricity bill has to be unbundled.
Fuel consumption CC owned fleet	Determine energy use	Use of petrol, diesel, electricity and hydrogen	CC owns the fleet (110 vehicles)	Internal CC Datasheet
Street lights	Determine electricity use	Use of electricity	CC owns the street lights	DONG as the electricity provider collects the data and is bundled in the monthly electricity bill to CC. To know the specific use the electricity bill has to be unbundled.
Parking of electric vehicles (EVs)	Determine electricity use and use of EVs	Use of electricity	CC owns the facilities	DONG as the electricity provider collects the data and is bundled in the monthly electricity bill to CC. To know the specific use the electricity bill has to be unbundled.
Parking of electric bikes (ECs)	Determine electricity use and use of ECs	Use of electricity	CC owns the bikes	DONG as the electricity provider collects the data and is bundled in the monthly electricity bill to CC. To know the specific use the electricity bill has to be unbundled.
District heat producing facilities	Determine heat production in CC	Heat consumption/ production	Some owned by HOFOR, fully owned by CC, some owned by private companies	HOFOR collects the data? The heat consumption data is provided to the CC as a monthly bill, unless CC has asked for a more specific bill.
District heating network	Determine how many are connected to the network	Heat transmission and heat consumption	Owned by HOFOR	HOFOR collects the data
District cooling network and facilities	Determine energy use and number of users	Cooling production and consumption	Owned by HOFOR	HOFOR collects the data
Electricity producing facilities	Determine electricity production in CC	Electricity production	Owned by private companies mainly DONG and HOFOR	DONG and HOFOR collects the data
Electricity grid	Determine how many are connected	Electricity production and consumption	Owned by DONG?	
Waste collection and combustion	Determine volume of waste collected, energy use for collection of waste and heat and electricity production	Volume of waste collected, energy use for collecting the waste, heat and electricity production at CHP	Waste collection is carried out by “Amagerforbrænding”, partly owned by CC where the waste is burned. Not sure who owns the waste collection system (including vehicles)	Data on total waste collected by “Amagerforbrænding”. Not sure how the data is provided to CC.
Urban biomass collection and combustion	Determine volume of biomass collected, energy use for collection of biomass and heat and electricity production	Volume of biomass collected, energy use for collecting the biomass, heat and electricity production at CHP	Biomass collection is carried out by “Amagerforbrænding” which also burns the biomass.	Data are collected by “Amagerforbrænding” . Not sure how the data is provided to CC.

Piped water for drinking	Electricity use for pumping the drinking water	Electricity use for pumping the drinking water	HOFOR is responsible for the this and owns the network. Data on water use is owned by HOFOR. HOFOR owns the data on electricity consumption.	
Removal of waste water	Electricity use for pumping the waste water	Electricity use for pumping the waste water	HOFOR is responsible for the this and owns the network? Data on waste water production is owned by HOFOR. HOFOR owns the data on electricity consumption.	The waste water is treated at Lynetten where the biomass is used to produce biogas. The cleaned water is discharge to Øresund.

Business case: Smart Energy Buildings

The below proposal for a design for the development of a business case for Smart Energy Buildings was co-developed with participants during a workshop with stakeholders, the so-called ILS, in Copenhagen, April 2014.

Note: The terminology of the *Flexible* Energy Building was adopted later than the ILS. In the Annex 8, the original terminology of the *Smart* Energy Building was kept unchanged.

Purpose of analysis
The purpose of the business case analysis is to develop a commercially viable business case that ensures Smart Energy Buildings solutions in Nordhavn. The analysis must target investors/developers and be suitable for use in the City of Copenhagen's work with 'Dialogue with Developers'.

Scope
The analysis must be based on a small group of buildings, so that potential benefits from the exchange of energy flows, or shared energy production facilities are taken into account.

Steps in the analysis

Step 1: Definition af Smart Energy Buildings solutions
First, it is necessary to define Smart Energy Buildings (SEB): How to define SEB? And thus how to characterise a SEB-solution?

Step 2: Analysis of stakeholders and flows of vested interests/money
Second, it is necessary to clarify the stakeholders around SEB, and in particular the flows of vested interests/money that the solutions may be assumed to generate. The analysis of flows of vested interests/money must cover all three levels from end users, to businesses and the socio-economic level.

Step 3: Appoint an Advisory Board and agree on shared vision
Based on the results of the analysis of stakeholders and flows of vested interests/money an Advisory Board must be established with key actors. As a key assignment the Advisory Board should agree on a shared vision to frame the business case analysis. The Advisory Board should only to a lesser degree be composed of technology/service providers, and yet more of potential investors.

Step 4: Development of definitions for potentials and baselines
It is challenging to handle such things as the effect of energy-saving initiatives, degrees of flexible energy consumption, or improved indoor climate of not yet built buildings. Hence the need to develop a shared set of definitions for how both quantitative and qualitative potentials can be established and capitalised on.

Step 5: Technological long-list
Based on a shared understanding of the vision, and on how to calculate benefits, a technological long-list should be developed. It should comprise a series of isolated or integrated solutions. At this stage, only rough estimates of investment-needs and their potentials are required.

Step 6: The Advisory Board establishes shortlist
The Advisory Board reduces the technological long-list, jointly with the group that suggested the long-list, to arrive at a smaller number of isolated or integrated solutions based on criteria that support the shared vision. It is well advised to address challenges such as inter operability at this stage.

Step 7: The business case analysis
A thorough analysis of the business case for the solutions on the shortlist is carried out. The business case must target investors/developers, and be based on existing legislation and practice.

Step 8: Sensitivity analyses
A series of external factors can be expected to influence the business case. Including for instance the introduction of variable tariffs. A sensitivity analysis is carried out, regarding a series of key factors that over time may impact the business case negatively or positively. The results may amongst other be used in dialogue with the legislative powers to improve political framework conditions.

Step 9: Increased incentives in new business models (option)
If the analysis of the business case suggests sufficient benefits to justify investments, but challenges in terms of incentives, it might be useful to carry out an additional step, and develop business models for reduced barriers to incentives.