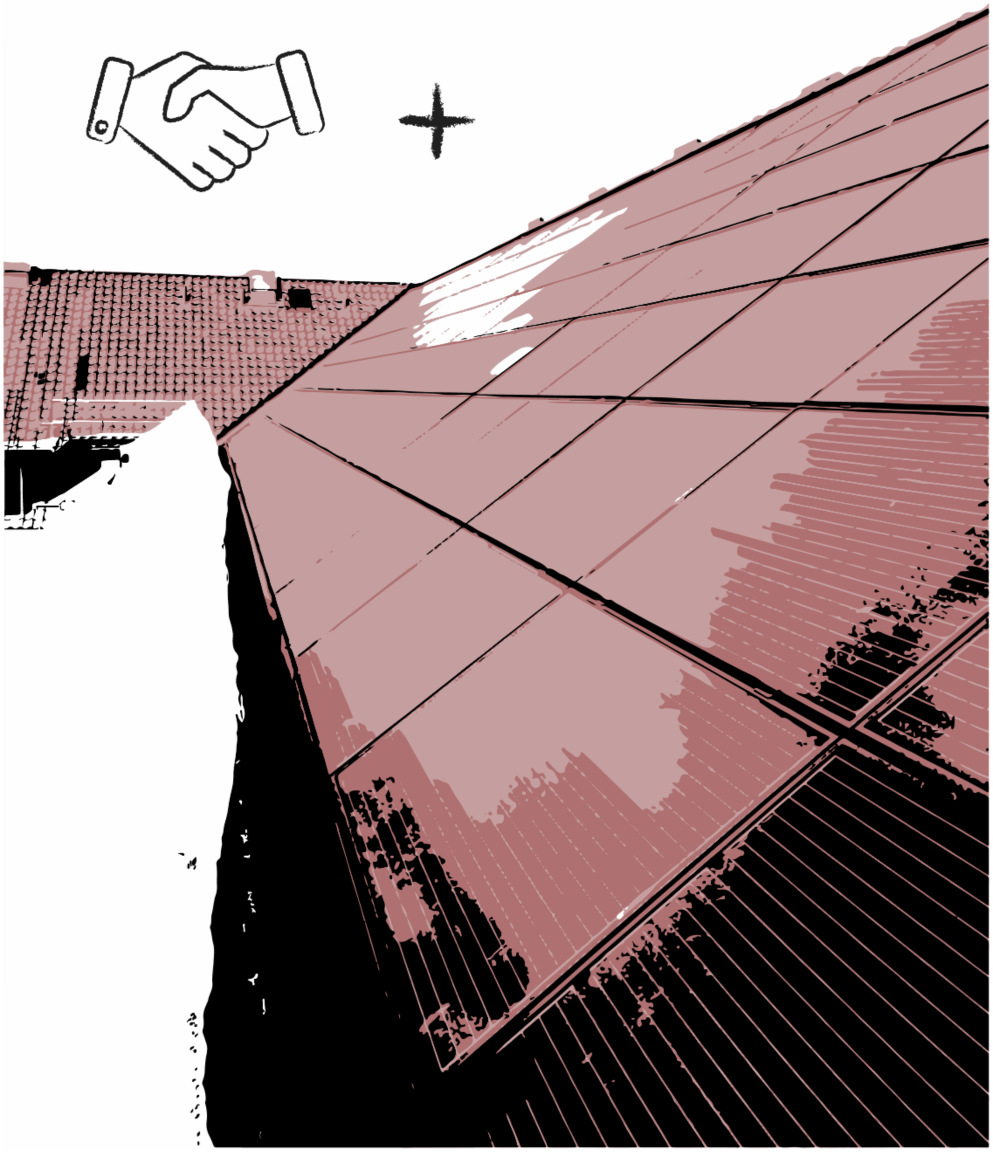
AALBORG UNIVERSITY
DENMARK

Inplementation of solar photovoltaics through collaborative governance in Copenhagen municipality



MASTER THESIS | Sustainable Cities

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Danish resume

På baggrund af adskillige skelsættende begivenheder (Paris aftalen, IPCC-rapporten, Europaparlamentsvalg samt Danmarks folketingsvalg) med fokus på klimaet og bæredygtig omstilling, er opmærksomheden på især energiplanlægning i de danske kommunerne blevet intensiveret. I Københavns Kommune (KK) blev det i 2012 vedtaget af Borgerrepræsentationen, at KK skulle være verdens første hovedstad til at blive CO_2 neutral i 2025. Dette har sat pres på bæredygtige tiltag i energiproduktionssektoren, hvortil KK med omfattende initiativer blandt andet ønsker at forøge den eksisterende solcellekapacitet, ikke kun på marker, men også på hustage inde i byen. ’Solar Distrikt NV’ er ét af disse tiltag, som forsøger at udbrede bygningsintegreret solcelleløsninger i det private boligsegment i Københavns Nordvestkvarter. Projektet består af et samarbejde på tværs af offentlige og private aktører, som udgør KK, beboerne i Nordvest samt diverse solcelleproducenter- og eksperter. Dette samarbejde ønsker at sætte fokus på solcelleløsninger på bygninger i København, som ikke går på kompromis med hverken de arkitektoniske eller bevaringsværdige værdier, og som overholder de lovgivningsmæssige rammevilkår for solceller. Dog har det vist sig, at dybdegående rammevilkår for solceller forringer muligheden for at opnå målet som KK har sat, samtidig med at interne barrierer, konflikter og endda styringsparadokser i samarbejdet understreger kompleksiteten ved solcelleplanlægning i Kommunens private boligsegment.

I dette speciale undersøges projektet og casen ’Solar Distrikt NV’ i KK, som omhandler kommunal solcelleplanlægning i det private boligsegment. Dertil følger en analyse af solcellers rammevilkår i Danmark, udviklingen af lovgivningen og reguleringen af solceller i Danmark de seneste to årtier samt en analyse af vigtige aktører i samarbejdet ’Solar Distrikt NV’, hvortil drivers, barriere samt styringsparadokser kortlægges. Disse elementer benyttes til at beskrive komplekse dynamikker og interne konflikter som kan forhindre samarbejdet i at lykkes med målsætningen.

Analysen viser, at de nationale rammevilkår for solceller i Danmark siden 2012 er blevet ændret markant, således at de gamle, lukrative støtteordninger er blevet lukket, og den nyeste støtteordning, ’øjebliksafregning’ lige nu udgør den eneste reelle støtteordning med afgiftsfritagelse for øjeblikproduceret elektricitet. Dette har haft signifikante konsekvenser for udbygningen af solceller i hele Danmark, og lige nu indebærer lovgivningen for kommunale solcelleanlæg, at de også skal betale fuld afgift af den strøm der bliver produceret, medmindre solcelleanlægget er særskilt i et kommunalejet selskab. Dette presser kommunerne på det administrative

arbejde med solceller, og mange har derfor valgt ikke at fortsætte med at investere i kommunale solcelleanlæg.

På trods af disse rammevilkår er der stadigvæk kommuner, der aktivt arbejder med solceller i deres klimastrategi. Hertil er KK opsat på, at solceller skal indgå i det samlede energisystem, både kommunalt og privat. Derfor arbejder kommunen i kraft af 'Solar Distrikt NV' på at opmuntre og vejlede private husejere i Nordvest til at investere i solcelleløsninger på egne tage, som kan demonstrere smarte solcelleprojekter på forskellige hustage. Dette samarbejde inkluderer også private organisationer, som ønsker at bidrage med solcelleløsninger i Nordvest. Samarbejdet er præget af de forskellige aktører, som hver har egne- og fælles interesser, men også forskellige positioner i forhold til hinanden, hvilket KK udgør med dens todelte rolle som bygningsmyndighed og energiplanlægningsmyndighed. Denne rolle udløser to styringsparadokser, hvor den første fokuserer på KK's interne forskelligartet holdninger vedrørende solceller på hustage, men også en overholdelse af at opfylde bestemt facade- og arkitektoniske udstrålinger. Afslutningsvis beskriver det andet styringsparadoks KK's ressourcemæssige begrænsningsposition, som blandt andet skyldes et anlægsloft og udløbende projektbeskrivelser, som rammer de medvirkende aktører.

Konklusionen på specialets problemformulering bliver således, at de nationale rammevilkår for solceller påvirkes af en kontroversiel historik med statslige indblanding og nedlukning af økonomiske støtteordninger, som har bremset udviklingen af solcelleimplementeringen i danske kommuner. Derudover af det beskrevet samarbejde i Nordvest præget af forskellige aktørers drivers, barriere men også fundamentale paradokser, som i sidste ende kan have bekymrende konsekvenser for samarbejdets målsætninger. Ønsker KK at lykkes med dette samarbejde, kræver det ligeledes omsiggribende forandringer i KK's planmyndighedsrolle og prioriteringer, men også en udadrettet indsats for at påvirke eksterne omstændigheder som f.eks. lovgivningen ved solceller.

Preface

This master thesis, *Implementation of solar photovoltaics through collaborative governance in Copenhagen Municipality*, was written in the time period 4th of February 2019 to the 7th of June 2019. This master thesis concludes the 4th and final semester on the Masters programme "Sustainable Cities" at Aalborg University Copenhagen.

This master thesis deals with the complex situation of how Copenhagen Municipality through the 'Solar Distrikt NV' collaboration with public and private stakeholders can achieve their climate goal of having solar photovoltaic covering 1% of the total electricity production in 2025.

This thesis is a product of an internship period and a continued parallel ongoing collaboration with the Climate Secretariat in Copenhagen Municipality, working with solar photovoltaic (PV) and municipal energy planning.

All the knowledge from my personal work, meeting-experiences and interviews with key actors from that internship has been incorporated into this thesis.

In advance, with the pre-understanding knowledge from the internship established, direct- and indirect observations has been made alongside with attending new meetings and workshops, interviewing new key stakeholders in order to understand the complex collaboration found in the case of 'Solar Distrikt NV'.

Moreover, the analysis of the mentioned collaboration shows more profound barriers in terms of *paradoxes*, which makes the case even more difficult and complex to steer and navigate, but nevertheless more interesting as well.

Throughout this thesis, the reference method used is the Harvard style, where the reference in the text is illustrated as: (Lastname, year).

Through the development of this thesis, multiple people have contributed with support, knowledge and encouragement. A special thanks to Rachel MacIntyre in the department of City Development, Mariann Andersson from the Climate Secretariat, Michael Madsen from the Danish Energy Agency and Hans Jakob Martinsen from HOFOR.

Lastly, I am thankful for the supervision provided by my supervisor, Lars A. Engberg, and for his encouragement, teaching, coaching, guidance and reflections in this semester project.

Enjoy!

Joakim Haslund Ryborg

1.0 Problem analysis

In this very first chapter, the setting of climate changes, tendencies of transitioning towards renewable energy technologies, national energy goals and Copenhagen Municipality's effort of becoming the world's first carbon neutral capital will be introduced

1.1 International awareness of climate changes

The current status of the implication of climate changes are well described in numerous academic papers, particularly in the IPCC report from 2018. This report tells of the consequences of exceeding a temperature increase above 1.5 degree Celsius, causing irreversible self-reinforcing effects on climate catastrophes (Masson-Delmotte et al., 2018). Therefore, the transition into fossil-free energy has never been more important than it is now.

The European Union (EU) have in an ongoing process contributed towards sustainable guidance and awareness on this topic, thus encouraging nations to make urban planning more holistic and integrating issues regarding energy consumption and production. This has come to shown in both legally binding EU directives, e.g. *Renewable Energy Directive* and other non-legally binding documents, e.g. *Good practice in energy efficiency* (Cajot et al. 2015).

With the IPCC report's profound eye-opening results and conclusion, the responsibility lies with each of the world's nations to act upon this information.

1.2 Transitioning into renewable energy

Denmark being one of the many nation's acting upon these statements by IPCC, the Danish government claims to be one of the leading nations to support a transition into renewable energy solutions within the national energy system. This claim is anchored in the Danish energy agreement called "Energiaftale" from June 2018. One of the goals is to reach a share of 55% renewable energy in the energy system in 2030 alongside with other initiatives e.g. technology neutral tenders, exemption of certain taxes on electricity, smart and flexible energy system etc. (Energi-, Forsyning- og Klimaministeriet, 2018).

Yet, strong critiques of the government's climate effort from different key actors and organizations have taken place recently, stating that the Climate Plan is not ambitious and detailed enough (Politiken, 2018). A noticeable voice in this debate have been the former president of the Danish Council of Climate Change, Peter Birch

Sørensen, claiming that with the government's new Climate Plan, the rate of the green transitioning would drop significantly, thus concluding that it will be very difficult reaching the 2030 and 2050 climate goal (Holst, 2018).

As mentioned before, the Danish government is determined on their goal of having more than 50% renewables covering the total energy consumption in Denmark by 2030. In order to provide a status of the progression in the Danish energy system, the Danish Energy Agency (DEA) produces a yearly technical assessment of how the Danish energy consumption and energy production evolves. The name of the assessment is "Energy and Climate Outlook 2018" (Danish Energy Agency, 2018), and it describes the progression based on a frozen-policy scenario, which entails that any new policies are introduced. Currently, the gross energy consumption based on this assessment from the DEA in Denmark is estimated to be approximately 740 PJ as seen in figure 1. This figure shows an expected increase in the national gross energy consumption towards 2030.

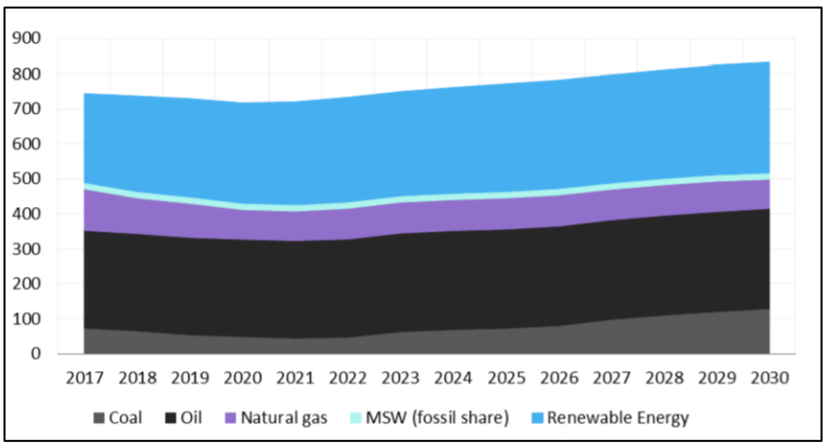


Figure 1 shows the expected national gross energy consumption from 2017-2030 (Danish Energy Agency, 2018)

Figure 2 shows the national gross energy demand alongside with the share of renewable energy sources, which is estimated to be approximately 270 PJ, as seen in figure 2. This shows that the amount of renewable energy increases, only to decrease again in 2022 as a result of the frozen policy principal.

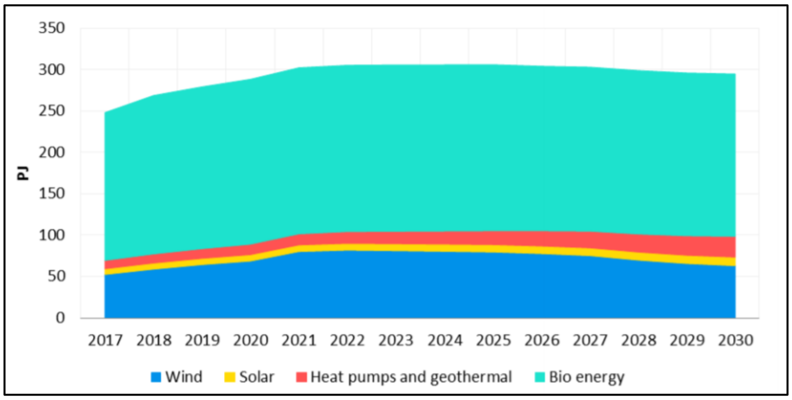


Figure 2 shows the expected share of renewable energy sources in the Danish energy system (Danish Energy Agency, 2018)

Based on the assessment from the DEA, the conclusion is that the total share of renewable energy sources is estimated to be 39.8% in 2030. This number gives a shortfall of 10,2 Pct. Points in comparison to the politically agreed vision of at least 50% renewable energy sources in 2030 (Danish Energy Agency, 2018). This indicates that additional renewable technologies are required if Denmark is to succeed with the green transitioning. One place in Denmark where this transitioning is taking place is in the municipalities.

1.3 Copenhagen Municipality as the world's first carbon neutral capital

The capital in Denmark is Copenhagen, and the Municipality of Copenhagen aims at becoming the world's first carbon neutral capital by 2025. This vision is grounded in their climate plan called "CPH 2025 Climate Plan", which presents multiple initiatives across different fields and time periods. In order to reach their 2025 goal, a number of green initiatives have been established in the four pillars (København Kommune, 2017) on which the climate plan is based:

- Energy Consumption (Black, 7%)
- Energy Production (Green, 80%)
- Mobility (Dark grey, 8%)
- City Administration Initiatives (Grey, 5%)

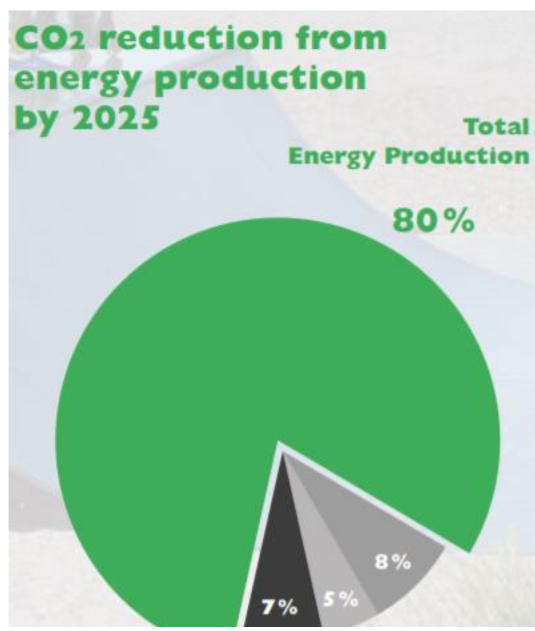
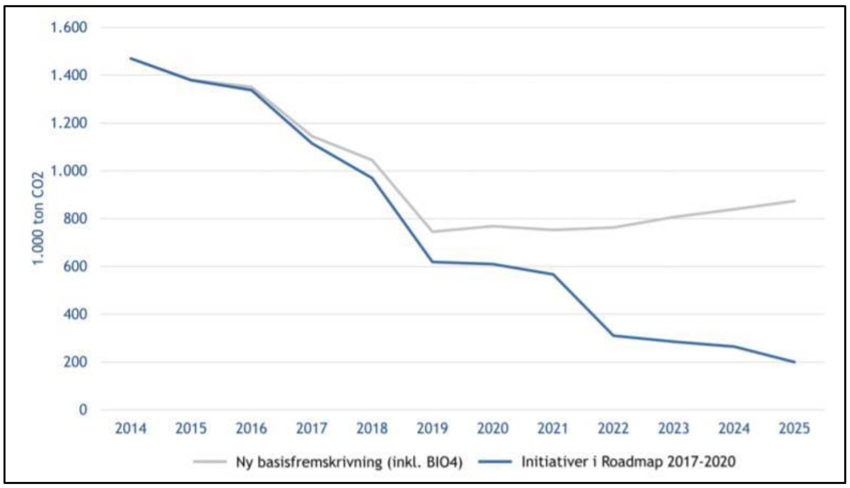


Figure 3 shows the four different pillars of Copenhagen Municipality's Climate Plan and the carbon reduction potential of each (København Kommune, 2017)

The initiatives in all four pillars are important for Copenhagen Municipality to succeed in regarding the goal of carbon neutrality, and the largest potential of reducing carbon emissions is within the frame of 'Energy Production' (See figure 3). Consequently, it is initiatives concerning production of electricity and heat that needs to be based on renewable energy sources and not from fossil fuels.

Copenhagen Municipality are currently working with a time schedule from 2017-2020, where a midterm evaluation of their upcoming initiatives shows a shortage in the green accounting by 200.000 tons/CO_2 in 2025 (see graph 1). This states that unless new initiatives are set in motion, Copenhagen will not reach their climate goal of becoming carbon neutral in 2025.



Graph 1 shows the midterm evaluation of Copenhagen Municipality's initiatives showcasing a deficit by 200.000 tons CO_2 (blue line) in 2025 (Københavns Kommune, 2018)

This deficit indicates that new initiatives for reducing carbon emissions are of paramount importance for the Copenhagen Climate Plan to become a reality in 2025. That is why new initiatives are being introduced, amongst them an initiative based on solar photovoltaic technology, which the next section will introduce.

1.3.1 Solar photovoltaic (PV) goal

This initiative consists of investing and expanding the existing PV capacity in Copenhagen Municipality. The target of the initiative is to have PV producing electricity corresponding to 1% of the total electricity demand in Copenhagen Municipality by the end of 2025. Currently, the production is 0,3%. The estimated energy demand in 2025 is 22,567 MWh/year in 2025, and currently 0,3% is covering 6567,3 MWh/year, providing that the existing PV applications have 900 full load hours of production.

The target of 1% (22,567 MWh/year) relates to an old assessment made in 2012, where the potential of the overall urban area including building stock and preservable houses were taken into consideration. In addition, the electricity demand in 2025 was estimated by having a presumed 10% reduction on the total electricity consumption in households and 25% reduction on the total electricity consumption of the trading and service sector (see appendix 6). This is illustrated in table 1:

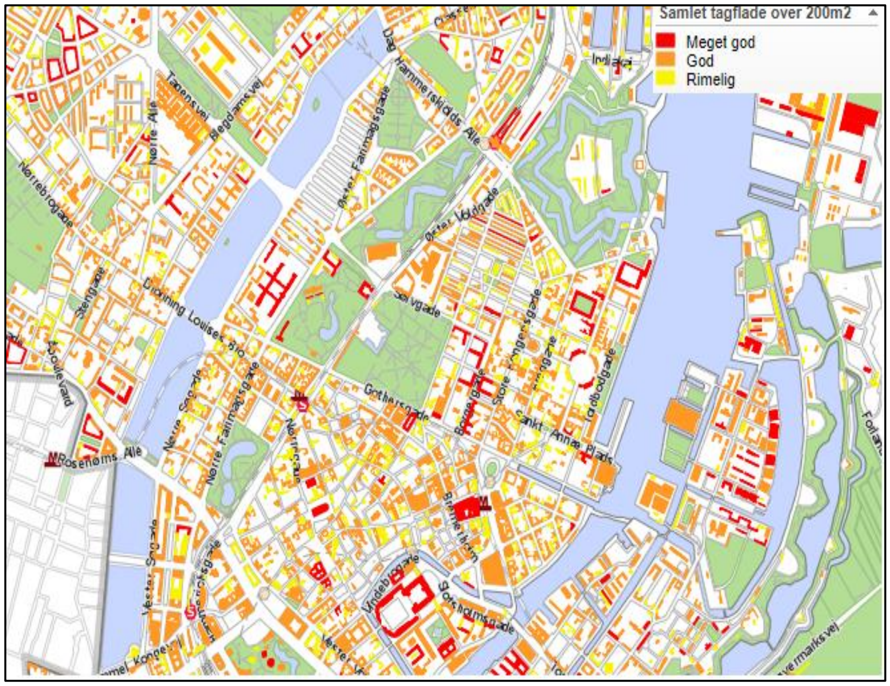
2010	Electricity demand in total 2010	2509745	MWh/year
	Electricity demand in households 2010	701920	MWh/year
	Electricity demand in trading- and service sector 2010	914059	MWh/year
	Electricity demand in the remaining sectors 2010	893766	MWh/year
2025	Electricity demand in households 2025 (10% reduction)	631728	MWh/year
	Electricity demand in trading- and service sector 2025 (25% reduction)	731247	MWh/year
	Electricity demand in total 2025	2256741	MWh/year
2025	Solar photovoltaics corresponding to 1% of the total demand in 2025	22567	MWh/year

Table 1 shows the estimated electricity consumption of Copenhagen in 2025 in addition to how much the electricity production needs to be in order to fulfill the 1% target

1.3.2 PV potential in Copenhagen Municipality

Establishing and quantifying a technical PV potential within the boarder of Copenhagen Municipality is a very difficult task (Wiginton et al., 2010). However, this is essential in order to provide the needed data for the potential to be measured.

Last year, the Department of City Data in Copenhagen Municipality made a PV potential assessment based on data from 2011, which also happens to be the data available for residents to use in an interactive solar map on the municipal website. (http://kbhkort.kk.dk/).



The interactive map shows all suitable rooftops for PV in Copenhagen in addition to the amount of electricity that a rooftop in theory would produce on a scale from "reasonable" to "good" and "very good". As illustrated on the picture to the right, the red areas are the best suitable rooftops for PV as they provide the largest production of electricity.

The before mentioned PV potential assessment took into account larger rooftop areas, and the result from the analysis is close to a similar PV potential assessment made by Aalborg University in 2017 (Mathiesen et al., 2017).

Table 2 shows how much electricity the accumulated building surface area in Copenhagen in theory would produce if implemented with PV. The blue column represents the results found in the analysis made by Aalborg University (AAU) with a total PV potential of 967 GWh/year. The green column represents the PV potential analysis from the City Data Department in Copenhagen Municipality. Their results are a bit higher, but close to that of the Aalborg University analysis. It is important to note that the presented data is based on the technical potential for Copenhagen Municipality, and not the specific or realistic potential. This would require a different and more comprehensive analysis with its unique specifications e.g. data covering the exact number of houses and the typologies of each rooftop. This however is something that the Climate Secretariat in Copenhagen Municipality is aware of and wishes to explore in 2019 in order to inquire updated data. The red numbers in the table is the build surface areas with the highest potential, that being mostly private homes, apartment buildings (housing associations), stores/shops and finally industries/office buildings.

	AAU	CPH
Build surface area (m2)	GWh/year	GWh/year
0 - 199	229,2	245,9
200 - 399	124,1	117,4
400 - 599	107,1	123,3
600 - 799	83,6	92,1
800 - 999	66,8	73,1
1000 - 1999	158,9	170
2000 - 3999	94,7	98,2
4000 - 13000	102,6	89,5
Total	967	1009,5

Table 2 shows the building surface areas of two PV potential analysis from AAU and CPH

To sum up, the indicative technical PV potential analysis shows a significant potential for PV in Copenhagen Municipality, especially the buildings with a building surface area of 0 – 400 m^2 and 1000 – 1999 m^2. This indication is important for the consideration of expanding the PV capacity thus showing where to focus the effort in different house segments i.e. private homes, apartment buildings, office buildings. In order for Copenhagen Municipality to cover 1% of the total electricity demand in 2025 with PV technology, they have to utilize 2.33 pct. of the total technical PV potential, which will meet the Climate Plan target:

$$22567\ MWh/year * 0{,}001 = 22.567\ GWh/year$$

$$(22.567\ GWh/year \div 967\ GWh/year) * 100\% = 2.33\%$$

1.4 Tendencies; national- and international influence on PV development

1.4.1 Industries and large conglomerates seek to invest in green technology, including PV's.

PV's are being affected by several tendencies in the society. The market development for PV's have experienced an acceleration in demand whereas the prices have been reduced significantly (see chapter 4, Analysis). Another tendency that is essential to the development of PV is the pressure from several Danish and international industries.

Recently, a group of industries has expressed their concern with the green transitioning in Denmark, wanting Denmark to become the "frontrunner" of green transitioning again (Erhvervsministeriet, 2019). The group consists of ten directors of influential conglomerates (e.g. Ørsted, Vestas, Grundfos etc.) who has established a 'Growth-Team' that represents Danish industries. Their vision is to support and sustain the Danish industries that can deliver green- energy and environmental solutions, so that they can accommodate the expected increase in climate related businesses (Erhvervsministeriet, 2019).

Other businesses beside those represented by the Growth-Team have also indicated their interest in green transitioning. Amongst them is the large conglomerate COOP, who runs a large portion of supermarkets in Denmark. Their spokesperson has stated that COOP wants to become carbon neutral in the next years (not specified), by transitioning to heat pumps and PV on their supermarket buildings (Falkengaard, 2019).

Finally, international industries in terms of large data centers present a major concern regarding the increasing electricity consumption in Denmark. It is companies like Apple, Facebook and Google who have decided to build data centers in different regions of Denmark, which will support the rising need for electronic- and cloud storage. Strong criticism has been given towards these industries because of their large electricity consumption, which will affect the national energy consumption in Denmark. However, all three industries have granted that they will look towards green sustainable projects e.g. wind turbines and PV plants that will sustain their electricity consumption. Lately, Apple has ensured that their data center will be running on green power produced by wind turbines and a 42 MW PV plant (Ritzau, 2019).

1.4.2 European Union Agenda; new renewable energy directive

In June 2018, a new renewable energy directive was accepted by the EU replacing an older version from 2009. This directive indicates that the EU have increased their goal of renewable energy share in the EU's total energy consumption from 27% to 32% by the end of 2030, thus presenting a new agreement with different changes in the existing EU regulation and legislation regarding renewable energy (Council of the European Union, 2018).

One of the new changes in the regulation relates to the taxation of energy produced by green technologies, stating that electricity generation: "(…) *from renewable sources should be deployed at the lowest possible cost for consumers and taxpayers*" (Council of the European Union, 2018 pp. 10). EU proclaims that one of their top priorities as a union is to promote renewable energy sources qua their 'Treaty on the Functioning of the European Union'. They acknowledge that an increase of energy consumption across the whole nation constitutes implementation of more green technologies to reduce carbon emissions (Council of the European Union, 2018).

However, in order for the EU not to disturb: "(…) *the financial stability of renewables support schemes, this incentive could be limited to small installations not larger than 30 kW*". (Council of the European Union, 2018 pp. 28). This indicates that owners of power plants (e.g. PV) smaller than 30 kW should *not* be charged with taxation or VAT for the renewable self-consumption that takes place. It is important to note this 30-kW limitation due to future cases where this may play a role regarding institutions or municipalities producing renewable energy from owned energy plants.

Moreover, another change in the legislation relates to size, number of projects and the ownership structure. The last one is important to point out because it allows renewable energy communities to: *"(…) choose any form of entity for energy communities as long as such an entity may, acting in its own name, exercise rights and be subject to obligations*". (Council of the European Union, 2018 pp.29) and "*Renewable energy communities should be able to share between themselves energy that is produce by their community-owned installations*." (ibid).

In summation, this section has briefly described some notable tendencies which are important for especially the PV technology, due to an increased focus, not only from industries and large conglomerates, but also international agencies like the EU.

1.5 Conducted initiatives to succeed the 1% goal: '*Solar Distrikt NV*'

As mentioned before, Copenhagen Municipality have set a goal for PV applications to cover 1% of the total electricity demand in 2025. With an established collaboration with the Municipality's City Development Department, the Climate Secretariat, KUBEN MANAGEMENT, Solar City Danmark and additional PV experts, all of these stakeholders are pursuing a shared goal of increasing the existing capacity of PV in Copenhagen Municipality.

Nevertheless, this project is still in the making, which makes it difficult to observe the process on which the actors are progressing because of very little structure and established framework. This inevitably leads to a project that could be compromised by the barriers and paradoxes presented in chapter 4, which is why this project is worth investigating.

Sub conclusion

Climate change are currently one of the most debated and discussed subjects of all times in the world's nations. More importantly, central organizations (i.e. United Nations, the EU, the Danish Government) are working on how to combat climate change through different initiatives. In Denmark, Copenhagen Municipality are currently working with solar photovoltaic (PV) technology as a way of reaching their Climate Plan of being carbon neutral in 2025. There are both international and national tendencies that indicates that PV are becoming more popular as a renewable technology due to profound changes in the renewable energy directive from the EU. These changes provide PV stakeholders with an advantage of implementing PV applications on different buildings or even on municipal buildings, which would benefit the green transitioning cause. Right now, one project in Copenhagen Municipality called 'Solar Distrikt NV' are currently working on implementing PV on residential buildings in the Northwest.

2.0 Problem formulation

From the problem analysis it is deducted that the awareness of climate changes inevitably affects the way the world's nations are reducing their carbon emission by different actions. One way of reducing carbon emissions is by focusing on energy planning and the transitioning into green renewable technologies. A technology that have seen a major breakthrough in both efficiency and a decrease of price is solar photovoltaic (PV), which is one of the important renewable technologies that needs to be implemented in the future energy systems. PV technology is well known and applied in Denmark and in Danish energy systems, but in the last decade it has been a debated technology due to the governmental framework and regulation of PV's. In 2012 the implementation of PV peaked in the Danish energy system due to profound lucrative conditions, which the government in the past years have tried to control with a controversial stop-and-go policy and less lucrative incentives regarding net metering on private- and municipal buildings. Private homes can no longer store the excess electricity in the grid as the old regulation allowed, which makes the PV business case less attractive as it used to be. In addition, the municipal owned PV plants needs to be separated in a municipal owned company, in order to not pay full taxes on the electricity produced. This has led to a current sceptical and unreceptive perception of the PV technology amongst the Danish population, but also in several municipalities in Denmark, who are hesitating to work PV as part of their energy strategy of reducing carbon emissions. However, Copenhagen Municipality are still working with PV as a part of their Climate Plan, in particular the collaboration project called 'Solar Distrikt NV', which aims at increasing the number of implemented PV in the Northwest area of Nørrebro. This project is an example of a collaborative governance process, which entails a private-public collaboration, that seeks to impact and change the current regulations to achieve more favourable circumstances for the private housing segment that wants to implement PV on their rooftops. Yet, Copenhagen Municipality still faces profound challenges both with PV and the stakeholders participating in 'Solar Distrikt NV', thus leading to analyse the collaboration down to the core of its internal dynamics and actions. The internal dynamics within this collaboration will encompasses not only drivers, but also barriers and paradoxes in them, which exposes the complexity and the difficulty of fundamental cross-boundary structures in the society. The paradoxes are viewed as structural- and steering paradoxes that entails conflict with self-contradictory factors, which the aim of this master thesis is to give such an understanding of. One example of a paradox is the internal municipal fight of having a certain architectural paradigm to follow while also preserving houses and buildings with a high heritage value, which makes it difficult to implement PV on the roofs on these types of buildings. This paradox and others are responsible for affecting the pursued outcome of 'Solar Distrikt

NV', thus illustrating the complexity of this collaboration, and why it is important for the stakeholders in this project to acknowledge these paradoxes, in order to navigate and lead the project in an optimal way. This leads to the problem formulation of this thesis:

Problem formulation: Based on the theory of collaborative governance, what are the framework conditions *of implementing PV in Copenhagen Municipality's private housing segment, e.g. social- and renting housing grounded in the specific case of 'Solar Distrikt NV' and what possible drivers, barriers and paradoxes may affect this collaboration and the pursued objective?*

- What is the overall system context, e.g. the framework conditions that encompass the technology of PV in Denmark?
- What is the collaborative governance regime of which the case of 'Solar Distrikt NV' exists in and who are the key stakeholders?
- What are the collaborative dynamics and actions in the case of 'Solar Distrikt NV' that affects the municipal decisions and ultimately the pursued outcome?

3.0 Methodology

Chapter three presents this thesis' methods and theoretical approach used to answer the problem formulation. Firstly, the project design will be explained. The second part will present the methods used and the third part describes the theory of *Collaboration Governance* and how it was operationalized to answer the problem formulation.

3.1 project structure

The structure of the thesis can be seen here on figure 4:

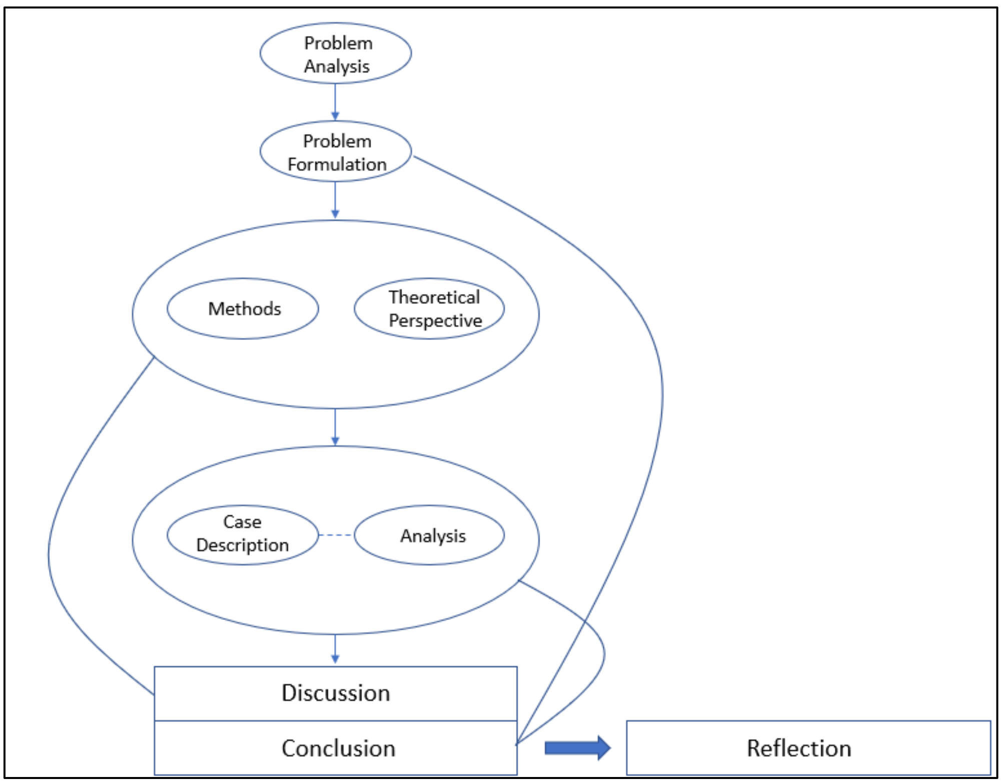


Figure 4 shows the thesis structure

3.1.1 Case study

This report is focusing on how Copenhagen Municipality is establishing collaborations with both the residents from Northwest Nørrebro, PV experts and PV suppliers in order to reach their PV goal of 1%. This collaboration is called 'Solar Distrikt NV', and it is an initiative from the Municipality to engage in a public-private collaboration that can help them succeed with this goal. This case was chosen explicitly due to an internship last semester in the Climate Secretariat in Copenhagen Municipality. During that internship, I worked with a preliminary PV strategy and a PV potential assessment. This was also done with an intention of maximizing the information from a single case (Flyvbjerg, 2006).

This case is obviously influenced by conditions and tendencies, that may be limited to Copenhagen Municipality alone, which also makes this case context dependent. It can be difficult to generalize the results found in this case to other Danish municipalities, but Bent Flyvbjerg argues in his “Five Misunderstandings About Case-Study Research”, where he states: “One can often generalize on the basis of a single case, and the case study may be central to scientific development via generalization as supplement or alternative to other methods. But formal generalization is overvalued as a source of specific development, whereas “the force of an example” is underestimated.” (Flyvbjerg, 2006, pp. 228)

In relation to that argument, the results found in Copenhagen Municipality can become strong examples of realistic behavior and possible solutions for PV planning.

3.1.2 Qualitative interviews

When writing this thesis, three specific persons have been interviewed based on a qualitative method. A qualitative interview entails a conversation with an individual within a professional field of research. These individuals offer a unique insight to different perspectives as well as understanding their lifeworld. When understanding the lifeworld of these interviewed individuals, vital knowledge and context shaped information will come to show (Kvale og Brinkmann, 2009).

Three semi-structured interviews were conducted representing three different lifeworld. The first interview was with Rachel Maclntyre (see appendix 1), who represents Copenhagen Municipality and the ‘Solar Distrikt NV’ project. The second interview was made with Michael Madsen (see appendix 2), who represents the government and its view on PV. Lastly, Hans Jakob Martinsen (see appendix 3) from HOFOR was the third interview person, who works with development projects, in particular wind and PV projects. All of the interviewed individuals are involved in working with PV and to some extend municipal energy planning, which contributes to the knowledge of this thesis.

The following paragraph introduces the persons interviewed:

Respondents

Michael Madsen, Economic Officer for the Danish Energy Agency

Michael Madsen works in the DEA's department called 'Center of Renewable Energy, where he focuses on the economy (e.g. subsidies and taxations) and the legislation on PV's in Denmark. Madsens' knowledge has helped understanding why the legislation is structured the way it is, and how the government is working with renewable technologies such as PV.

Rachel Maclntyre, Project Leader of 'Solar Distrikt NV'

Rachel Maclntyre works in the Department of City Development in Copenhagen Municipality. Macnltyre is the project leader of 'Solar Distrikt NV', but also engage in matters concerning architecture in Copenhagen. Her knowledge has led to a deeper understanding of the collaboration found in 'Solar Distrikt NV', and what motivates her to continue that project.

Hans Jakob Martinsen, Developer Manager for HOFOR

Hans Jakob Martinsen works in the utility company HOFOR, which is a 100% municipal owned company. Martinsen works with development of both wind turbines and PV and is familiar with the relation and collaboration HOFOR shares with Copenhagen Municipality.

3.1.3 Meetings and workshops

Throughout the collaboration with Rachel Maclntyre and Mariann Andersson, a great deal of meetings and workshops has taken place, which has influenced this thesis significantly. These meetings and workshops have consisted of different actors and stakeholders from either private parties or public organizations. This has somewhat helped me understand how municipal energy planning looks like in the real world, but also what affects planners internally in a municipality as well as private actors in relation to societal changes.

Seminar regarding 'Solar District NV'

With an established collaboration with the City Development Department in the Municipality, the project leader, Rachel Maclntyre, with help from the Climate Secretariat and Solar City Denmark arranged a PV seminar in Nørrebro's 'Nordvest' neighborhood the 11th of December 2018. With this seminar, the abovementioned organizers invited different stakeholders, PV experts and people from homeowner associations with residency in that area. The goal was to inform the attendees of; 1) how the municipality wants to use Nordvest as a showroom for building integrated PV's, 2) what the experts says about the development of cheaper and more efficient PV's, and 3) how the homeowner associations could support this development by investing in PV's themselves with possible subsidies from the municipality covering 25-33% of the total expenses. Lastly, the organizers invited the attendees to meet again in February 2019 with the opportunity to talk about investing in PV's on their own building, talking with experts about the possibilities and business cases, and to form a group of homeowner associations that collectively seeks funding's and subsidies to help finance the investment. This meeting however was postponed being held in May 2019.


Workshop regarding 'Solar Distrikt NV'

This workshop held in May 2019 was a continuation of the last seminar held in December last year regarding solar photovoltaic (PV) in Copenhagen and in Nordvest. The workshop was focused on gathering residents, construction developers, experts and suppliers of PV, different housing associations etc., to discuss and unfold the vision of Solar Distrikt Nordvest and present the work of Steen Hartvig (Rubrik and freelancer) who in collaboration with Copenhagen Municipality, Solar Distrikt NV and Solar City Danmark has worked on constructing an economic modelling tool for residents to calculate the potential of a PV investment. This presentation was aimed at public housing associations to present a business case for PV on their building.

3.1.4 Literature studies and document analysis

When dealing with a large subject such as municipal energy planning or collaborative governance, the need for scientific papers is equally important for understanding the complex processes. To achieve a holistic understanding of this thesis problem area, both papers municipal of energy planning, collaborative governance, PV articles, magazines and papers have been studied and read. This is very crucial for preserving a scientific quality and a high credibility (Olsen & Pedersen, 2003). The studied material has provided much needed insight and understanding of the problem area.

3.1.5 Direct observations and participating observations

Some of the applied methods in this thesis have been direct observations and participating observations. This has especially occurred during different encounters and meetings with both Rachel MacIntyre, Mariann Andersson, experts and suppliers, and whomever attend meetings and workshops before and during the making of this thesis.

Participation observations give insight towards the personal behavior and motivation which can be found during everyday meetings or conversations. It is a method where the observer tries to describe and observe the reality, but with the constraints of changing the observed reality by the presence of the observer. Changing the course of a meeting can alter the data collected thus not showcasing the ideal and untouched reality (Olsen & Pedersen, 2003). An example of participation observation related to this thesis would be the interaction in both formal and informal meetings with key actors and stakeholders, where the intended outcome was that of interacting with participants with knowledge of the mentioned subject. This happened both with meetings at the Municipality, seminar and workshop with residents, but also with different employees at the Danish Energy Agency.

Direct observations also engage the observed reality, but over a longer time period than the participated observations. Here, the observer will experience realistic situations, which can be used to describe the real situations in a person or in a group's lifeworld. However, these observations take long time to conduct, and these observations are usually limited to a few cases. Additionally, the observer does not have access to the observed people's thoughts and intention in a given situation, and the presence is still a factor that affects the situation, and finally the results (Olsen & Pedersen, 2003). An example of this would be related to the whole process of working as an intern within the Climate Secretariat, observing how the development of working with PV has progressed and advanced towards different actions, e.g. Solar Distrikt NV.

One can argue that by combining these two observation methods, I have gained crucial knowledge and experienced unique situations which have offered insight and valuable information for this thesis.

3.1.6 Epistemology

It is vital to argue for the validity of the information and data presented to the reader in this thesis. In order to demonstrate knowledge and truth, one must demonstrate how this was done in an epistemological sense (Olsen & Pedersen, 2003). While studying Copenhagen Municipality's work with PV and analyzing the stakeholders within the system, two different approaches have taken place.

The first approach can be categorized as a *positivistic* perspective, meaning that knowledge is made with rigid observations and methods, which is in favor of measurable and empirical data. The term *positivism* originates from the French philosopher, August Comet, and entails that one is certain of specific knowledge, which can be quantified both logically and empirically, and be made into general claims (Sismondo, 2004).

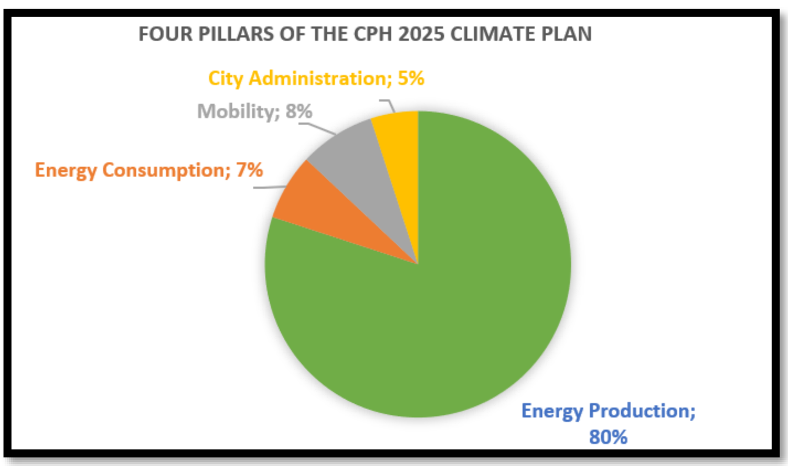
In the internship period, one of the goals was to identify the potential of PV in Copenhagen Municipality, thus showcasing an empirical estimation and mapping the most suitable rooftops within (see chapter 1, Problem formulation). This knowledge was made inductively by calculating and measuring quantitative data collected by employees in the Climate Secretariat and in the Department of City Development.

The other approach was influenced by a *pragmatic* perspective, entailing that creating new knowledge demands the engagement of the observer with the world he observes and reflect upon it (Boisvert, 1999). This approach was experienced after the internship period, and to an extend when writing this thesis, where it was made possible to reflect on the different tasks that was appointed, and how these were executed.

Pragmatism is presented by the philosopher, John Dewy, who addresses the way knowledge is created. According to Dewy, the world we observe is everchanging, and it is impossible to deduct knowledge merely by observing the world. One must engage in the world, become an inquirer who investigates the subject to complete the objective (Boisvert, 1999).

3.1.7 Internship knowledge

This thesis and the offered results are accompanied by the author's experience as an intern within the Climate Secretariat in Copenhagen Municipality. The Climate Secretariat's mission is to facilitate and achieve the climate goals and visions of the city before the end of 2025. The main goal is to become carbon neutral in the geographical sense, meaning that Copenhagen is to become carbon neutral within the geographical borders e.g. the transitional traffic and commuting. To achieve this goal, different sets of initiatives have been established in 'roadmaps', which enlists the mentioned initiative, how long this initiative will take and how much carbon emissions it will suppress. These initiatives have been placed under a specific 'pillar' in the Climate Plan, which is illustrated on table 3 below:



Out of the four pillars, 'Energy Production' presents the largest share of carbon emissions, which is why PV initiatives are placed here amongst other initiatives. PV projects is something that the municipality has worked with in many years, and through the internship I learned how the Municipality works with PV, which is illustrated with figure 5. Copenhagen Municipality is working in three different parts;

1) One of the initiatives is focused on the possibility of investing in large PV plants on fields or dryland outside of Copenhagen, due to limited area availed for such applications. This task is assigned to the municipality's utility company HOFOR, who is monitoring the price and future tenders of PV's. However, they have still to invest in large PV plants due to the business case and legislation of PV, which is why this initiative is an ongoing process.
2) The Municipality is also the authority when contacted regarding construction of PV on rooftops within the city boarder. It is usually permitted when private homeowners want to install PV on their own homes, opposed to large building communities or private institutions such as kindergartens etc.
3) Finally, the Climate Secretariat and City Development Department are currently working on a project called *Solar District NV*. This project revolves around the possibility of expanding the current capacity of PV's within different housing associations, e.g. common housing, private homes or apartment buildings in the Northwest area in Nørrebro. The project is currently being arranged and planed for by a small team from the Climate Secretariat and City Development Department alongside with private actors.

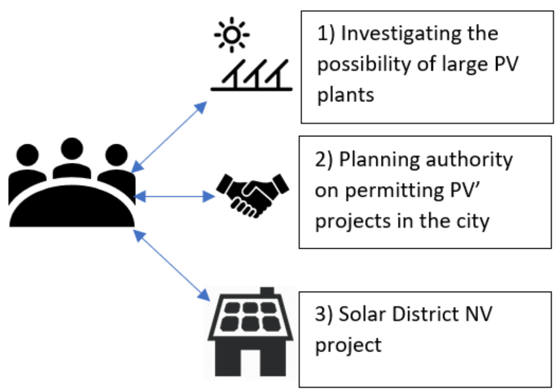


Figure 5 shows the three different ways that Copenhagen Municipality are working with PV

During the internship, the Solar District NV was one of the initiatives that I worked on alongside with the preliminary analysis of a PV strategy in the time period of four months. Before working with PV's, it was crucial to get a thorough understanding of the Climate Plan of Copenhagen. While getting an overview of the Climate Plan, the role of PV technology became clearer through a summary of what work had already been done in relation to PV's. In addition of understanding the Climate Plan, the next order of business was to learn the internal structure of Copenhagen Municipality, who the key actors were and how to involve them in my own work.

Knowledge-sharing concerning barriers of PV

When discussing barriers and experience working with PV, it was important to get an extended understanding from not only Copenhagen Municipality's perspective, but also other Danish and foreign municipalities. This meant an interview session with Aarhus, Høje-Taastrup, Sønderborg, Amsterdam and Sydney Municipality. The main barriers found has been written in a preliminary analysis (see appendix 7), which will not be presented in this thesis.

3.2 Theoretical perspective: Collaborative Governance

The following chapter presents the theory of *Collaborative Governance* which was used to answer the problem formulation.

3.2.1 Theoretical perspective

The theoretical perspective used to analyse the case of 'Solar Distrikt NV' in Copenhagen Municipality in this thesis project is collaborative governance, in particular collaborative governance understood and elaborated in "Journal of public administration research and theory" by Kirk Emerson, Tina Nabatchi and Stephen Balogh (Balogh et al., 2011) and with inspiration from "Collaborative Governance in Theory and Practice" by Chris Ansell and Alison Gash (Ansell & Gash, 2007). The theory helps unravel the complex structure of collaborative governance found in 'Solar Distrikt NV', thus illuminating shared purpose, stakeholders, drivers, impacts and barriers. The authors argue that the term 'governance' is used inconsistently in public administration literature which makes it difficult to define and to further develop and test the theory. Therefore, their work addresses these limitations but also helps widening the term, thus creating conceptual frameworks for the reader to help practicing and evaluate collaborative governance (Balogh et al., 2011).

The following paragraph first describes collaborative governance and key elements of the theory. Secondly, a description of how this theoretical perspective is applied to the specific research/case. Collaborative Governance; system context, collaborative governance regime and internal collaborative dynamics

3.2.1 Collaborative Governance

Firstly, the term and framework collaborative governance is defined by the authors "(…) *as the processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished*" (Balogh et al., 2011, pp. 2). This broad definition helps analyse collaborative governance in a larger perspective and captures new forms of cross-boundary governance or hybrid constellations, thus surpassing the conventional way of only focusing on the formal public agencies that engage nongovernmental stakeholders (ibid). These cross-boundary- or even hybrid constellations can be seen as partnerships between the local community, public-private organizations, the private sector, civil society or even the state.

Balogh et al. introduces collaborative governance as a framework of nested dimensions that encompass 1) a larger system context, 2) a collaborative governance regime and finally 3) its internal collaborative dynamics which can lead to actions that generate impact and adaptations cross-sectoral in the system (Balogh et al., 2011).

This framework is illustrated in figure 6:

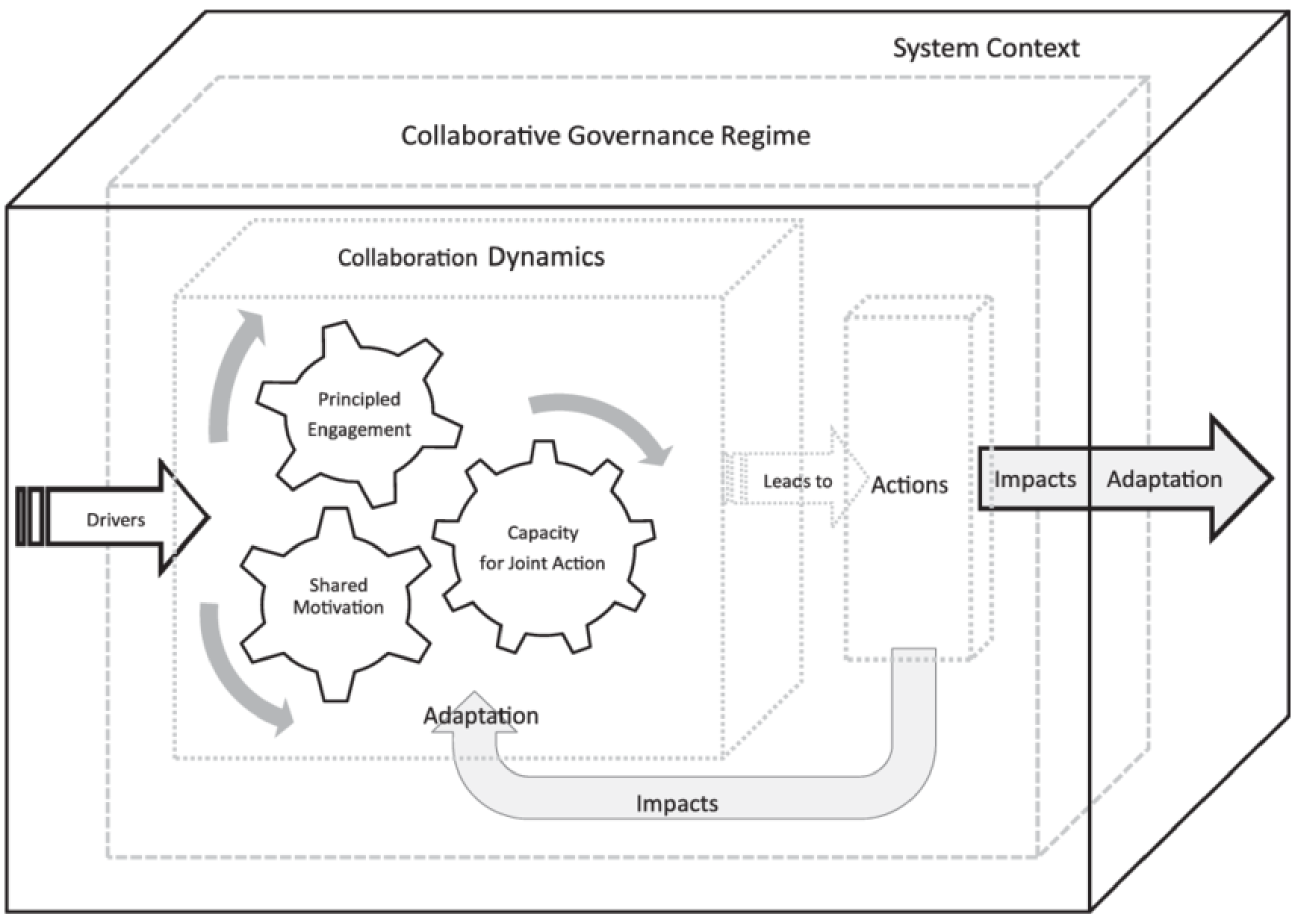


Figure 6 shows the framework for Collaborative Governance with the three dimensions (Balogh et al., 2011 pp. 6)

This figure displays the three dimensions which will be elaborated later on in the following text. The framework helps simplify the complex structure of Collaborative Governance applied in different fields of the society, such as the collaboration between the Copenhagen Municipality, residents in NV and the experts and suppliers of PV. There are three fundamentally important aspects of this framework: the general system context, collaborative governance regime and collaborative dynamics.

3.2.2 System Context

The outermost dimension in the framework is the general system context. Although figure 6 displays the framework of Collaborative Governance with a bold line, it is important to note that it is not a closed system, but rather a larger system that consists of what the authors describes as: "*(…) a multi-layered context of political, legal, socioeconomic, environmental and other influences."* (Balogh, et al., 2011 pp. 8) Collaborative Governance is being initiated and shaped within the system context, which shapes the next dimension called *collaborative governance regime*, which will be introduced shortly. The system context is affected by external conditions such as profound legislation changes, economic growth, global events e.g. climate changes etc., which influences the prospects for all three dimensions. But, most importantly, the system context changes the dynamics of collaboration seen in the society, thus creating new possibilities or new rising challenges (Balogh et al., 2011).

3.2.3 Drivers

Before introducing the next dimension of the framework it is essential to present the conditions by which collaborations either appear or on the other hand fail to establish cooperation among the key actors. This is called *drivers*, which includes leadership, incentives, interdependence and uncertainty. *Leadership,* being the first driver, refers to an identified leader (or leaders), who is willing to initiate and support the regime. This could be a member of the official organisations that are involved in the project, who are committed to a collaborative effort, showcasing a willingness to include a variety of stakeholders that may or may not share the same point of view as the leader.

Consequential incentives is the next driver, referring to an internal or external situation, where the involved participants are aware of possible issues illuminated by stakeholders and profound changes in the everyday life, where the absences of action may induce negative impacts. In all, these incentives, negative or positive, must engage both leaders and participants.

The third driver is *interdependence*, which entails a feeling of powerlessness or the constraints of the participants or organisations who are unable to succeed on their own with the project. This is perhaps the best example of a precondition for collaborative action.

The last driver, *uncertainty*, proclaims that a certain 'wicked' societal problem exists, and the uncertainty of how to solve it forces groups of people to collaborate with the goal of either solving or minimizing the problem to a certain degree (Balogh et al., 2011).

These four variables are the essential drivers for the impetus of the collaboration to unfold, and finally the establishment of a collaborative governance regime.

3.2.4 Collaborative Governance Regime

A central part of the presented framework is called *collaborative governance regime*, or CGR. The regime paves the way for cross-boundary collaboration to form, which is affected by the *drivers* as well as the *general system context* which was covered in section 3.2.2 earlier. The regime however is developed in an iterative process over time by two key components: *collaborative dynamics* and *collaborative actions* (Balogh et al., 2011). The next paragraph will elaborate on these two components.

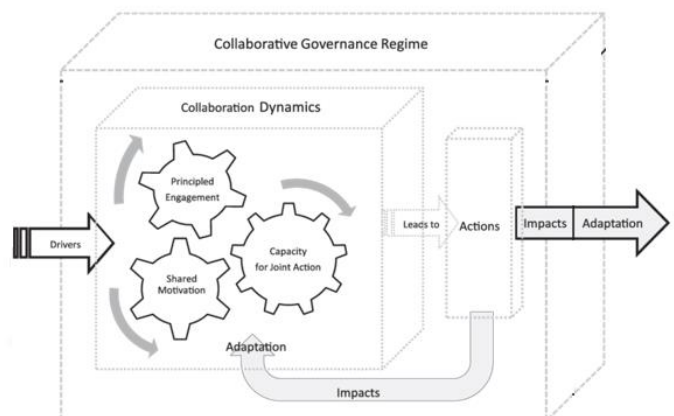


Figure 7 shows the Collaborative Governance Regime and the two components; Collaborative Dynamics and Collaborative Actions

3.2.5 Collaborative dynamics

In order for the collaboration to begin between different stakeholders or groups, there must be certain dynamics which inspire the participants to set the collaborative actions in motion. The overall target is to let the actions and dynamics over time form the collaborative governance regime. Collaborative dynamic actions are accounted for by three interacting components: *Shared Motivation*, *Principled Engagement* and *Capacity for Joint Actions*. Together, they form the collaborative dynamics which is one out of two key components to the regime.

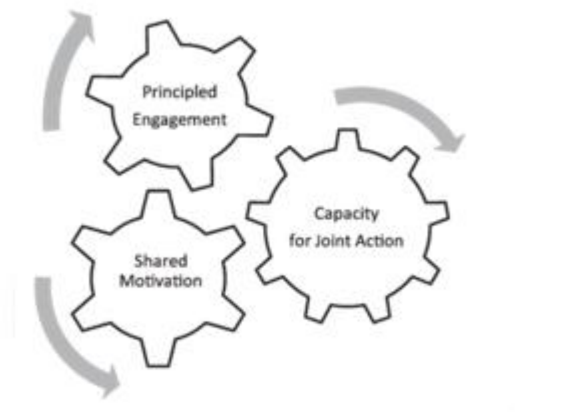


Figure 8 shows the Collaborative Dynamics showcased as Principled Engagement, Shared Motivation and Capacity for Joint Action

Principled Engagement describes a process that occurs over time and includes the involved stakeholders at different points in the project, where the stakeholders with different relations, goals or content engage across their professional boundaries regarding their position. Through this process it is likely that stakeholders begin to share a sense of purpose which reflects in their engagement towards the project.

Shared Motivation refers to a self-reinforcing process where mutual trust, understanding, legitimacy and commitment creates a foundation on which relational and interpersonal configurations form. This process is highly motivated and in part initiated by the *Principled Engagement* as described earlier.

Capacity for Joint Action describes the purpose of collaboration, which is to fulfil desired outcomes as a unit. This requires a combination of four elements:

1) Procedural and institutional arrangements
2) Leadership
3) Knowledge
4) Resources

The first element describes the structure of the organisation alongside with procedural protocols that succeeds network interaction. There are also formal and informal rules affecting these arrangements and the decisions made within the organisation.

The second element of *Joint Action* is leadership, which is also mentioned earlier as a *driver* for the *collaborative governance regime*. Here, leadership can be thought of as a facilitator role or a mediator between different parties.

Thirdly, knowledge is crucial when dealing with multiple stakeholders with different levels of knowledge. Once shared with others, knowledge can also generate new knowledge and data not known to the group or stakeholders, which in return can help overcome the increase of complexity a case or project might experience over time.

The final element is resources, which indicates that collaboration can help deal with potential scarce resources in a project, or the resources of technical skills, time and expertise etc. Direct power can also be thought of as an important resource, but often a resource unevenly distributed across participants (Balogh et al., 2011).

3.2.6 Collaborative actions

Turning from the dynamics mentioned above, it is vital to present what would typically be the outcome of any given collaborative governance framework, which is *actions* that provides new mechanisms for the collaboration partners that fits their determined outcome (Balogh et al., 2011). There are many different ways of describing collaborative actions in accordance with the theory, and sometimes it can be difficult to separate both the undergoing processes and outcomes because they are much likely tied together. However, some examples of actions would be deploying staff members to guide a process, secure external resources to support a given project, educating or creating awareness for the public to a certain subject etc. (Balogh et al., 2011). Again, it is important to state that these actions are highly connected to the aims of the *collaborative governance regime*, where some have broader goals, and some goals of lesser ambitions. These actions may be carried out by agencies, partners or other entities carrying out missions that are agreed upon through the *regime*.

Collaborative actions can also be difficult to carry through or have a much lesser impact if the shared goals or the engagement for action is not made clear. It is highly necessary for people to have explicit goals and a shared feeling of action if they are to work together, which is why the *collaborative dynamics* are so important because they generate the much-needed capacity for joint actions.

Through these actions, both impacts and adaptions can be deduced, which is why these will be explained last.

3.2.7 Impacts

Impacts directly derived from the *collaborative governance regime* are also difficult to determine, and the authors expresses this by saying: "(…) *we need to generate better conceptual clarity about impacts*" (Balogh et al., 2011 pp. 18). The challenge is to operationalize both the direct and indirect impacts produced by the previous mentioned actions, and to measure, clarify and evaluate them. Typical impacts may be described as being environmental-, social- and economic based impacts, but also physical or political. Another important statement made by the authors explains that when: (…) *accountability for collaborative outcomes is deemed important, these impacts are likely to be more explicit and measurable".* (Balogh et al., 2011 pp. 18). This points at the importance and awareness of explicit and specified outcomes from the *collaborative actions*.

3.2.8 Adaptation

As important as the impacts of the *regime* are, so is the *adaption* in the *general system* context that Collaborative Governance is capable of enforcing. Adaptation can transform the context and change the direction of a complex situation, for the benefit of a community.

3.3 Applied theory

This thesis project focuses on understanding and analysing the case of 'Solar Distrikt NV' and does so by operationalising the theory of collaborative governance based on the figure 9. Moreover, when operationalising the theory, it becomes clearer who the stakeholders are, what motive e.g. the suppliers (experts) of PV's express and what drivers the residents of NV may enforce. The case of 'Solar Distrikt NV' becomes a useful example to showcase these dimensions, i.e. *system context, collaborative governance regime and collaborative dynamics and actions*.

To illustrate the theoretical perspective of Collaboration Governance used on the case of 'Solar Distrikt NV', the following figure 9 is made:

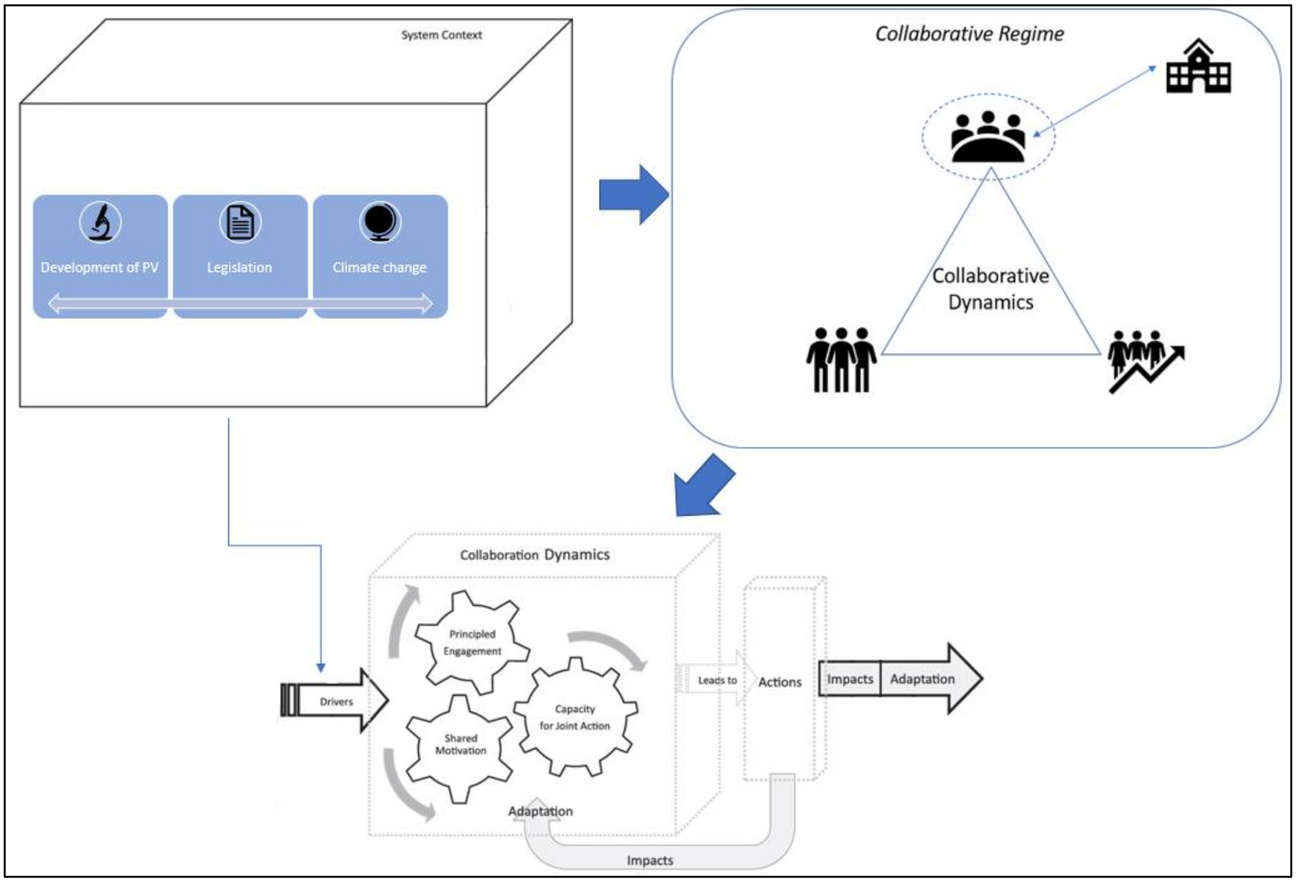


Figure 9 shows the theory of Collaborative Governance operationalized to this thesis

As illustrated above, this research analysis shows the complex construction of the collaboration found in 'Solar Distrikt NV'. The collaboration is constructed based on a general system context, which in this case is affected by external conditions such as the development of PV, a political enacted regulation of PV's and the influence of climate changes. These sets of conditions then influence the collaborative regime which consists of three main actors (Copenhagen Municipality, the residents of NV and the supplier/experts of PV), which in return affects the dynamics and performances of the collaboration between the actors, leading to new possibilities or posing difficult challenges.

The acquired outcome of using this theory is four-folded:

The process of collaborative governance, and thereby the case of ‘Solar Distrikt NV’, will therefore be analysed to understand the different mechanisms that takes place within the *collaborative* dynamics while also understanding the necessary cross-boundary relationships that holds together important stakeholders and actors so in the end they can induce *collaborative actions*.

To operationalize the integrative framework for Collaborative Governance based on the case of ‘Solar Distrikt NV’ is to find and observe *collaborative governance* within a *system context* (that consists of a multi-layered reality influenced by politics, environmental issues, economics etc.) which creates a *collaborative governance regime* in which certain dynamics and actions causes impacts and adaptation throughout the regime and system context.

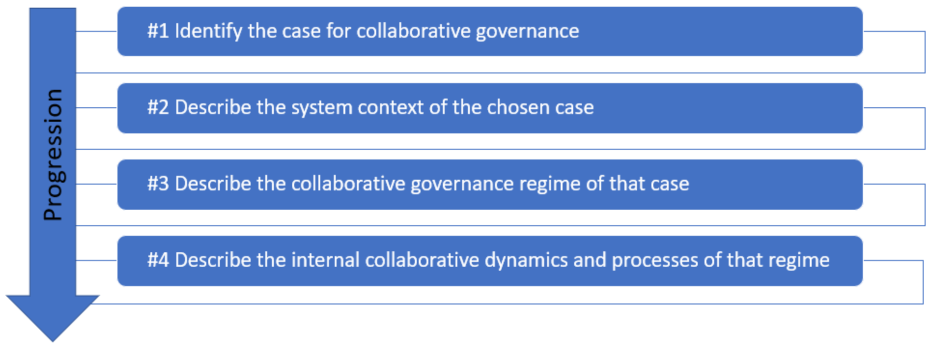
The system (if properly executed) would provide opportunities that would otherwise be difficult to create for the participants, who then would use the established cross-boundary relationships to set an initial direction for the project, thus succeeding in gathering stakeholders and unifying them, in an effort to achieve the established purpose.

Impact and adaptation: paradoxes

Throughout the analysis chapter, occasionally a box will appear, introducing a paradox related to that specific part, which opens up for a discussion regarding that matter. These paradoxes are what impacts and affects the collaboration found in ‘Solar Distrikt NV’, which can have consequences on the desired outcome. That is why these paradoxes in the first place briefly will explain the why the observed situation can be regarded as a paradox, and later will be discussed for the purpose of contributing the involved stakeholders with this knowledge.

4.0 Analysis

The following chapter presents the analysis of this thesis, which is constructed based on the theory of collaborative governance in the following way: 1) Identification of the case for collaborative governance, 2) description of the system context of the chosen case, 3) description of the collaborative governance regime of that case, and 4) description of the internal collaborative dynamics and processes of that regime. See illustration below.



The progression shown with the illustration creates a coherent flow of the analysis, which first presents the chosen case of 'Solar Distrikt NV', in order to establish a base of knowledge concerning that case, e.g. "who is in charge of the project" and "what are the pursued goal". The next order in line is to describe the system context, which is the overall framework of the case, e.g. what drivers or dilemmas are causing a certain reaction from different groups of stakeholders. This leads to the third order of business, where the stakeholders form a collaborative governance regime in order to act upon the external changes from the system context, e.g. how to navigate and steer in a specific direction and with a pursued goal. The last step in the analysis is to describe the internal collaborative dynamics of this group of stakeholders who is trying to create actions that impact and causes adaptation in both the regime but also in the system context.

While going through these four steps certain paradoxes are illustrated for each step, where the purpose is to describe not only important drivers, stakeholders or even barriers, but also paradoxes that show the complexity of this case, the foundation and structure of …

In the end, a summary of these four steps are presented, showcasing important findings and illustrating the complex structure of the 'Solar Distrikt NV' collaboration with its internal dynamics and external challenges.

The next paragraph will present the first step of the analysis; the case for 'Solar Distrikt NV'.

4.1 Case description: 'Solar Distrikt NV'

The position of 'Solar Distrikt NV' is located Northwest of Nørrebro and is surrounded by Vanløse, Frederiksberg Municipality and Hussum (see map 1). The area is charrecterised by having a large number of social houses, old industry buildings and recreational green spaces such as Bispebjerg Cemetery or the Utterslev Marsh. Currently, a large portion of the old industry buildings are beging revnovated, making room for associations or companies to accomodate them.

Map 1 shows the location of Northwest area and the surrounding city parts

The initiative of 'Solar Distrikt NV' is the endavours of City Development, Climate Secretariat, KUBEN MANAGEMENT and Solar City Danmark (Macnltyre, 2019). These five stakeholders are currently working towards the vision of making the Northwest area a place where building integrated solar photovoltaic (BIPV) solution can be desplayed for the sake of interested construction developers, residents or technical advisors for different housing associations.

Rachel Maclntyre, the project leader of 'Solar Distrikt NV' explains why exactly this area was chosen:

"*Basically, it was because of the area renewal, and therefore building renewal got some money, to do building renewal in the area. And then there was Landsdommergården and Rentemestervej 94 (red. Projects regarding*

BIPV). (…) And someone said: We can make this a solar district. (…) So, the idea that we could get PV on the roof. So, it was a combination of many things that came together. (…)". (Macnltyre, 2019 [07:38 – 9:25]).

This area was alocated subsidies to perform building- renovation and renewal, which meant that projects like Landsdommergården and Rentemestervej 94 became the first projects to kickstart the idea of having the Northwest area being a citypart for BIPV solutions.

4.1.1 Purpose of 'Solar Distrikt NV'

As for now, the purpose of this project is to focus on BIPV solutions for the buildings within the Northwest area. Macnltyre elaborates the goal of the project, where she states that:

"(…) the purpose is to engage, to inspire and start a dialogue with and get people together who have an interest in PV (…). But the long-term plan for me is that building owners think of PV, they think of integrative solutions when they build, change the roof or windows. (…)". (Macnltyre, 2019 [20:14-22:08]).

It is clear that Copenhagen Municipality seeks to increase the capacity of the existing PV's by focussing on PV solutions in the Northwest area. This can be done by establishing a collaboration with residents who want to contribute to the green transition, and to encourage them to speak with other housing associations who have invested in PV's themselves. But it is not only the residents, that this project is seeking to collaborate with, it is also to change the current paradigm of energy renovation, to make constructors and technical advisors consider the possibility of PV before they start to build, or before a roof needs to be renovated.

This purpose is also inspired by the overall Climate Plan from Copenhagen Municipality, as Macnltyre explains:

"We have an ambition in the Climate Plan, we have 40 MW (ed. 40 MW PV) in 2025. (…) Right now, we need to look at every possibility. (…) Right now, we have around 500 kW (ed. 500 kW PV's in NV) and in 2020 I would like that to be doubled (ed. 1 MW). (…)" (Macnltyre, 2019 [09:45-11:56]).

The next paragraph will present the system context of this case and thereby the second step of the analysis structure.

4.2 System context of 'Solar Distrikt NV'

This section will introduce the reader to the overall system context of 'Solar Distrikt NV' with regards to the limitations of three important aspects, which are: 1) The development of PV technology, 2) The legislation and regulation of PV in a Danish context and 3) The role of PV in the future energy system. This is illustrated below:

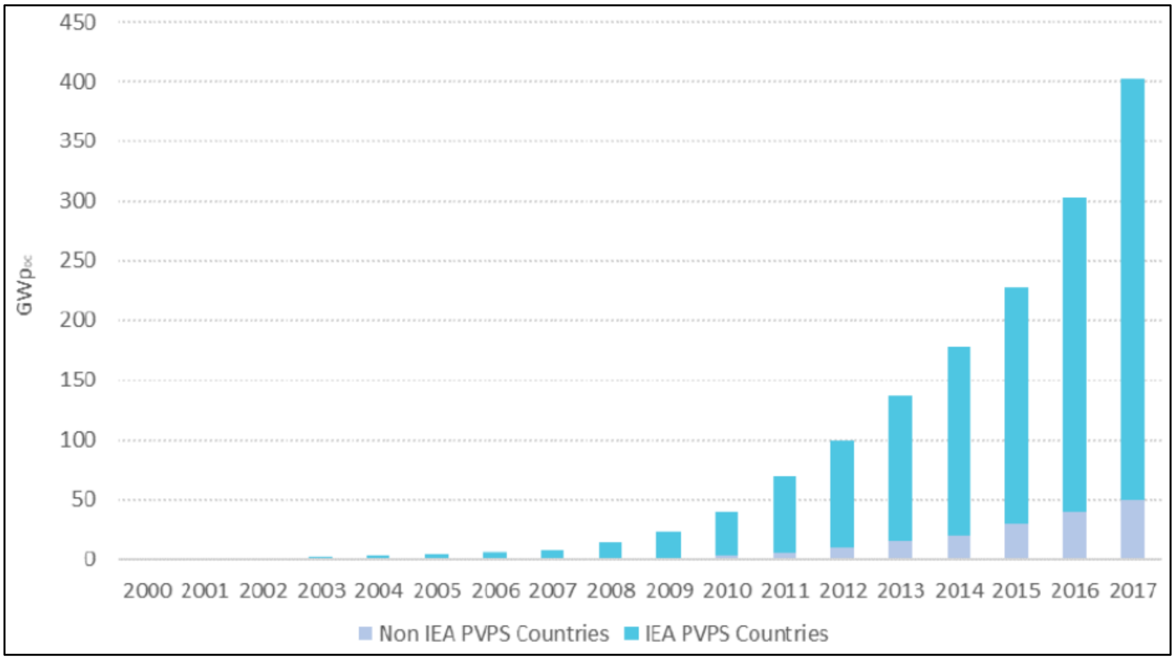
The first aspect (the development of PV technology) is to be viewed both in terms of international-, national- and municipal development and the technology progression. The next aspect (Legislation) will be focusing on the legislation and regulation of PV in a Danish context, and finally how PV fits in the notion of an energy system based 100% on renewable energy technologies.

4.2.1 Development of PV

This paragraph serves as an overview for the development and status of PV's over the last decades up until now, both international-, national- and municipal-wise.

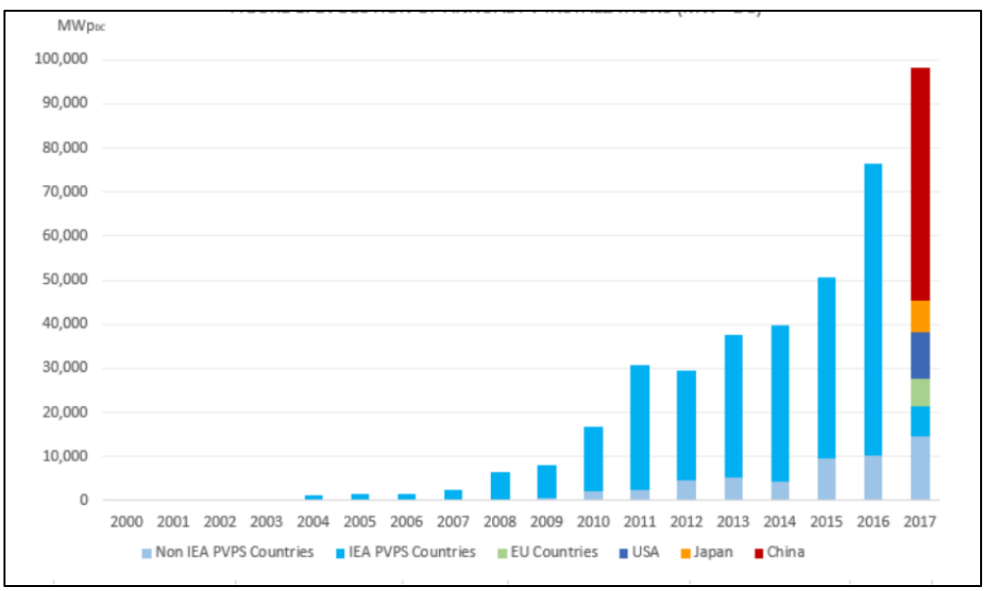
PV development in an international perspective

With the ever-present attention towards carbon neutral energy production, the PV technology has seen a remarkable growth in the last decade. A report from the International Energy Agency (IEA) estimates that the cumulative global PV installed capacity is 403,3 GW with almost every application grid connected by the end of 2017 (IEA PVPS, 2018). See graph 2:



Graph 2 shows the cumulative PV installations (GW) in the IEA PVPS Countries (IEA PVPS, 2018)

The growth of installed PV applications in 2017 broke the record from 2016, having almost a 33% increase of capacity with 403,3 GW PV. China is yet again the leading country for PV's having the largest installed effect by 131,1 GW. China is also in the first place for installing approximately 53,1 GW in 2017, placing the U.S. on a second place for installing 10,7 GW. Graph 3 shows the different contributors to the global PV installations:



Graph 3 shows the contributors towards the global PV installation in 2017 (IEA PVPS, 2018)

PV development in a national perspective

In early 2012, there were favorable and lucrative conditions for PV's, which is also reflected in the number of PV that were built in that period. According to figures from Energinet.dk, 70,221 PV systems were installed, corresponding to an effect of approximately 406 MW. This occurred, among other things, due to the net metering system, which will be presented in the next section of this analysis. But in 2013, there was a profound change in forms of support for PV, and in the following years the number of PV systems installed was reduced significantly, which meant that in 2017 there were only 2640 PV system installations that were built, corresponding to an effect of 60.2 MW. In the meantime, the government has replaced the net metering scheme with instant settlement which means that owners cannot store surplus electricity in the electricity grid anymore but must use the power when it is produced. Since 2012, there has thus been a declining market development for PV's, which is why more actors in the field believe that there should be some in-depth changes in relation to the legislation for PV (Mathiesen et al., 2017).

On the first of August 2018, the Danish Energy Agency estimated that there was a total of 100,251 net connected PV systems in Denmark with a total effect of approximately 968 MW. According to IDA's 2015 analysis "IDA Energy Vision 2050", they point out that in the future energy system more PV's should be installed up to 2035 and 2050. In 2035 the number of PV capacity is estimated to be 3,127 MW and in 2050 it is estimated to be 5,000 MW.

PV development from a municipal perspective (Copenhagen Municipality)

Over the last decade, the interest in PV has been fast growing for both municipalities and regions in Denmark (Ahm, 2017). This is derived from e.g. climate plans and ambitious goals of becoming carbon neutral by a certain year. Many municipalities have already installed PV's on municipal buildings like schools, sports facilities, kindergartens etc.

Copenhagen Municipality has also chosen to invest in a number of PV projects back from 2013, which has proved problematic after the government's law intervention, which deprives Copenhagen of the opportunity to produce and use the electricity itself, without paying taxes and VAT (value added taxes). In addition, a municipality must also allocate energy production in a separate power company, whereby the municipality has a share in the company, which requires extra administration. However, Copenhagen still works with the vision that PV's should contribute to the green transition of a sustainable energy system, together with other forms of fossil-free technologies.

There are many types of solar cells, and in Copenhagen, based on the typical characters of the roofs, there has been a focus on a number of specific solar cell types. These types are:

- BIPV
  - Red PV's on red tile (demo)
  - Black PV's on slate roof
  - Thin PV's on roofs and surfaces
- BAPV
  - PV's placed on flat roofs or with a certain slope mounted on a metal frame
  - PV's on facades

The next paragraph will deal with the development and changes related to legislation and regulation of PV's in a Danish perspective.

4.2.2 Changes in legislation and regulation of privately-owned and municipal-owned PV applications

4.2.2.1 Support schemes and public regulation for private PV application in Denmark

It is important to recognize that throughout the last two decades, PV's have received different kinds of support in terms of subsidy or favorable pricing, some more effective than others, which have resulted in the current state by which we observe PV's. This paragraph will elaborate some of the main changes in the regulation and support schemes in Denmark from 1999 until present time (2019) in order to describe the system context that affects the PV framework and a directly impact in the collaborative governance regime.

PV applications in Denmark came to be in the 1970's where the first project was a stand-alone project from Jyske Telefon developed as an energy source for remote telephone posts. The PV's were combined with a wind turbine, a battery and diesel generator (Beuse et al., 2000). This project was supported by the Danish Energy Research Program "EFP82" which was a program designed to create the technological solutions in Danish energy politics (Energistyrelsen, 2005).

1998 – 2004: First support scheme for private PV applications

After the stand-alone project from Jyske Telefon, several other PV projects were implemented, making PV technology development interesting for the government to closely follow. Later, additional residents in apartment buildings installed PV applications and began to understand how the electricity could sustain their consumption on sunny days, only to be provoked by the low price for power they sold to the national grid when producing too much. The low price of 60 øre/kWh was later discussed on a governmental level, and in 1998 the Danish parliament agreed upon the first support scheme for private PV applications on a four-year period. The support scheme was mainly focused on private homes, but non-commercial institutions was also eligible to use the support scheme. This scheme later became known as the '*net-metering scheme*' (Beuse et al., 2000). With the net-metering scheme it was possible to "store" the electricity production in the national grid when there was a surplus of electricity, and the ratio between production and consumption of electricity was accounted for only once a year, making the 'storing' option viable. This was especially effective when having surplus in the summer month and using the surplus in the winter month with low production from PV's. Up till 2004, the surplus electricity was sold to a feed-in-tariff (FIT) of 60 øre/kWh during the first 20 years of operation (Mathiesen et al., 2017).

2004 – 2012: The 60/40 scheme

During 2004, the scheme for surplus electricity was reformed so that any surplus of production would have a FIT of 60 øre/kWH within the first 10 years, and after that a FIT of 40 øre/kWh for the next ten years. This led to a time where the prices on PV dropped drastically up till 2012, but also an increase in both electricity price and taxes. These factors made it very profitable for the owner to invest in PV applications, which led to a significantly growth rate for installed PV applications in 2012 (Beuse et al., 2000) (Mathiesen et al., 2017).

2012 – 2018: Hourly net-metering

The direct consequence of the favorable conditions for PV's induced by the Danish parliament was an approved political agreement on the 20th of November 2012, with the purpose of reducing the support and subsidy for PV owners that made use of the net-metering scheme. This changed the practice of the net-metering scheme profoundly, making it only possible for people to "store" the surplus of electricity in the grid within the same hour the electricity was produced, thus naming it the hourly net-metering scheme (Methiesen et al., 2017) (Rigsrevisionen, 2014). This also meant that people who still wanted to make use of the 60/40 scheme was required to buy the PV application at latest the 19th of November 2012 and connect it to the grid the 31 of December 2013.

To make sure that people who invested in PV's on the premise of using the net-metering scheme still was able to contribute to the expansion, a so-called transition settlement was made with a FIT of 130 'øre/kWh for any surplus electricity production in a period of ten years. This FIT was reduced with 14 øre every year for ten years, that in the end surplus electricity would be sold to market price.

In addition, the net-metering scheme was to include all PV applications with a capacity lower than 400 kW, which also included land-based PV plants. However, short after this it became clear that larger PV plants would be able to receive the FIT of 130 øre/kWh, which was not the intention of the regulation. Some owners managed to divide the PV plant into sections of 400 kW which inevitable made them intitled to the settlement tariff. This meant yet another complementary agreement from the Danish parliament implemented in the 19th of March 2013, which enhanced the conditions for PV plants to only include roof mounted or building integrated PV applications with an effect of 6 kW corresponding to the consumption of a standard house (Rigsrevisionen, 2014).

All of the abovementioned agreements had not yet settled the massive expansion of PV's, and so another agreement was implemented in June 2013, which stated that only PV plants with the intention of supplying electricity to the owner was intitled the high FIT price and not PV plants whose intention solely was to sell the electricity for the settlement price. The scheme was furthermore limited to a total capacity of 20 MW/year in the period 2013-2017, a total of 100 MW (Rigsrevisionen, 2014) (Mathiesen et al., 2017).

2019 – ?: Instant net-metering

The latest political intervention regarding PV's are the implementation of the instant net-metering scheme from February 2019. This scheme ends the hourly net-metering scheme and accounts for the electricity produced immediately thus making the owner use the electricity once it is produced or to sell it to market price. It is PV plants over 6 kW that is affected by this new scheme opposed to plants under 6 kW who will still be on the hourly net-metering scheme until 2032 (Mathiesen et al., 2017).

Summary of support schemes for private PV application

To sum up the different changes over the last two decades in the support schemes for private PV applications, an overview can be found in the table below:

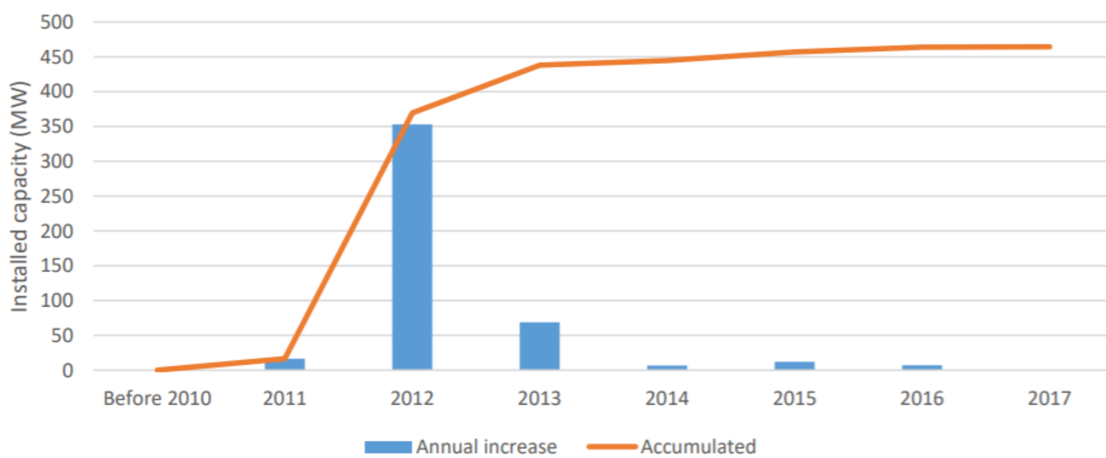
Time period	Net metering	Allocated FIT's
1999-2004	Yearly net-metering	Market spot price
2004-2008	Yearly net-metering	FIT of 60 øre/kWh for the first 10 years and 40 øre/kWh for the additionally ten years
2008-2012	Yearly net-metering	FIT of 60 øre/kWh for the first 10 years and 40 øre/kWh for the additionally ten years
November 2012	Hourly net-metering	130 øre/kWh the first 10 years, afterwards reduced yearly by 14 øre/kwh
March 2013	Hourly net-metering	Only private PV installations (roof mounted or building integrated) up to 6 kW is allowed the FIT of 130 øre/kWh
June 2013	Hourly net-metering	PV installations up to 6 kW would be entitled to the FIT of 130 øre/kWh and only for total capacity of 20 MW annually
May 2016	Hourly net-metering	Market spot price
February 2019	Instant net-metering	Market spot price

(Rigsrevisionen, 2014) (Mathiesen et al., 2017).

The next paragraph elaborates on the correlation between the installed PV applications and the regulatory changes induced by the Danish government.

Correlation between private PV applications and regulatory changes

As already mentioned, the profound changes in the regulation and settlement of private PV applications have had a significant effect on the amount of installed PV in Denmark. Graph 5 illustrates the correlation between the annual installed capacity of private PV applications as well as the accumulative capacity. It is worth pointing out, that the time period between 2012-2013 the installation of PV's was at the highest opposed to the following years were the slope begins to stagnate. See graph 4:



Graph 4 shows the annual development of installed PV capacity and the accumulative capacity (Mathiesen et al., 2017)

Next section describes the changes of settlement schemes for municipal owned PV application.

4.2.2.2 Political regulation of municipal-owned PV applications

PV separation in a private limited company

In 2013, the Danish parliament made a political agreement which entailed that whenever a municipality was operating PV applications, then this act should be viewed as an example of an electricity producing entity that is regulated under the law of Electricity Act (Mathiesen et al., 2017). This meant that a municipality was required to separate PV applications operated by the municipality in a private limited company (Ltd). However, a dispensation was giving from a settlement of 20 MW, which the 98 municipalities was eligible to use, but not guaranteed to receive due to the limitation. This settlement however was fully used the day it was introduced with 786 applications, whereas only 438 was offered the dispensation by a draw, leaving the rest to separate their PV plants. This shocked a majority of institutions already running-, or planning to implement PV's on their buildings, making the municipalities even more confused and angry with the government managing the situation. According to many municipalities back then, a lot of PV projects was in pipeline or was already implemented, making the business case of these projects less attractive, giving the circumstances of the municipality not being able to use the electricity produced without paying taxes and valued added taxes (VAT). A great debate also rose during this time, when complaints was stated against regional- and governmental buildings, since they were not supposed to pay taxes and VAT.

Deduction of block grands

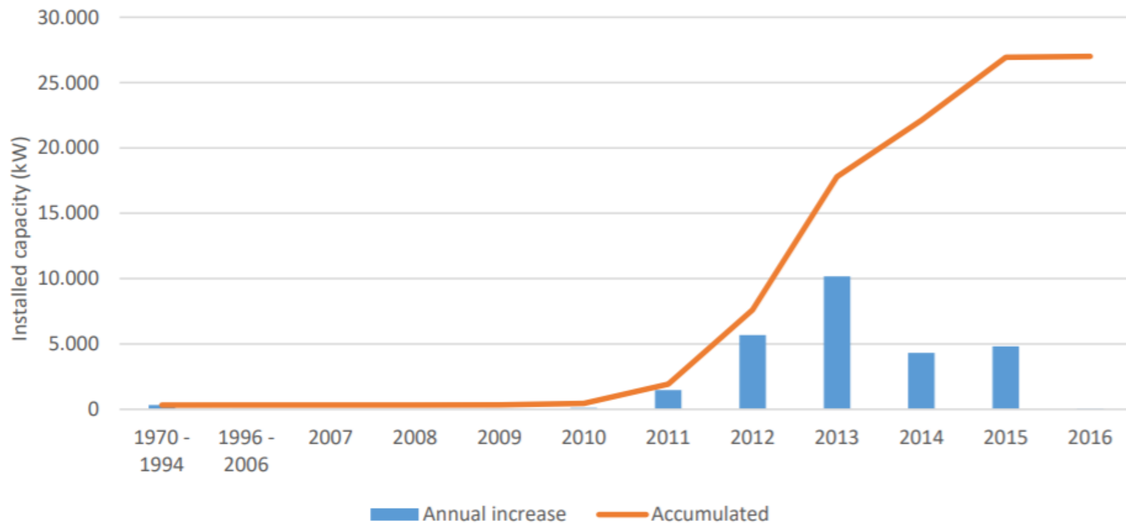
Another critical outcome of this concept meant that the profit of any municipal owned PV application would be deducted from something called 'Block Grands', which represents a specific type of subsidy from the Danish Government (Mathiesen et al., 2017). This concept can be found in the Electricity Act mentioned earlier and the deduction of block grands is controlled by the Danish Energy Regulatory Authority.

There are of course some cases of legal municipal owned PV applications, which does not result in block grands deduction. An example of this would be if the Ltd company was organized separately from the municipal administration (Mathiesen et al., 2017)

Correlation between changes in regulation and installed PV applications

One of the most significant changes in relation to municipal owned PV application is the concept of a Ltd company. In December 2014, the DEA notified and charged 76 municipalities for illegal PV plants to the state administration. This happened due to the government intervening with the new agreement ("whoops-legislation") (Wittrup, 2017), demanding municipalities with PV plants to separate them in a limited private company (ltd) owned by the municipality, unless they got a dispensation from the settlement of 20 MW (Mathiesen et al., 2017).

This effect can be seen on graph 5:



Graph 5 shows the annual development of the installed capacity of municipal owned PV applications and the accumulated capacity (Mathiesen et al., 2017)

Closing remarks

It is found that there is a correlation between the regulatory changes and the actual implementation of PV, where the changes led to drastic reductions in the implementation rate of PV in Denmark. The "stop-and-go" politics has affected the development significantly and, for all of the ownerships, it can be observed that the implementation rate has been reduced drastically and that very few PV applications were built between 2016 - 2017.

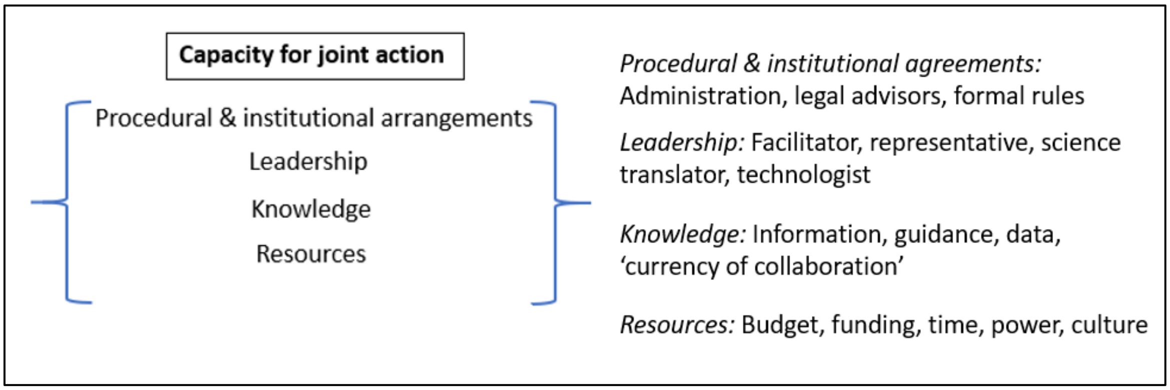
The following presents the first out of three paradoxes in this analysis:

PARADOX #1: Governmental "stop-and-go" policy

This paradox refers to the government's PV policy through the last two decades, where legislation and regulation have changed radically. This has slowed down the rate of installed PV and thereby the capacity for both private and municipal owned PV plants, which can be seen in the different graphs regarding private- and municipal PV applications.

The paradox comes to show because this is the outcome of a political process, where the government on the one hand wants to create optimal circumstances for the society to invest in renewable technologies, whereas the other perspective shows the government in a desperate position where they chose to make radical restrictions towards this technology. These are actions which contradicts themselves and causes the market to develop trust issues with the government, ultimately making it difficult for PV to play a role in the long-term future energy system if this is the standard procedure of handling an unforeseen PV growth.

The implication of this paradox affects the 'Solar Distrikt NV' collaborative dynamics in different ways, mainly in the *capacity for joint actions*. For the sake of convenience, box 1 shows the attributes for *capacity for joint actions*, which consists of sub elements illustrated with examples.



The formal rules of the system context, and thereby the *regime*, becomes unclear or difficult to comprehend. This is experienced through the conversations and observations in meetings and workshops, where residents and suppliers seem to be frustrated of the current changes in the PV legislation (See appendix 4). To fully understand changes in the PV legislation, a technical- and/or political translator is needed, as mentioned by Balogh et al., in order to comprehend what the changes brings with it. The last implication caused by this paradox relates to the element of *resources*, where funding or subsidies provided to PV projects in some cases are necessary for the completion. If these resources no longer are available to some extent, then certain PV projects will end up being paused or ultimately turned down, which feeds back into the ability to create *capacity for joint actions.*

4.3 The role of PV in the future energy system

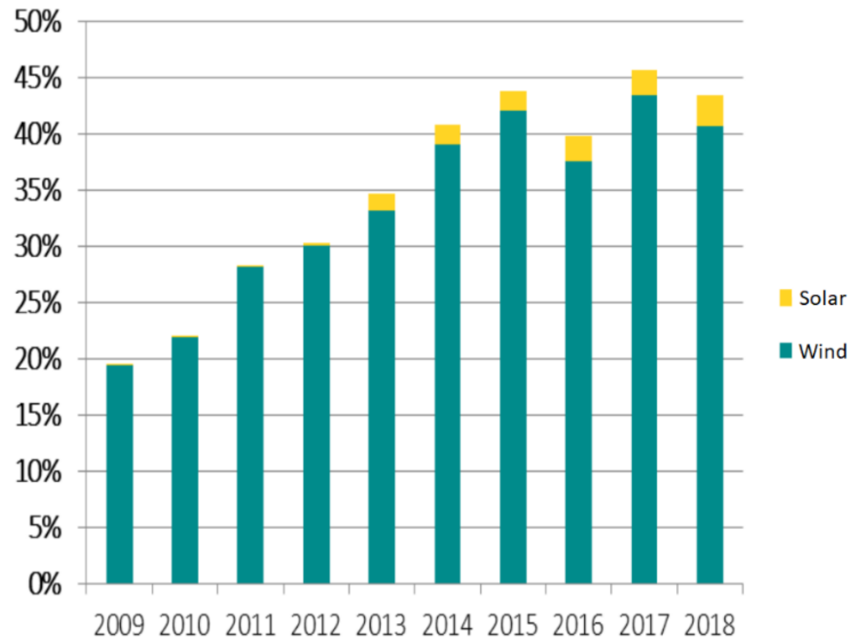
Throughout this thesis, PV technology is mentioned as one of the solutions Copenhagen Municipality pursues in terms of reaching their Climate Plan goal of 2025. Therefore, a brief explanation of how PV's fit into the existing energy system today and predictions of PV in future energy is in order.

Role of PV in the present energy system

The Danish energy system predominantly consists of the following energy sources; coal, oil, natural gas, waste and renewable energy sources (RE). Within the last segment of RE, this segment consists mainly of wind, solar, biomass and geothermal heat (Danish Energy Agency, 2018).

On the first of August 2018 the DEA announced that there was 100,251 PV net connected systems in Denmark with a total capacity of approximately 968 MW. PV technology (as mentioned in chapter 4) has increased in capacity over the last decade, and this supports the increased wind capacity, as wind and solar power synergizes in the overall energy system. One of the reasons for this synergy is due to the weather patterns in Denmark; if the wind energy output is low, generally the sun energy output is higher, thus complementing each other. Especially in the summer period, solar power is used to substitute powerplants and support CHP plants to produce only energy, because the need for district heating production is low (Mathiesen et al., 2012). Another reason worth mentioning is the cost of both technologies, which starts with a high initial investment, but with a long service life of these technologies, and a relative low operation- and maintenance cost (ibid).

Illustrated with graph 6, the share between solar- and wind power in Denmark shows that wind is still dominating with 40,7%, however, the share of solar power has increased over the last decade (from 0.3% in 2009 to 2.8% in 2018), and continues to increase according to several experts (Energinet, 2018).



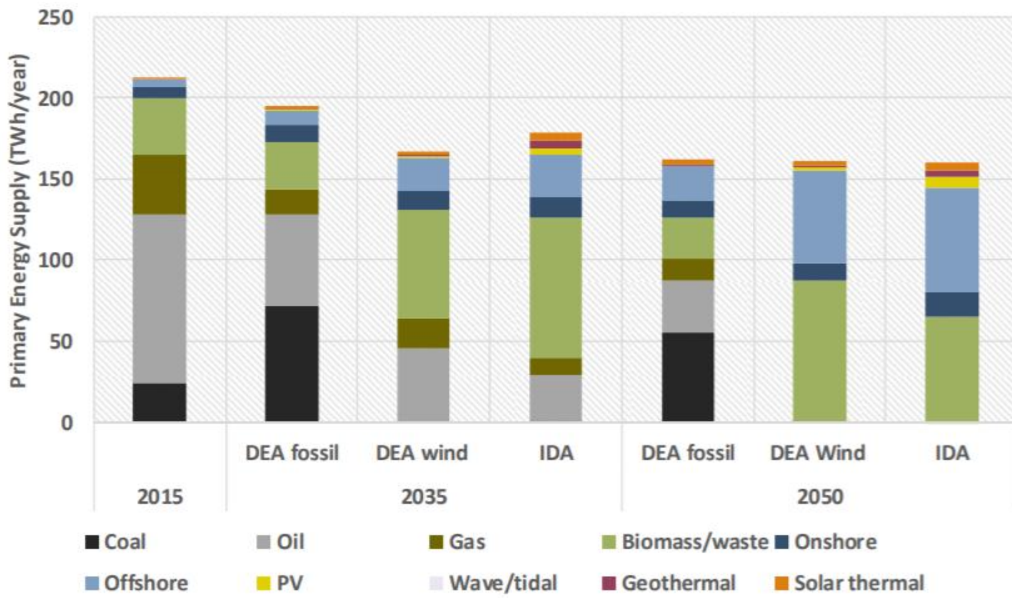
Graph 6 shows the share of wind- and solar power production compared to each other (Energinet, 2018)

Role of PV in the future energy system

In the annual ‘Energy and Climate Outlook’ from the DE, it is mentioned that the overall energy consumption in Denmark will increase alongside with an increase of the total RE share. PV technology continues to be a part of this constellation, and energy groups have conducted different analyses regarding the role of PV in the future energy system. One of these is the Danish associations of engineers (IDA), which has made a report elaborating how Denmark’s energy system can consist of 100% renewable energy resources.

According to IDA's 2015 analysis "IDA Energy Vision 2050", experts suggest that in the future energy system more PV capacity should be installed towards 2035 and 2050. In 2035 the amount of PV capacity is 3,127 MW and in 2050 it is estimated to be 5,000 MW. The figures reflect the opinion of several experts that 10% - 20% of the total energy production in the future must come from PV, as the technology achieves synergy with other forms of energy production, and reduces critical electricity overflow, where overproduced electricity is sold at a low electricity price on the market (IDA, 2015).

The 2015 IDA report compares different energy scenarios from the DEA with its own predictions, showcasing how the Danish energy system in 2050 based on 100% renewable energy resources would turn out. This is illustrated with graph XX, where PV technology (Yellow bar) is part of both scenarios:



Graph 7 shows different energy scenarios from the DEA and IDA, where PV technology is part of the overall energy system in 2035 and 2025 (IDA, 2015)

A closing comment on this topic will be an illustration of the overall energy system, illustrated in the different sectors of which PV would be a part. The illustration bellow illustrates how PV (the blue line) contributes to the electricity production in households and industry, heating production via heat pumps, and electricity in terms of producing hydrogen.

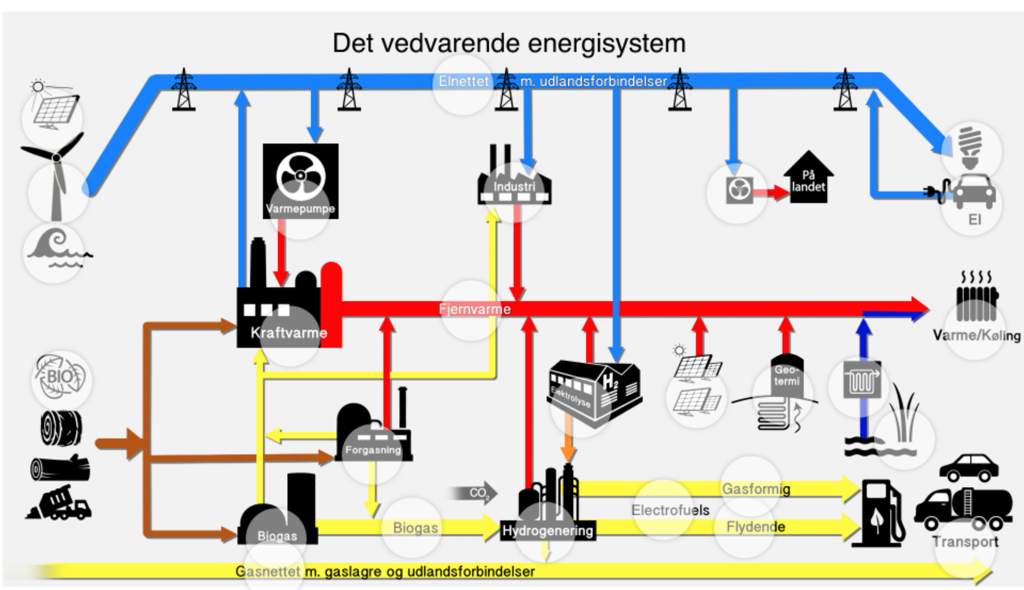


Illustration shows the overall energy system where the role of PV technology is illustrated (Videnomvind, 2019)

4.4 Collaborative governance regime of 'Solar Disktrikt NV'

The following paragraph describes the stakeholders related to 'Solar Distrikt NV', the drivers, barriers and paradoxes observed in the 'Solar Distrikt NV' project and an investigation of the relations characterising the establishment of the *collaborative governance regime*.

Figure 9 illustrates the scope of this part of the analysis by showcasing four of the important stakeholders (Residents, Experts, Suppliers, Copenhagen Municipality and the Danish Energy Agency) within 'Solar Distrikt NV', what their *collaborative dynamics* between each other consists of which may disturb the current collaboration and project to succeed. All of this is linked to the *collaborative governance regime* explained in chapter 3.

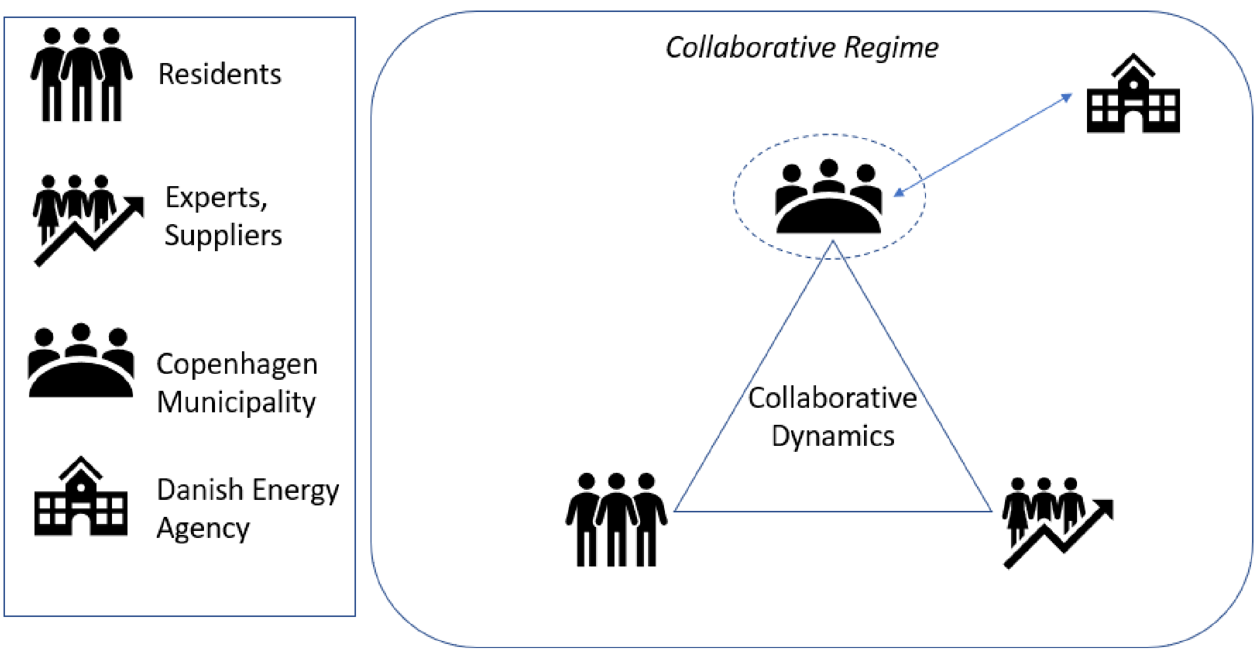


Figure 9 shows the collaborative regime consisting of the four stakeholders; Copenhagen Municipality, Residents, Experts & Suppliers and the Danish Energy Agency

4.4.1 Stakeholders

This section presents the four different stakeholders, starting with Copenhagen Municipality. For each stakeholder, their *collaborative dynamics* will be illuminated, thus pointing out strengths and weaknesses for each stakeholder and relation.

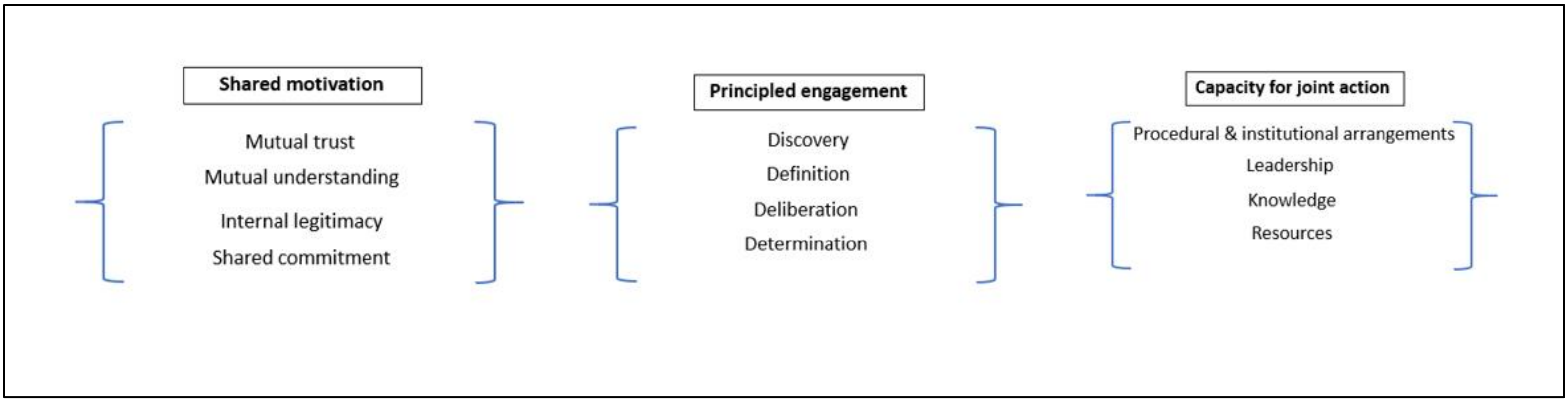


Illustration shows the three components of collaborative dynamics; Shared motivation, Principled engagement & Capacity for joint action (Balogh et al., 2011)

The three interacting components of collaborative dynamics is showcased above, which consists of; *Shared motivation, Principled engagement and Capacity for joint action* followed up by their individual elements (Balogh et al., 2011). These components will be described for every stakeholder with the addition of personal quotes from the stakeholders or observations made in their company, thus viewing their personal interactions in this collaboration.

Copenhagen Municipality

Copenhagen Municipality shares a bipartite role in the scope of the collaborative regime. Through 'Solar Distrikt NV', the Municipality is determined to encourage the people in Northwest to further investigate the potential of implementing solar photovoltaic (PV) on their building for economically- and environmentally reasons. On the other hand, the Municipality functions as the planning and building authority meaning they have to approve projects related to PV if this affects building with certain aspects, e.g. red tile roof, high heritage value etc. The Municipality is the link between residents, manufactures and suppliers when a dispensation is required, thus allowing a PV project to continue.

<u>*Principle engagement:*</u> In the last decade, the Municipality of Copenhagen have gathered multiple individuals, groups and other stakeholders with both individual- and shared interest, in order to create and streamline a common purpose, which the involved people agrees/relates with. Another indicator for engagement is the

determination shown from the Municipality by facilitating procedural decisions, e.g. setting agendas, establishing a work group etc., and trying to reach agreement on actions and recommendations.

This is also noticeable with the work done in 'Solar Distrikt NV', where Macnltyre explains that the past efforts of collaborating with both private residents and manufactures have paid off. She tells that:

"(…) you start seeing potential and start talking to building owners, that becomes awareness of this (ed. PV solutions), and we should make use of that (…). All of these things need to keep going, and keep the energy up, so more people come together and start talking (…)". (Macnltyre, 2019 [28:36-30:29]).

Shared motivation: Another important aspect is the shared motivation which is derived from 'Solar Distrikt NV'. Seeing different groups of people showing up for seminars and workshops indicate that people are curious to take part in this endeavour, and as Macnltyre explains, there is perhaps split interest across the different stakeholders, but there is also some interest that unifies these people:

"We have these strategies, we have a climate plan, that is all good and well but the thing that can bring us together and the thing that can actually change things and do things faster is this whole idea of climate breakdown, (…) but you absolutely need to have hope. That idea of hope and bringing together people, you can do something. (…) This crisis we are in, that can bring us together, and we need to communicate that to people without scaring them." (Macnltyre, 2019 [26:45-28:25]).

Capacity for joint actions: The administration of this collaboration is something that Copenhagen Municipality shares a vital role in, thus actively making sure that meetings, workshops etc. takes place, but also following up on these activities, managing the structure of the collaboration and making sure formal rules are being preserved. Managing this structure requires leadership, which is why Rachel Maclntyre is taking up the role as the leader in this collaboration, but with other leadership roles such as Mariann Andersson, who shares the facilitator role and contributes with funding from the Climate Secretariat. Both Macnltyre and Andersson also contributes with their knowledge and access to a large network, which they can consolidate with in terms of data or who to contact in certain situations (see appendix 4 & 5). Lastly, Copenhagen Municipality are contributing with resources in terms of funding, time (i.e. having employees working on this project) but also a certain level of power, which states their position in this collaboration.

Residents of NV

The fact that 'Solar Distrikt NV' is geographically placed in the Northwest of Nørrebro indicates that the residents living there are indeed important stakeholders to this project. The residents of the many different housing associations are curious towards the concept of having PV on the rooftops, which is why common people, general secretaries of different housing associations and technical advisors for the large housing associaitons (e.g. FSB, AKB and AAB) shows up to the events facilitated by Copenhagen Municipality.

Principled engagement: As stated by Rachel Maclntyre, the residents in Northwest has indicated that they are interested in investigating the possibility of implementing their own PV plants due to several reasons. One of them relates to the climate change awareness, which motivates people to focus on how to change their carbon footprint. Another important reason is the business case of investing in PV plants, which will affect the electricity bill, reducing the cost of the electricity consumption, both private and in shared appliances e.g. hallway lights, washing machine etc. The residents that participate in this collaboration are also engaging Macnltyre, Andersson and the experts and suppliers present at the events mentioned earlier, which entails that the residents shares a feeling of a 'safe-space', where they can ask difficult question and have constructive dialogue with the other stakeholders (see appendix 4).

Shared motivation: It is difficult to state the resident's clear commitment towards this project, due to the limited meetings where they have been invited. This is also affected by their stability towards engaging this project, because it very much depends on the voluntariness of that person, to continue the engagement and devoting personal time resources to this project (see appendix 5). Maclntyre explains in the interview why it is difficult to for residents to engage themselves:

> "(…) because they sit in the committee and it is their free time (…) unless they are 'enthusiasts' it is hard to make people come (…)." (Maclntyre, 2019 [31:46 – 33:03]).

When it depends on the level of voluntariness, it makes the collaborative process vulnerable for the shared motivation if people don't show up and support this project.

Capacity for joint actions: The abovementioned vulnerability from the lack of shared motivation among the residents in Northwest is something which affects their capacity for joint actions, because this requires necessary structures that manages the repeated interactions over time (Balogh et al., 2011), and there are no official representative for all of the residents because of the amount of different housing associations. Another important factor for joint actions is the level of knowledge or information regarding this case, and based on the meetings held by the Municipality, it seems that it is very difficult for residents to comprehend the complex process of investing in- and installing PV (see appendix 4 & 5). It also comes down to the amount of resources invested in this project, both time and cultural wise, which relates the quote from MacIntyre regarding the difficulty of making the residents engage in this project.

Suppliers and experts of PV

During the internship and the making of this thesis, a great deal of experts, suppliers and manufactures have contributed to 'Solar Distrikt NV' by attending intern meetings within the municipality, but also the official meetings mentioned. This group of stakeholders are deeply connected in the PV development and commercial activities, which makes them important to Copenhagen Municipality as an ally in this project. The group mainly consists of a collaboration with Solar City Danmark and KUBEN MANAGEMENT, but also with a freelancer reporter and PV expert, Steen Hartvig, who is dedicated towards expanding the PV capacity in Copenhagen.

Principled engagement: The abovementioned group of experts and suppliers have shown ever since the internship period up till now, that they are willing to engage in this project. They have a shared interest in seeing an increase of the existing PV capacity, not only the traditional PV plants, but also building integrated PV (BIPV). There is also a shared purpose of making the Northwest area a showroom for BIPV projects, that will encourage other developers to consider similar investments. This group also have good personal relations with Rachel MacIntyre and Mariann Andersson, which encourage constructive dialogue and critical questions to be asked (see appendix 4 & 5).

Shared motivation: As mentioned before, this stakeholder group have shown commitment throughout the project period and are still engaged in 'Solar Distrikt NV'. This indicates stability, and even though this groups position in this project also reflects their interest in profit, MacIntyre explains that:

> "(…) Yes, the manufacturers want to make money, but most of them can see the climate and environmental perspective. They want to make it as easy as possible to place PV's on the roof". (MacIntyre, 2019 [20:35 – 28:25]).

This is also observed in many of the intern meetings in the Municipality, where this group of stakeholders shows a genuine interest that crosses the structural boundaries that might be between private and public stakeholders.

Capacity for joint actions: These groups of suppliers and experts are being administrated by their own company, which entails that there exists a necessary organisational structure that manages them to repeat this interaction over a period of time. This matter because it means that they are representative and facilitators, led by their respective superiors who funds their effort and support their engagement. However, sometimes at the internal meetings in the Municipality it became clear that these participants also have other projects to attend to, which means that money or profit also affects how much time they invest in this project (see appendix 4 & 5).

Danish Energy Agency

While describing the main stakeholders of the 'Solar Distrikt NV' project, e.g. residents, experts & suppliers and the municipality, it is also important to mention the Danish Energy Agency (DEA). This is due to their authority regarding the legislation of PV, which undoubtedly affects the relation and outcome of the established collaboration. However, the DEA is not partaking an active role in this matter, rather they are perceived as a passive stakeholder that does not directly interferes with the collaboration, but still shapes the system context of the collaboration as explained in chapter 3. While being an important contributor to the framework of PV, the DEA acts as the authoritative body.

As mentioned, the DEA is not per se an active stakeholder in this case, however, as Michael Madsen from the DEA mentions, their job:

"(…) *consist of working with net metering that for now is instant settlement, but that are still a lot of work with the way of working with the old settlement, and how they fit in the new settlement, (...) we spend a lot of time working with the old way of handling (red. PV's)."* (Madsen, 2019 [09:05-09:54])

In other words, their role is to manage the new instant settlement (ed. Instant net-metering) mentioned in chapter 4, in regard to the old settlements which some people still are benefiting from. Another important aspect of the DEA's position is the new concept of technology neutral tenders, which Madsen elaborates:

"The vision is no longer technology specific (...), in 2018 and 2019 we have the technology neutral tenders. With the Energy Agreement from June 29th, 2018, these technology neutral tenders are planned to continue from 2020 to 2024. It is the market that decides which technology the energy system will consist of (...)". (Madsen, 2019 [10:40 – 11:35])

This explains that the DEA does not favour a particular renewable technology group, but instead looks at the development and demand in the market. However, the prior history of changing the PV legislation have made its mark on the PV market as mentioned in chapter 4, which still indicates that the DEA can cause profound impact in this project.

Closing remarks

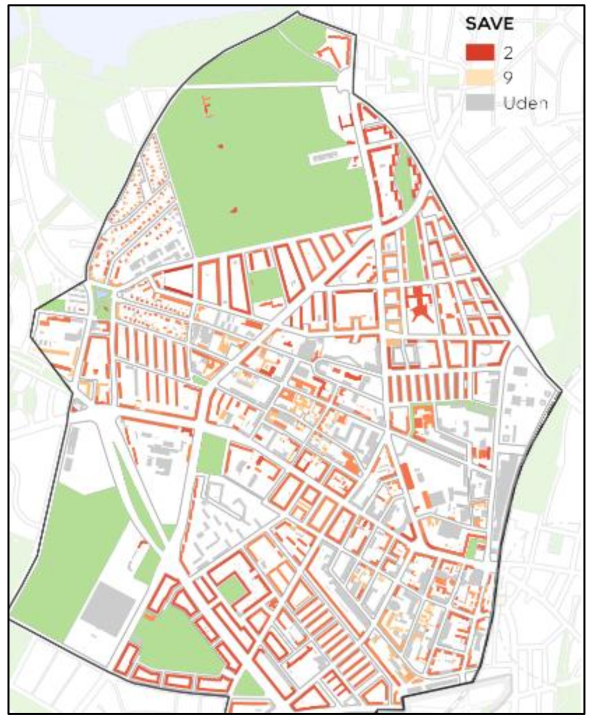
Although this project is still in the start-up fase, different barriers and dilemmas evolves to become paradoxes for the stakeholders to deal with in the collaboration.

The following presents the second out of three paradoxes in this analysis:

Paradox #2: Copenhagen Municipality's bipartite role as building authority and energy planning authority

Internally, Copenhagen Municipality deals with the responsibility for the buildings architectural and aesthetic design. This means that several demands are posed by the municipality, in order to maintain a cohesive building standard, which fits the overall picture. However, these demands are in most cases of PV or BIPV making it difficult to proceed with the project, thus removing the incentive to plan for PV in general.

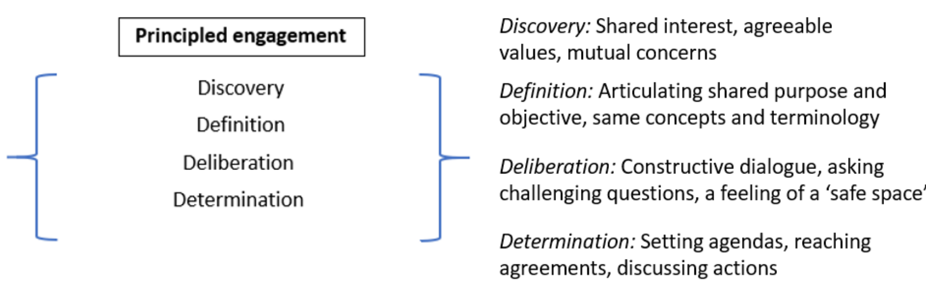
Macnltyre acknowledges this, stating that: *"(…) Probably the most limitations (ed. Planning for PV) are aesthetics and heritages values, it is what we meet all the time."* (Macnltyre, 2019 [01:02-02:28]).



She continues to say that: *"The first thing you get meet with is the heritage value, buildings with this high value, and people the other day asked where our sense of urgency was. (…) We have some good aesthetic solutions now, but it is still difficult because we focus a lot on this."* (Macnltyre, 2019 [25:05-26:33]).

It is necessary to view the heritage value of the individual buildings where the potential of implementing PV is significant. A relatively large proportion of buildings in Copenhagen have a high conservation value, which is labelled with a 'SAVE value'. Buildings with a SAVE value from 1-4 are considered to have high conservation value, and the number of these differs from district to district. A section from Northwest on Nørrebro to the right shows that there is a high number of buildings with the SAVE value "2". This makes it difficult to make major changes in the architectural appearance of the building, and therefore there is a particular need to work with architects on the development of PV and BIPV.

The implication of this paradox affects the 'Solar Distrikt NV' collaborative dynamics in different ways, mainly in the *principled engagement*. Box 2 shows the attributes for *principled engagement* with related sub elements.



With the acknowledge bipartite role of Copenhagen Municipality, agreeable values and shared interest risks of being compromised because of dispersed interest (e.g. Department of Buildings in the Municipality prioritizes in many cases building architecture and building heritage value more than e.g. the Climate Secretariat and their goals related to energy planning). This affects constructive dialogues and reaching agreements, which

MacIntyre explained in her quote. If this is the future of deciding between these two choices, then it backfires on the concept of *principled engagement*.

The last paradox takes it origin in the dilemma of resources.

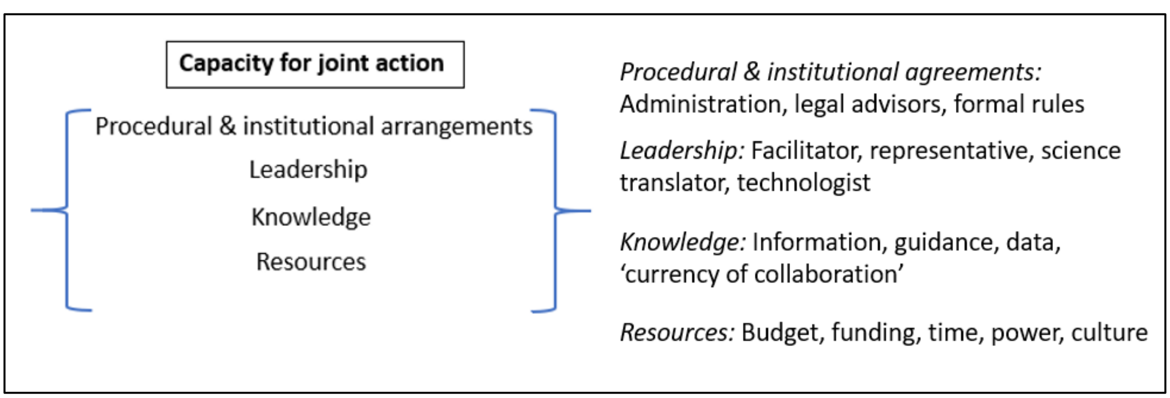
Paradox #3: Limited resources

Another dilemma is the 'time aspect' of this project, which MacIntyre elaborates:

"Our time is very limited (…). We need a strategy, and I feel after the workshop, the manufactures, producers, they want things to be delivered, but I'm trying to put the ball over to them. (…) We cannot be the only ones being responsible for ringing round to every single building owner in NV because it takes so much time. (…) And now they are pushing for the internal process and that is really hard, that takes time, and that is what Mariann is working with. (…) They are pushing for a very short process-time, they want a task force that looks at PV." (Macnltyre, 2019 [12:45-17:05]).

It is clear from this quote that time restriction is something which MacIntyre and other associated employers are subjected to. This gives an understanding from the observer's perspective, that time- resources and limitations are a serious matter when it comes to projects like 'Solar Distrikt NV'. MacIntyre realizes this and explains that they cannot be the only ones to perform this task, if they are to succeed.

The implication of this paradox affects the 'Solar Distrikt NV' collaborative dynamics in different ways, mainly in the *capacity for joint actions*, which box 3 presents.



With few resources, the collaboration and its main stakeholders' risks getting fatigued, thus slowing the process down or in worst case terminating the project. In the long-term collaboration, few resources can end up offsetting the *capacity for joint actions*.

4.4.2 End summation of the analysis

During the analysis, three paradoxes have been highlighted in order to explain the complexity of the collaboration found in 'Solar Distrikt NV', but also why this project might increasingly face profound difficulties achieving the pursued objective, if not dealt with these paradoxes.

Table 3 summarizes the three paradoxes found:

Paradox	Capacity for joint actions	Principled engagement	Shared motivation
Governmental "stop-and-go" policy	• Formal rules e.g. legislation and regulation are made more unclear • Requires stakeholders to have a science- and/or lawyer translator • Uncertainty regarding subsidies and/or funding towards PV projects in the future		
Copenhagen Municipality's bipartite role regarding building authority and energy planning authority		• Contradictory interest and values when dealing with heritage value and architectural solutions	• Contradictory in mutual trust, mutual understanding and shared commitment when dealing with PV projects
Limited resources makes it difficult for 'Solar Distrikt NV' to continue	• Resources are limited, e.g. time, people, budget, power • Few resident representatives		

Table 3 shows the three main paradoxes that threatens the collaboration if allowed to continue unanswered

5.0 Discussion

Throughout this thesis, the chosen theory and methods have had certain impacts on the analysis, which will be discussed in this chapter. The discussion is structured based on 1) the results in a theoretical perspective, 2) the methods used.

5.1 Results in a theoretical perspective

The presented analysis in chapter 4 was structured by using the theory 'Collaborative Governance' and Balogh et al.'s integrative framework approach. The integrative framework presents collaborative governance in three-nested dimensions, e.g. system context, collaborative governance regime and collaborative dynamics and actions. This structure was used on the case of 'Solar Distrikt NV' to illustrate how to operationalize Collaborative Governance in practice, thus showcasing the dynamic and iterative processes that takes place in a collaboration between private- and public stakeholders, and the complexity of an established collaboration with all of its internal dynamics which impacts the outcome of the collaboration.

By using the theory of Collaborative Governance and its integrative framework as a logic model, Balogh et al. arguments that it can be used to analyse and test the input and output of a collaboration, such as 'Solar Distrikt NV'. In other words, the model becomes a tool for evaluating the project and its performance, which is important for the stakeholders participating in the collaboration, but also to people outside of this framework, observing a case for collaborative governance.

It is difficult to state how successful this collaboration has been or will be, let alone the relations between each stakeholder and giving the depth and magnitude of the different components and factors that affects and shape the collaboration. Another critique of using *Collaborative Governance* is the time aspect, and the time spend on observing this collaboration. It is clear that a period of four months is not enough time to fully gain insight of these complex relations. However, it can be argued that through the analysis of the 'Solar Distrikt NV' case and with the knowledge gathered from an internship and a continued parallel collaboration, this position presents a decent precondition towards handling, discussing and making claims of the findings of the analysis.

5.2 Results based on methods

Certain methods have been used during this thesis, and the findings in the analysis are based on a case study, specifically the case of 'Solar Distrikt NV'. Selecting this case was based on the experience from the internship, which introduced this collaboration that fitted well with the premise of *Collaborative Governance*. However, it is important to note that generalizing based on a case study can lead to the risk of being biased (Flyvbjerg, 2006). Though actively selecting this case can result in showcasing how collaborations such as 'Solar Distrikt NV' might be observed in a Danish context, thus making it a strong example of the complexity of a private-public collaboration.

Interviewing certain persons and neglecting others have also affected the outcome of this analysis. Three semi-structures interviews were carried out, starting with the project leader Rachel MacIntyre, an employee from the DEA, Michael Madsen and a developer manager from HOFOR, Hans Jakob Martinsen. These three was selected based on a specific role they have in this case, but other stakeholders were also interesting interviewing: a resident from Northwest and a supplier or PV expert. Instead of interviewing these stakeholders, observations and small conversations made during intern and official meetings was used to exemplify their roles. These observations are supported by quotes from the interviews that was carried out, so that, despite not having the information directly from the stakeholders themselves, still can serve the purpose of useful insight.

6.0 Conclusion

This chapter presents the collective conclusion found in this thesis and thereby the answer to the problem formulation:

Based on the theory of collaborative governance, what are the framework conditions of implementing PV in Copenhagen Municipality's private housing segment, e.g. social- and renting housing grounded in the specific case of 'Solar Distrikt NV' and what possible drivers, barriers and paradoxes may affect this collaboration and the pursued objective?

When analysing the national framework conditions on solar photovoltaic (PV), the "stop-and-go" policy in the legislation and regulation have proven to be one of the crucial key points towards the perception of PV technology today. This has also led to a decrease in PV projects in Danish municipalities, due to the taxation of electricity produced by municipal operated PV and the difficulty of administrating PV plants in a separated, municipal owned company. This development in the framework has decreased the rate of implemented PV projects and caused a trust issues in investing in PV.

However, Copenhagen Municipality are still working with PV in their Climate Plan, and one of their PV projects relates to 'Solar Distrikt NV', which is a collaboration between public and private stakeholders, including governmental actors from the Copenhagen Climate Secretariat and Copenhagen City Development. This project focusses on facilitating a process on which the residents in Nørrebro Northwest area are encouraged and guided to seek out the possibility of investing in PV plants on their own residential building, with noticeable benefits such as lower electricity bill or acting upon climate changes.

The collaboration between the Municipality, the Danish Energy Agency, Residents and the Suppliers are described through the theory of collaborative governance, where the system context, the collaborative governance regime and collaborative dynamics and actions for each stakeholder is crucial to understand. Especially the collaborative dynamics indicates how well the established collaboration are structured and sustained among the stakeholders. It becomes clear through the interview and observations that the four important stakeholders are finding common ground when it comes to the green transition, an urge to improve the existing regulation for PV and the sense of a greater good regarding climate change actions. However, in this collaboration, barriers are also important to acknowledge, due to their impact on the pursued goal, which in this case are the limitations caused by the voluntariness which the residents are subjected to, a lack of technical knowledge regarding PV implementation, and continuation of supporting the project. But most importantly, there are steering paradoxes that affects the collaboration and thereby the pursued outcome, which is found to be: 1) the legislation and regulation of PV in Danish municipalities regarding taxations and operation duties, 2) internal contradictions due to Copenhagen Municipality's bipartite role as the building authority (e.g. handling of building architecture and buildings with high heritage values) and the role as energy planning authority, that needs to pursuit shared objectives and finally 3) the limiting effect of few available resources in terms of employees working on the PV goal of 2025, budget cuts due to fixed assets and few residents to empower the collaboration. These steering paradoxes presents the complexity and fundamental dilemmas in a municipality that seeks to do energy planning with PV technology, not only on municipal buildings, but also PV implementation in the private housing segment.

If Copenhagen Municipality wants to succeed in this collaboration, it takes profound changes of the Municipality's role as a planning authority with sometimes contradictory priorities, but also contribute to an effort in order to impact an external context such as the legislation of the PV technology.

7.0 Proposition towards a new collaboration

Based on the analysis results of the collaboration in 'Solar Distrikt NV', it is clear that such collaboration is comprehensive due to several reasons, one of them being the residents in Northwest and their role of investing in PV. As mentioned, the buildings of which the residents live in are in most cases owned by a third-party group, e.g. a housing association company, and there are many residents in a single apartment building, who needs to agree collectively on a large investment such as implementing PV. These factors play an essential role regarding the time perspective or deadlines, which in this case is 2025.

This chapter will present the fundamental proposition of having a collaboration between Copenhagen Municipality, HOFOR, owners of industry- and business buildings. This proposition will be followed by thoughts and reflections from the interviewed persons mentioned in chapter 3 towards this new collaboration and elaborate how this could benefit and complement the already existing projects regarding the expansion of PV capacity in the private housing segment.

7.1 Proposition

This proposition will be focusing on having a taskforce or workgroup consisting of Copenhagen Municipality, technical advisors from HOFOR and the knowledge from PV experts and suppliers, in order to facilitate a collaboration with different companies or industries whose property or building presents a large, coherent and suitable rooftop for PV, and is within the borders of Copenhagen. This proposition could enforce a greater and more detailed investigation and analysis for suitable rooftops in Copenhagen, but with a different building segment than in 'Solar Distrikt NV' case. This proposition is aiming at companies and industries who are willing to make an impact regarding green transitioning towards renewable energy production, such as the tendencies described in chapter 1 explains.

7.2 Thoughts and reflections on this proposition

Rachel Maclntyre's response

During the interview with Rachel Maclntyre, I presented this proposition of having another collaboration with a different building segment than the one in 'Solar Distrikt NV', to which she responded positively:

"I think it is a great idea, because we want to take these focus meetings that will be the last meetings, but at the moment I don't think we have spoken to people that have industry buildings in NV. I think after the meeting with Boparken and FSB, that is a possibility and you can take that idea up. (…) There is a huge potential to get

PV up, and they (red. Companies, industries) use the energy during the day so it makes perfect sense. (…) It would be a good idea to have a meeting with them or a workshop (…)”. (MacIntyre, 2019 [38:39 – 40:30])

MacIntyre responds to the fact that they have not yet contacted stakeholders with relation to industry- or company buildings in Northwest, which she is openminded for. Another important mention is that she acknowledges the concept of industry- or company buildings having a large potential, typically due to their unused rooftop space or the fact that they use the electricity during the peak hours or when the electricity production is at its highest.

Michael Madsen's response

As an employee in the DEA, Madsen takes reservations on commenting on any particular proposal of PV applications. However, in relation to his comment on how the DEA focusses on technology neutral tender, he acknowledges that especially large PV plants have gathered momentum concerning efficiency and a decrease in cost. The stakeholders of these industry- or company buildings would in some cases have access to a large disposable are, on which they could implement PV. Another important fact to consider is that these larger (liberal) companies only have to pay a small tariff called 'process tariff' opposed to the taxation a municipality might have to pay (without a Ltd company), which can increase their incentive for PV applications:

“You can encourage companies to invest in solar PV because they are not regulated in the same way as the municipalities (paying taxes of own produced energy red.). Before the energy agreement, it was only so-called process companies that was not affected by the taxation, but now so-called liberal professions is also affected by the process taxation, which is a electricity tariff of 0.4 øre/kWh (...)”. (Madsen, 2019 [53:16 – 55:00])

Usually when it comes down to the business case, a private company will look towards a short payback time when investing in something that is not their core value (Madsen, 2019). Without the considerable taxation to pay, a company investing in PV applications could prove to be a reasonable business case.

Hans Jakob Martinsen's response

It has been established in an earlier chapter that Copenhagen Municipality have appointed HOFOR the task of analyzing and evaluating business cases for PV projects and monitoring the market regarding the prices. In the interview with the developer manager from HOFOR, Hans Jakob Martinsen, he too responded positive towards the proposal of a different collaboration that included HOFOR's technical experience. When asked what his opinion of a public-private collaboration was, he stated that:

"(…) it is not our core competence - We would not succeed with establishing a project (ed. Only with HOFOR as the facilitator) (…). But we could collaborate with the municipality, because they have the contact with industries and private citizens." (Martinsen, 2019 [42:38 – 43:30])

He continues to reflect on this collaboration, with the premise that Copenhagen Municipality maintains it role as the facilitator, to which he replies:

"That would be possible, it depends on what the business case is, how we can synergize with the municipality. But that said, it sounds realistic. It could be a task force, where we could contribute (…)." (Martinsen, 2019 [43:42 – 44:30])

Closing remarks

Based on the responses receiving in the presented interviews, it can be argued that this type of collaboration could be realistic if facilitated by the right actors. This collaboration would of course not overpower the project in 'Solar Distrikt NV' but rather it would become a parallel project with the same objective of increasing the capacity of PV in Copenhagen Municipality, and perhaps with better conditions than the conditions found in the private building segment.

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9.0 Appendix

Appendix 1: Interview guide for Rachel MacIntyre

Appendix 2: Interview guide for Michael Madsen

Appendix 3: Interview guide for Hans Jakob Martinsen

Appendix 4: Notes and observations from meetings

Appendix 5: Workshop notes

Appendix 6: Template for PV

Appendix 7: Preliminary PV analysis

To access the mentioned appendices, see link:

https://drive.google.com/drive/folders/1tObIZOZ8yNcGxHo39XClopUGzWkwlnnh?usp=sharing