EMPOWERING LOCAL CLIMATE ACTION

PRELIMINARY ANALYSIS OF MUNICIPAL ACTION PLANS IN THE REGION OF SOUTHERN DENMARK

Region Syddanmark

SDU University of Southern Denmark
UNESCO Chair on Urban Resilience

unesco Chair

SCC SDU Climate Cluster

AALBORG UNIVERSITY

Coordinators: Vita Jakumsen[1] & Jacob Pedersen[1]

Authors: Nicola Tollin[2], Martin Lehmann[3], Clarissa Attombri[2], Simon Wyke[3], Thomas Skou Grindsted[4]

Contributors: Anna Brigitte Deeg[3], Maria Pizzorni[2], Philip Mc Kay Boyle[2]

[1] Region of Southern Denmark

[2] UNESCO Chair on Urban Resilience and SDU Climate Cluster, University of Southern Denmark

[3] Aalborg University

[4] Roskilde University

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ACRONYMS AND ABBREVIATIONS

AFOLU	Agriculture, Forestry, and Other Land Use
BBR	Bygnings-og Boligregistret (Building and Housing Register)
CAPF	Climate Action Planning Framework
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
GHG	Greenhouse gases
KKR	KommuneKontaktRådet
KPIs	Key Performance Indicators
MoI	Means of Implementation
MRV	Monitoring, reporting and validation
MtCO2e	Million tons of carbon dioxide equivalents
PtX	Power-to-X
RCP	Representative Concentration Pathway
RE	Renewable Energy
SDGs	Sustainable Development Goals
SDU.Resilience	UNESCO Chair on Urban Resilience

EXECUTIVE SUMMARY

This report was prepared for the Region of Southern Denmark (RSD) by the UNESCO Chair on Urban Resilience of the University of Southern Denmark (SDU.Resilience) and Aalborg University. It offers a view on the status of the planning of climate mitigation and adaptation – climate action - in the 22 municipalities in Southern Denmark who through the DK2020 project have developed their plans according to an adaptation of the C40 Climate Action Planning Framework (CAPF). The first plans were produced in 2020, the last one in early 2023.

Over 100 indicators were developed to extract data from the climate plans and other additional documents, with the following objectives:

- Produce an overview of the current planned efforts, their potential effects, and a stakeholder engagement analysis.
- Identify key challenges for the development and implementation of the climate action plans.
- Prepare a set of recommendations for responding to identified challenges, focusing on initiatives that can be brought into play in the cooperation in and between municipalities, KommuneKontaktRådet (KKR) and the Region.

This report presents a preliminary analysis of the plans. The analysis was conducted from March to July 2023, and provides basis for a second stage where missing data will be integrated, and barriers and potentials further investigated.

The work has been performed in continual dialogue between the Region and the academic institutions, counting five meetings until the delivery of the final report.

Following are key findings:

1. The total value of regional emissions in 1990 amounts to 22.3 MtCO2e, while the current to 13.16 Mt CO_2e.
2. The regional residual emissions by 2030 amount to 6.56 Mt CO_2e, 1% better than the 2030 national target
3. The regional residual emissions to achieve climate neutrality by 2050 amounts to 4.06 Mt CO_2e (82% of the target).
4. Climate risk assessments included the risk of risk of flooding in the totality of the municipalities, drought in 16 cases, extreme wind in 10, temperature rise in 13, heatwaves in 14, coastal erosion in 9 and wildfires in 8.
5. Exposure, vulnerability and loss and damages are mostly assessed for the risk of flooding.
6. The majority of actions prioritize the risk of flooding (16 counts), followed by temperature rise and drought, and heatwaves.
7. For each action, almost all municipalities clearly indicated the actors, existing budgets in some cases, budgets were indicated for each action. In other cases, only potential funders were annotated, or budgets were identified only in general to respond to action sectors.
8. Eight municipalities did not list the KPIs for monitoring their implementation and evaluating effects.
9. The most common barriers include:
    a) Lack of support for climate action from international frameworks and national legislation.
    b) Competing uses of land and schemes, motivating landowners towards different pathways.
    c) Lack of financial resources.
    d) Dependence of voluntariness.
    e) Uncertainty in necessary timely technological advancements and data availability.
    f) Knowledge gaps on climate-related topics within the local administrations.
    g) Insufficient local support due to lack of general awareness on climate issues.

INTRODUCTION

Denmark aims at contributing to the Paris Agreement by achieving climate neutrality by 2050. National targets are in place to reduce GHG emissions by 70% in 2030, compared to emissions levels in 1990, which is equivalent to a reduction of 55% GHG emissions from 2018 to 2030.

The DK2020 project was started to provide a common framework for all Danish municipalities to develop climate action plans – covering both mitigation and adaptation – that align with the national targets. The municipalities participating in DK2020 have been developing the climate action plans in three different rounds:

- Pilot project (2019): 20 municipalities (5 in the Region of Southern Denmark). The twenty pilot plans were assessed in 2022, analyzing in particular the emission reduction efforts, to understand if the plans have higher ambitions than the national level policies (Ea Energianalise, 2022).

- Round 1 (2020): 44 municipalities (14 in the Region of Southern Denmark).

- Round 2: (2021) 31 municipalities (3 in the Region of Southern Denmark).

Figure 1 shows at which round the municipality of the Region of Southern Denmark initiated their involvement with the DK2020 project.

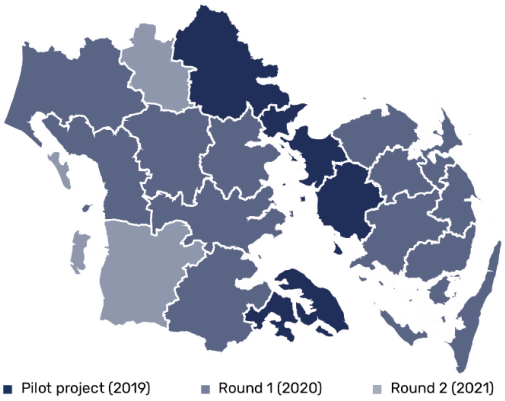

Figure 1: Municipalities in the Region of Southern Denmark according to the different rounds of involvement to the DK2020 project.

The objective of this report is to produce a preliminary overview of the current local climate action efforts, considering both climate adaptation and mitigation, and to identify key challenges in the developments of the plans and in their implementation.

The report aims at supporting the harmonization of the climate plans and at strengthening cooperation at regional level by developing recommendations for the Region of Southern Denmark on how to address key challenges in the development and implementation of the local climate action plans.

This preliminary analysis will be followed by an in-depth assessment, expanded to all relevant documentations related to the climate plans, and a wider engagement of stakeholders, through interviews and surveys. The in-depth assessement will produce further insight and a set of recomandations for the Region of Southern Denmark on how to continue and strenght its support for the development and implemeantation of the local climate plans.

The work is developed through a collaboration among the Region of Southern Denmark, the UNESCO Chair on Urban Resilience at the and the Climate Cluster at the University of Southern Denmark, and Aalborg University.

1. METHODOLOGY

The preliminary analysis of the municipal climate plans for the Region of Southern Denmark combined the review of the local climate plans, and related technical documents, with scoping interviews and a survey.

1.1. Local Climate Plans and Technical Documents

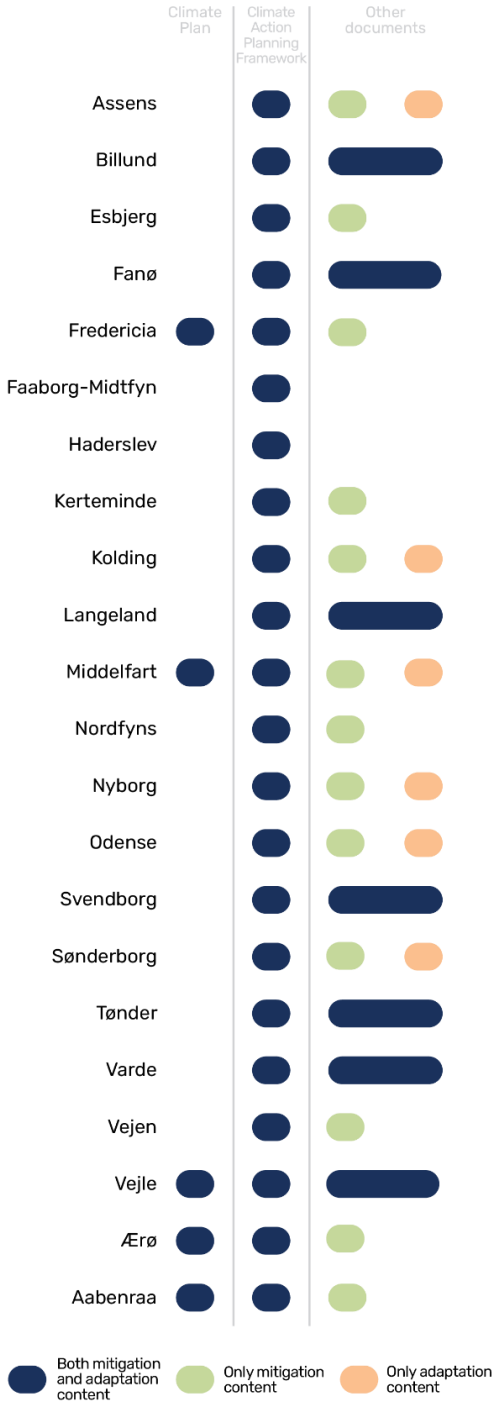

Figure 2. Type of documents analyzed.

The local climate plans, and main technical documents (see Annex 2 and *Figure 2*), of 22 municipalities in the Region of Southern Denmark (listed in Annex 1) were analyzed in this report. The primary documents reviewed for each municipality were the Climate Action Planning Framework (CAPF), which follow a common structure and type of content, which facilitate the comparison among plans. The Climate Plans, "Klimaplan" in Danish, were also analyzed; these are available only for some municipalities and are not following a common structure. Moreover, some additional technical documents were analyzed; these technical documents are usually integrating the information contained in the CAPF (see *Figure 2*). Both CAPF and Climate Plans include climate mitigation and adaptation, instead other technical documents are focusing on adaptation, mitigation, or both mitigation and adaptation.

A novel methodology for assessing the climate plans and technical documents was developed, combining, and expanding, the methodologies developed by the UNESCO Chair on Urban Resilience at University of Southern Denmark (SDU.Resilience) and United Nations Human Development Programme (UN-Habitat), for classifying challenges and response for urban mitigation and adaptation (UN-Habitat, 2022), and by the European Local Climate Plans initiative (EURO-LCP) for assessing the potentially effectiveness of the plans (African Development Bank Group, 2022), (Reckien et al., 2023). A set of 96 indicators (see Annex 3) was compiled, based on current scientific and grey literature, and the indicators were clustered using the taxonomy enumerated in the following page, and used for the data collection and analysis.

1. Mitigation challenges (including GHG emission inventory)
2. Mitigation goals (including GHG emission projections)
3. Mitigation actions
4. Residual emissions
5. Adaptation challenges (including climate risk assessments)
6. Adaptation goals
7. Adaptation actions
8. Implementation
9. Monitoring, reporting and validation
10. Barriers

This taxonomy allows to identify key gaps between climate challenges and actions, and between challenges and goals, for both mitigation and adaptation. Through the mitigation challenges and the adaptation challenges is possible to define the baselines for mitigation and adaptation; respectively, by sector, taking also into account residual emissions, and for climate risks by type of climate hazard, accounting also for exposure, vulnerability and quantification of losses and damages. Moreover, the taxonomy allows to identify if the goals are quantified and if they are aligned with the means of implementations, including through means for monitoring, reporting and validation. Finally key implementation barriers, explicitly mentioned in the documents analyzed, were also identified.

This methodology was initially tested on a small number of plans and then refined, before employing it for the whole analysis. The data has been collected in a Microsoft Office Access database, and a set of queries were developed to extract the data, analyze it and prepare graphical representations.

For mitigation the following emission sectors were identified: energy, transport, agriculture-forestry-other land use (AFOLU), waste management, wastewater and chemical processes. These sectors were used to produce a preliminary overview of the current GHG emission inventory and the emission projections by 2030 and 2050. A binary score (0 or 1) was assigned to track if each sector was explicitly mentioned, or not, within mitigation goals, challenges, and actions, or in relation to residual emissions. Residual emissions were required by the CAPF and defined as those emissions remaining after all technically and economically feasible opportunities to reduce emissions, in all covered scopes and sectors, have been implemented ((C40 Cities, 2020)). For this report, also the 2030 emissions gap has been calculated, as the gap between the 70% reduction target by 2030 and the residual emissions, since all municipalities expressed their intention to align with the national target: the value of the 2050 emission gap equals to 2050 residual emissions.

The analysis of adaptation challenges, goals and actions, focused on climate risk, and its three variables:

- hazards (e.g., sea-level rise, flooding);
- exposure (e.g., people, infrastructure or asset located in a climate hazard-prone area);
- vulnerability (e.g., the physical, social, economic and environmental, conditions that make people, infrastructure or assets more susceptible to the effects of climate hazards).

For adaptation, the following climate hazards were considered: flooding (from heavy rainfall, river overflow, storm surges, high groundwater), sea water rise, drought, temperature rise, heatwaves, extreme wind, land degradation, wildfire, water acidification, water intrusion, and vector-borne diseases. In the analysis, a score was assigned depending on whether the climate hazard was not considered (0 points), only mentioned (1 point), or mentioned and quantified (2 points). The quantification related to each specific climate hazard (e.g., sea water rise: increase of water level; or heatwaves: increase of heatwaves), to exposure (e.g., maps identifying floods or coastal erosion) and to vulnerability (e.g., whether specific assets were mentioned, such as through loss and damages estimations) was taken into account.

Means of implementation (MoI), monitoring, reporting and validation (MRV) were also analyzed, with reference to mitigation and adaptation combined. The absence or presence of MoI and MRV for climate action was analyzed using a binary score (0 or 1 point).

1.2. Interviews

In total 7 interviews have been conducted out of 22 responders that have been invited for interview. All interviews were recorded and took 30-60 minutes. All respondents are part of the DK2020 network. The Region of Southern Denmark has taken part in the identification of stakeholders for interviews as well as provided a list of potential respondents with expertise in the DK2020 framework. These include key stakeholders from the municipalities, industry, agriculture, civic society. Interviews have been anonymized.

Initial empirical data collection consists of respondent from different organizations most of which are based in Southern Denmark. The respondents have different functions and different levels of experience, and their engagement with the DK2020 work within their organization vary. As a consequence of the responders' diversity and different work experiences, Tanggaard and Brinkmann (Tanggaard, 2020) suggest to focus on the interview as a conversation with the respondent as the primary research method. Moreover, Holstein and Gubrium (Gubrium & Holstein, 2012) suggest that undertaking the interview as a conversation, imply focusing on the interaction between two or more participants. Hereby the interview is explicitly understood as a conversation in which the responders' statements become negotiated and contextual depending on the interaction between the parties. Interviews, regardless of specific method are constructed conversations (Tanggaard, 2020), whereby both the interviewer and the respondent are active participants, specifically engaging in socially constructed negotiations of content etc. The interviewer, therefore, has responsibility in stating open and neutral questions, not misinterpreting the conversation towards statements of what is relevant to the interviewer, or holding determined structure, but rather keeping the interview open as a conversation which allow the respondent to negotiate the content and emphasize specific topics that the respondent wants to address.

Thus, the pre-defined questions below act as a semi-structured guideline, whereby the interview guide are followed or supplemented with open questions once the responder addresses topics of relevance to them regarding the DK2020 framework. All interviews have been conducted by two interviewers, of which the second interviewer makes sure the overall interview guide is followed and that topics of relevance to the responder are included. Interviews were conducted mainly in Danish, however, in a few cases, interviews took place in English. The 2nd interviewer also acted as translator, if necessary, e.g., if respondents needed to explain or clarify certain aspects in Danish.

Basic interview methods, following Tanggaard and Brinkmann (Tanggaard, 2020), have been followed:

1) All respondents have been anonymized; personal data (such as name, place of work, job function, etc.) are stored securely.

2) All interviews are documented via video or sound recording, and all interviews are carried out with an interviewer and an observer.

3) All interviews are a structured conversation that systematically follows the topics in the interview guide. All interviews are between 30-60 minutes.

4) The scope of the taxonomy (see below) for the interview analysis allows new coding based on the structured interview conversation.

5) The interview guide is developed based on the taxonomy (see section 1.1.), with follow-up questions that invite the respondent to provide concrete examples based on his/her experience.

6) The questions in the interview guide (section 1.3.1) follow the questions from the survey. Only follow up questions differ from the survey.

The interview aimed to guide the conversation toward the respondents' work experiences with DK2020, as well as when, how, and why DK2020 has had effects on the municipality and the respondents' daily work. Finally, questions were centered around motivations of the respondent

and what they believe would lead to successful or unsuccessful climate adaptation and mitigation implementation. Thereby, the interview guide aims not only to document and let the respondent reflect on the DK2020 process framework within their organization, but also to let sensemaking methods guide respondents' success/failure judgements through the narrative they present. Thus, the conversation sought to encapsulate the rationale of the respondents' value system, and thereby let the participants reflect on why the expected outcome, aim, and result are not always commensurable to one another.

The analytical method also follows the taxonomy of the entire study. All interviews were recorded, and notes were taken by the interview observer each time topics of relevance to the taxonomy were addressed. Then we conducted a thematic coding on all the interview material based on the transcriptions using the taxonomy.

Each theme undergoes double coding both regarding the taxonomy as well as cross-thematic content between the interviews.

All participants are protected by anonymity and the videos recorded will only be shared among the research partners. Further the respondents have variables on sex, gender, work experience among others, making anonymous indicators for comparison. The interviews are transcribed and only the interviewer and the observer know the background information, name, municipality and DK2020 affiliation. Personal information will not be published but kept securely on encrypted servers.

Following are the interview questions transcribed in Danish, the language used to conduct the interviews.

A. Angiv venligst navnet på din arbejdsplads?

B. Angiv venligst din nuværende jobtitel/ rolle

C. Angiv venligst hvor mange års faglig erfaring du har (1-5, 6-10, 11-15, 16-20, 20-25, 25+)

1. I hvilken grad er bæredygtighed og bæredygtighedsmålsætninger (FN´s Verdensmål) defineret og inkluderet i politikker, strategier og handlingsplaner (samt politisk beslutningstagning) i din kommune?

2. I hvilken grad ser du mulighed for at anvende The Climate Action Planning Framework i det daglige arbejde i din kommune?

3. I hvilken grad er de økonomiske omkostninger og budgettering af finansieringen en del af planlægningen af forebyggelses- og tilpasningstiltag? Hvad er din vurdering af, om der på kort mellemlang og lang sigt er/vil blive afsat de fornødne ressourcer (penge/årsværk) til at implementere indsatserne?

4. I hvilken grad er klimaplanlægning integreret i andre planlægningsprocesser in din kommune?

5. I hvilken grad engageres interessenter/ samarbejdspartnere i klimatilpasningsplanlægning?

6. I hvilken grad engageres interessenter/ samarbejdspartnere i klimaforebyggelses?

7. I hvilken grad vurderer du din kommunes vil have succes med implementering af forebyggelse/ tilpasning?

8. Beskriv venligst de primære udfordringer du har observeret i din kommune angående klimaforebyggelse.

9. Beskriv venligst de primære udfordringer du har observeret i din kommune angående klimatilpasning

10. Beskriv venligst de(n) vigtigste motivationsfaktorer for at opnåelse af effektive/ funktionsdygtige resultater ifm. implementering af klimaforebyggelses.

11. Beskriv venligst de(n) vigtigste motivationsfaktorer for at opnåelse af effektive/ funktionsdygtige resultater ifm. implementering af klimatilpasning.

1.3. Survey

In addition to the semi-structured interviews making up the qualitative data acquisition, a survey questionnaire was also developed and sent to DK2020 stakeholders in the Region of Southern Denmark, to attain a quantitative overview of climate and sustainability efforts conducted in the region.

The questionnaire was developed based on a stakeholder analysis. In all, 11 questions were developed, allowing the respondents participating in the survey to rate to what degree certain topics, efforts, and results were relevant, important, successful, or not, or observed with respect to DK2020. The questions used in the survey were the same as those utilized in the semi-structured interview (see section 1.2.1.) and used the same common taxonomy (see section 1.1.)

In addition to the 11 survey questions, 3 meta questions were implemented in the survey, allowing tracking of respondents' workplace, job title, and years of experience, to make it possible to reference survey questions by the meta question categories, without revealing the name of the respondent.

The survey questionnaire was set up in SurveyXact and sent by email to the selected respondents. 9 of the 11 questions were answered using a 5-point Likert scale, an additional "do not know" option, and a supplementary comment section allowing respondents to explain their answers. The final two of the 11 questions were comment based.

The survey was sent directly to 22 respondents, who then redistributed it to colleagues and associates, yielding a final number of 27 respondents participating in the survey.

Of those 27 respondents, 14 completed the survey, making the final response rate for completing the survey 51.8%.

Both complete and incomplete answers of the survey are used in the analysis presented in chapter 2.3. Concerning the analysis of the data, given the size of the dataset, the intention of the survey was done solely to provide indicative comparison in the sample as well as identifying overlapping themes with the document analysis and the interviews. No statistical analysis was performed on the survey data, as the low amount of data would not provide any significant result. Hence, only the summary report, generated from the SurveyXact software, was used in the evaluation of the survey results. The report included diagrams showing how the respondents answered the questions by number and percentagewise, providing a structured overview of the data.

1.4. Limitations

This is a preliminary analysis of the municipal climate plans, that aims at establishing a broad understanding of current barriers and opportunities for the development and implementations of local climate action. The preliminary findings are used to design an in-depth review of local climate plans and identify the support for their implementation.

A limited number of municipal climate plans and technical documents were reviewed for this analysis, considering both the availability of documents and of resources to conduct it. Other climate-related municipal documents may be included in a future in-depth analysis (e.g., climate adaptation plans elaborated before DK2020, and/or risk management plans).

This current work does not aim at assessing the quality of the plans but to have a comprehensive overview of the development of the key elements included in the plans.

At this stage, only a list of relevant stakeholders for scoping interviews and survey was created. A full stakeholder mapping and analysis will be realized in the next phase and followed by more interviews.

2. PRELIMINAR REVIEW OF LOCAL CLIMATE PLANS

2.1. Analysis of Documents

2.1.1. Status of Climate Mitigation Planning

For the overview of the current emissions and those projected for 2030 and 2050, a mix of data sources were used. Less than half of the municipalities in Southern Denmark used data from 2019 as reference year for their current GHG emission inventory. The others (12) used 2020, 2017 and 2018, in order of occurrence (Figure 3).

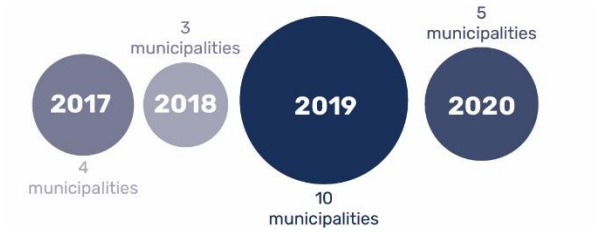

Figure 3. Base line years for GHG emission inventories.

In few cases, the GHG inventory is defined using a combination of data from two different years, depending on the specific sector considered. For this reason, the data from the latest regional emissions estimation was used instead, as it gathered municipal data from the same reference year (Viegand Maagøe, 2019). However, the values of projected emissions by sectors in 2030 and 2050 refer to those stated in the climate plans. Figure 4, in the following page, shows an overview of the emissions by sector. The value from the regional estimations of current emissions (2019 as reference) amounts to 13.16 MtCO_2e. Through analysis of the climate plans, the cumulative emissions from the different years would amount to 13.4 Mt CO_2e when data from all sectors is summed with additional estimations from other sectors, (e.g. non-road, which includes mobile machinery for farming and construction) that only a few municipalities calculated. The difference in the number is attributed not only to the different reference years but also to the fact that before 2019, the municipalities used different methodologies for the calculations.

The agricultural sector, main component of the AFOLU, is the most emitting sector, both in current emissions and in the future projections, going from around 41% in 2019 to 52%of the total emissions in 2050. In order to achieve climate neutrality by mid-century, this AFOLU sector would need special attention to prevent and limit emissions. Scope 3 emissions, represented by waste, wastewater, and chemical processes, represent the smallest percentage assessed.

At a national level, 1990 was indicated as the baseline year, from which to calculate national and local GHG emission reduction. The regional emissions in 1990 amount to 22.26 Mt CO_2e (Viegand Maagøe, 2019).

The values of estimated residual emissions (*manko* in Danish, equal to the emission projections or scenarios by a given year) were retrieved for all municipalities, however, nine reported the emission gap instead, hence the emission values in this report were calculated as indicated in section 1.1. The regional residual emissions by 2030 are estimated to be 6.56 Mt CO_2e, equivalent to a 71% reduction compared to 1990 (Figure 5): this means that the region is on a path to reduce 1% beyond the national reduction target of 70%. In particular, 10 municipalities are set to perform better than the requirement of the 2030 target: Fanø, Fredericia, Kerteminde, Nordfyns, Nyborg, Odense, Svendborg, Sønderborg, and Vejen. For example, Odense aims at achieving climate neutrality by 2030, with the current actions. With reference to residual emissions by 2050, it is estimated to be 4.06 Mt CO_2e in 2050, which equals to 82% progress towards the target. According to their planned actions, Nyborg, Sønderborg, Odense and Vejen will achieve climate neutrality by 2050. Most municipalities indicate that their current actions are not enough to reach the 100% GHG emission reduction by 2050.

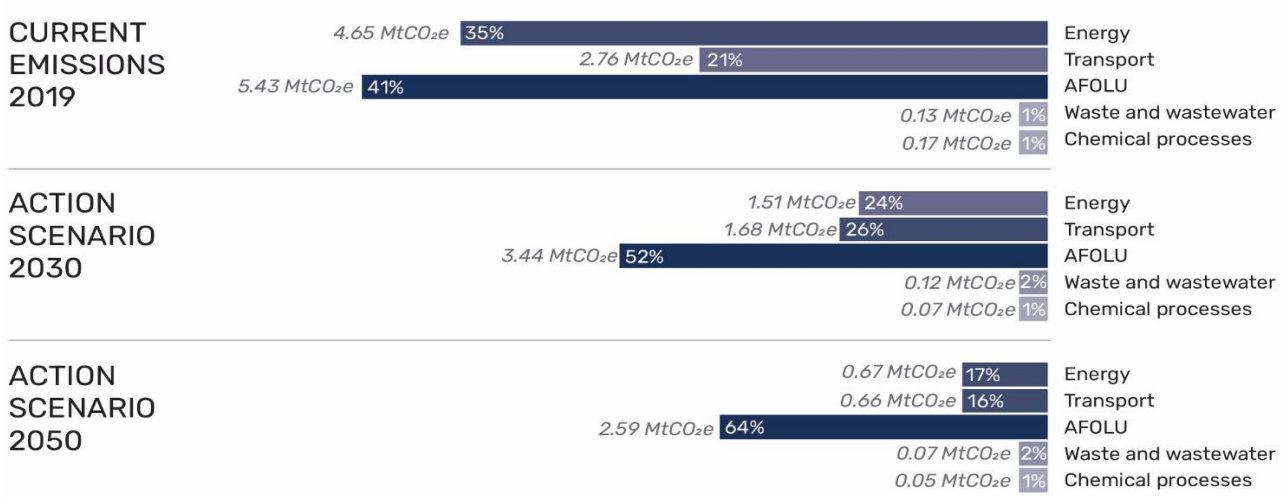

Figure 4. Current and estimated emissions of the Region of Southern Denmark.

In some cases, the emissions from the energy sector were identified according to the sub-sectors of emission (e.g. households, manufacturing companies, business, and the public sector most commonly). In other cases, the emissions are identified according to the energy source (e.g. electricity and district heating most commonly, but also including gas and oil). The municipalities of Haderslev and Tønder plan to achieve neutrality in the energy sector by 2030; the municipalities of Billund, Faaborg-Midtfyn, Langeland, Nyborg and Aabenraa by 2050. As for the transport sector, circa a third of municipalities considered road-related emissions, sometimes determining specific emissions by type of vehicle (e.g., cars, trucks, and vans), together with rail, air, and sea transport.

In the case of AFOLU sectors, most municipalities only considered the agriculture sector, while four also considered other land use. Finally, most municipalities considered emissions from the waste and wastewater sectors separately, while a few calculated them together, and in one case only waste was considered. In two cases, biogas production was included within waste calculations, and accidental fires in one case. Fanø municipality plans to achieve neutrality in the wastewater sector by 2030. Only two municipalities considered the construction sector on its own. Emissions from chemical processes were calculated by all municipalities but two.

Figure 6, on page 16, shows an overview of the municipalities' estimation of current emissions (challenges), projected emissions (goals) and mitigation actions by sectors, as currently planned. Almost all municipalities planned for GHG emission reduction related to energy, transport and AFOLU. AFOLU, was not considered by some municipalities (e.g. Fredericia), as it accounts for only a negligeable share of the local emissions.

Concerning the energy sector, the most mentioned actions are related to phasing out of oil and gas boilers and fossil-free district heating (16 municipalities each), installation of solar cells (15) and wind turbines (11), energy optimization of buildings (10), carbon capture (11) and PtX (7).

Many municipalities, for the transport sector, mentioned the transition to fossil-free public transport (14), but also promotion of cycling (11), creation or expansion of charging stations (10), collaboration with companies that make apps for car-sharing (9) and the green transition of heavy transport (7) were among the most common actions.

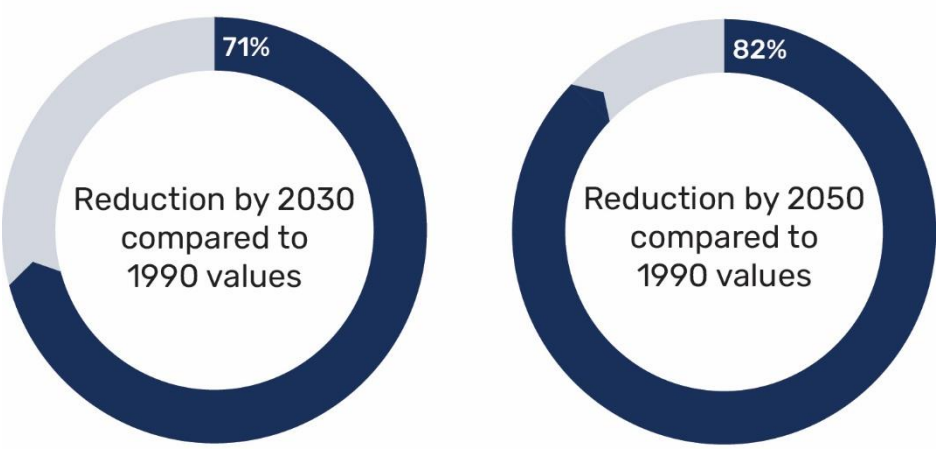

Figure 5. Regional progress towards the emission reduction targets by 2030 and by 2050.

Related to AFOLU, for the agricultural sub-sector, the actions most included in the plans were the extraction of low-lying soils and taking organic soils out of operation were the most mentioned action (15), followed by use of livestock manure, or other organic matter for biogas production (10), and change in feed composition for cattle (6). For forestry and other land uses sub-sectors the actions most included in the plans was reforestation (20), with some mentions about the establishment of areas with eelgrass in Odense Fjord, Sydfynske Øhav, Little Belt, Kolding Fjord (9) and wetlands (3).

The actions related to waste sub-sector were partially less considered in the plans, in only few cases combined with wastewater sub-sector (Assens, Esbjerg, Fredericia, Sønderborg, Nyborg, Ærø, Aabenraa). Actions mainly relate to the improvement of waste management and recycling (8 municipalities), with focus on circular economy (5) and, in particular, the waste of food (5), plastic (5), textile (3), electronics (1) and wood (1).

When referring to actions involving the wastewater sub-sector, a few municipalities mentioned climate neutral wastewater treatment and the preparation or update of their wastewater plans.

Only four municipalities identified clear actions concerning industrial chemical processes sector.

A total of 12 municipalities plan mitigation actions involving the construction sector, for example through asphalt reuse in road maintenance, increase of recycled materials in buildings and sustainability certifications.

In total, 15 municipalities identify actions related to the operation of the municipal administration sector, for instance by converting the municipal car fleet to electric (9), improve the energy efficiency of their buildings (6), converting the municipality's machinery (1), and opt for green procurement (e.g., for their canteens) (6), and installing solar cells on municipal roofs (1).

Other sectors include actions for the conversion of non-road mobile machinery (5), promotion of sustainable tourism (4) and citizen awareness (7); as well as actions related to behavioral change and awareness raising, such as education of children in schools and information campaigns.

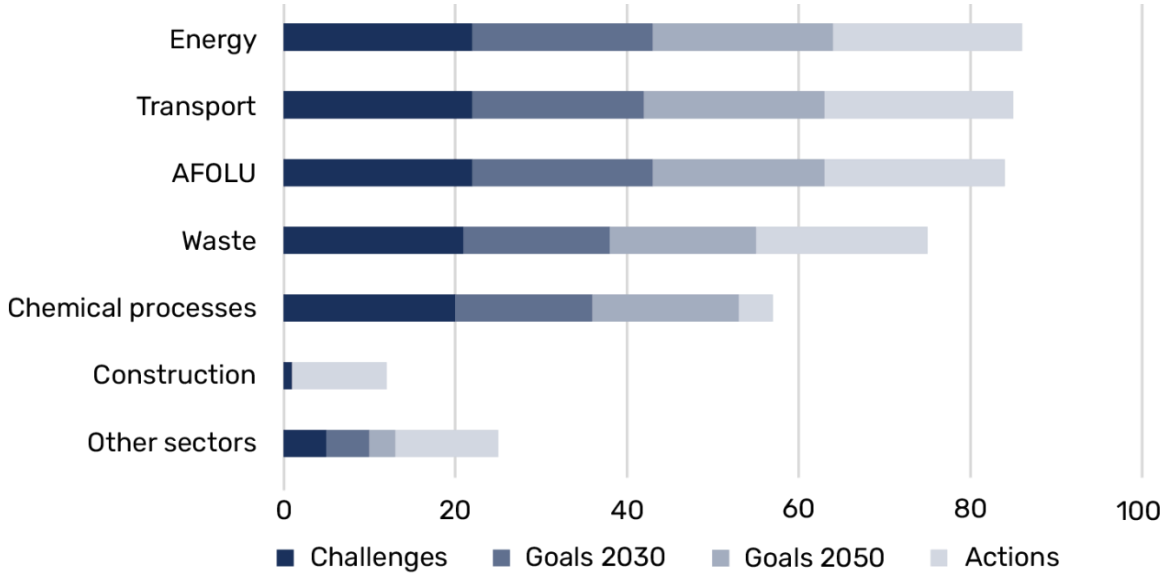

Figure 6. Number of municipalities considering mitigation challenges, goals and actions by sector.

2.1.2. Status of Climate Adaptation Planning

The alignment of climate challenges, goals and actions by hazards is summarized in *Fig. 8*. Climate adaptation challenges are represented by the climate risk assessment, by type of hazard, performed by each municipality. For the modelling of flooding, RCP 8.5 was used in most cases, and sometimes also RCP 4.5. Extreme wind (or storm events) and storm surges are two different phenomena, though they are strictly related. While storm surges are often considered, extreme wind is only included by 10 municipalities, 5 of which identify it as not a priority to be assessed. Drought was assessed by 16 municipalities, 2 of which identify as low risk in the short term, while 5 chose to not assess it due to irrelevance in the short/medium period. The irrelevance in the short/medium period was pointed out by 3 municipalities about coastal erosion. Billund and Vejen do not consider storm surges and coastal degradation in their climate risk assessments for obvious geographical reasons, as neither has any coastal area in their territory.

Other hazards have been also considered: Middelfart, Nordfyns and Svendborg and Sønderborg discuss the risk of saltwater intrusion, while Odense mentions the risk of water acidification, in addition to the risk of vector-borne diseases that also Kolding entertains.

Loss and damages are considered only when assessing the challenges, and only 10 municipalities calculated them, usually by examining flooding events only. The assets of a territory considered for the estimation of the damages, in financial terms, usually include buildings, but also infrastructure such as roads, cycling and hiking routes, then technical facilities like water supply, heat, electricity, waste and wastewater, and natural areas. A few municipalities indicate that they used the Damage Economic model for the estimations, "which was developed in a collaboration between the Fyn municipalities, GeoFyn, DTU, KL and several suppliers" (Assens Kommune, 2020). Another method being mentioned is the one of EnviDan's damage calculation tool (Kolding Kommune, 2022).

Figure 7. Target years to achieve adaptation goals, weighted according to number of occurrences.

The adaptation goals of almost all municipalities are linked to a timeline, where 2030 and 2050 are the most mentioned target years (Figure 7), by 14 and 17 municipalities respectively.

Different hazards are touched by the same Adaptation actions are often responding to multiple hazards contemporarily, as in the case of flooding events generated by different causes, or temperature rising together with heatwaves, or storm surges together with coastal erosion. Actions related to flooding were included by 16 municipalities, followed by temperature rise and heatwaves that were touched by 11 municipalities, drought by 10, coastal erosion by 7, extreme wind events by only 2 and, finally, wildfires by only 1.

The municipalities don't always specify the specific causes of flooding events, particularly in relation to their goals and actions. It is also for this reason that the figure 8 doesn't distinguish flooding goals and actions by specific sub-types of hazards.

Exposure and vulnerability are considered both for adaptation challenges and actions, but not for goals. In most cases, when exposure is considered in the plans, it is also only referred to flooding events, with the exceptions of Kolding that considered erosion events, and Varde that also considered drought events. Vulnerability is also usually expressed in relation to flooding events only, but in a few examples also temperature rise, and heatwaves events are considered, by identifying vulnerable population groups (i.e., children and elders) and other forms of life.

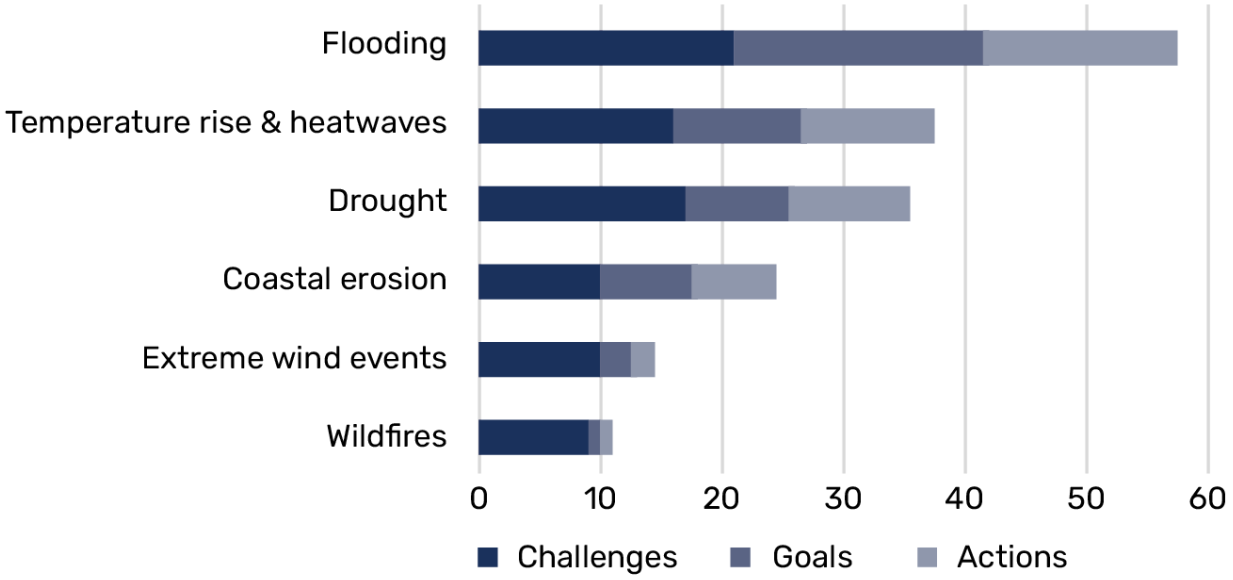

Figure 8. Number of municipalities expressing adaptation challenges, goals, and actions.

2.1.3. Implementation

Almost all municipalities identified key actors in relation to each climate action, which in many cases included a clarification on the role of the municipality itself.

Almost all municipalities specified a timeline for every single action, in some cases only with a deadline (e.g., 2030), in other cases with both the beginning year and the ending (e.g., 2026-2030), also with the aid of graphics, for example Middelfart that used a Gantt chart.

Information related to (financial resources) funds for every individual action was included in

the local plans, and positively assessed when mentioning specific funders and a budget estimation was performed. In a number of cases, budgets were not expressed for each single actions, but more generally for a goal (e.g., energy goals in general).

Actions need to be prioritized, thanks to the guidelines of the CAPF, all municipalities clarified their methodology to do so, though with different levels of transparency. Recurring criteria for general prioritization include the actions' potential for CO_2 reduction or for climate adaptation, as well as the potential for impact on both mitigation and adaptation. Other criteria for prioritization were also included, as: feasibility, scalability, potential for added value, co-creation and citizen commitment. In a few cases, the criteria have been expressed by emission sector.

The identification of co-benefits focuses on social benefits (e.g. public health, education of youth, sustainable development of urban environments), economic benefits, (e.g. job creation, green innovation, improvement of tourism) and environmental benefits, (e.g. increase of biodiversity and access to nature).

Most municipalities mentioned relevant SDGs that guided their planning. In particular, work on SDGs has been undertaken by Sønderborg municipality from 2017 in the project "Vores Verdensmål", initiated by the Danish Parliament's 2030-Panel with Danmarks Statistik to prepare a baseline at national level that makes the 17 UN's goals local and at the same time select indicators for a sustainable future in Denmark. Furthermore, two communities of Nyborg were involved as pilots in workshops organized by Bæredygtig Lokal Udviklings Proces (BLUP), a nation-wide project aligned with the global SDGs to create sustainable local communities.

All municipalities describe how they intend to monitor implementation and evaluate the effects of the actions, though only a little more than half municipalities identified KPIs related to the implementation of the climate plans.

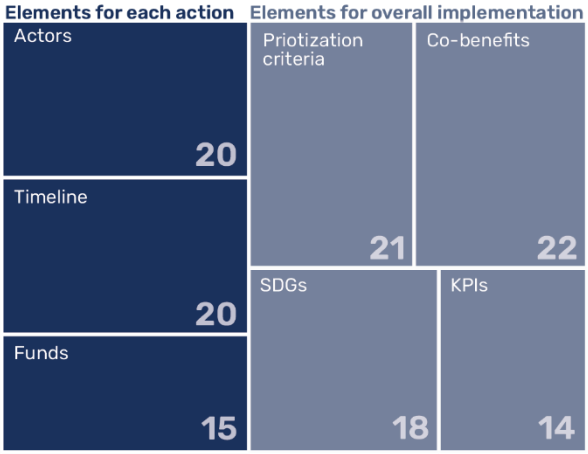

Figure 9. Number of municipalities including clear elements on individual actions and overall implementation.

2.2. Results of the Interviews

In this section we only report commensurable findings that have been identified across the interviews. The interviews suggest significant variations between rural municipalities and more urbanized municipalities in Region Southern Denmark. Significant variations in development phases exist between municipalities that have recently committed to the DK2020 endeavor compared with municipalities of long-term commitment. Most importantly, political support, top-management engagement and resources allocated to DK2020 efforts vary significantly across the cohort of interviews. Nevertheless, commensurable themes exist across the dataset. The themes identified across the interviews include:

1. DK2020 and climate action framework: Interviews suggest DK2020 mark a starting point where climate action planning frameworks become coordinated and integrated across municipal departments (respondent with 15-25 years' work experience). Thus, DK2020 marks an entry point whereby politicians, top-level management and different bodies begin to take climate planning seriously. However, DK2020 framework is not used directly in the climate planning, but more as a sort of framework or checkpoint list (respondent from a rural municipality).

2. Network and Learning: All interviewees stress the need for a new mindset and that the municipalities lack significant competences for green transition. The knowledge gap includes lack of integrative competences and coordination between different planning entities to strategic energy, planning, authority processing as well as public participation processes and stakeholder involvement (respondent from an urban municipality). The DK-2020 network has been illuminating important for capacity building especially from the smaller municipalities, and without the network and coordination between municipalities environment departments etc. competences would not have existed (respondent from a rural municipality).

3. Financial sustainability: All respondents, when asked to which degree climate plans are financed, stress that budget negotiations in the municipalities and the lack of security limit long-term climate actions. Especially the smaller municipalities find that their climate action plans are not financed but, that each implementation goal stated in the plan needs to be negotiated (respondent with 1-5 years' work experience). Several planners report frustration and uncertainty whether concrete actions will be implemented.

4. Mitigation and adaptation planning: across the cohort we identify differences in rationality of adaptation and mitigation planning. Climate adaptation planning is more advanced and in a later phase than mitigation planning. Moreover, there is a stronger focus on adaptation planning interviews report (respondent with 15-25 years' work experience). Especially, they find, politicians going for their next election, find it easier to communicate how citizens are being protected from heavy rains or flooding, than for actual carbon reduction. Thus, we identify a carbon gap as neither the transportation sector nor the construction sector is mentioned. The interviews stress that community involvement, public support and participation are critical if projects and targets should success. Implementation goals with public resistance are likely to fall apart (respondent from an urban municipality).

5. Barriers and drivers: Apart from the gaps identified above, the evaluation also shows that no clear decision-making structure exists. Responders find coordination of planning a real barrier, for example from initial planning phases toward implementation, or cross municipal planning (respondent from an urban municipality). Among the responders, political commitment remains the most important driver, and direct top-management support and finance for implementation goals is critical for transforming climate action planning frameworks to successful implementation.

2.3. Results of the Survey

Respondents from 13 municipalities in the Region of Southern Denmark participated in the survey questionnaire, with most of the respondents fulfilling the role of climate coordinator, climate and sustainability coordinator or program leader for climate actions.

In terms of experience of the respondents, 42% of the respondents had experience between 1 and 15 years, or more than 15 years of experience, showing that an equal distribution of experience was present in the survey, including respondents with both little and great amounts of experience. 18% of the respondents did not provide a response to their degree of experience.

When asked to what degree sustainability and the SDGs were defined and included in policies, strategies and action plans in the respondents' municipalities, the answers ranged from "to a low degree" to "to a high degree", with "to a high degree" being the most answered, in 41% of the cases, followed by "to a moderate degree", in 29% of the cases. Some of the additional comments to the first question of the survey explained how one municipality has seen that the implementation of climate actions plans has resulted in a "more green perspective" in the strategies of the municipality. Another respondent noted that sustainability is defined to a very high degree in their municipality, however, with specific goal only being described to a very low degree.

When asked about how the CAPF can be utilised in the daily municipal work, 12% of the respondents indicated "to a low degree". This is, however, not a significant result, as the answer on the 5-point Likert scale with a "do not know" option was equally distributed, with "to a moderate degree" being the most indicated answer with 24%, and "to a low degree", "to a high degree" and "do not know", all being indicated by 18% of the respondents. In the additional comments section of this question, one of the respondents noted that the CAPF is not used in this respondent's municipality. They further added that the question seemed "weird" as CAPF is made for the development of a plan, and not for use in the daily work processes. Another respondent described that the framework was used for the development of the climate plan in their municipality, which is then used in daily operations.

With respect to question three, focusing on the financial aspects of planning of mitigation and adaptation, most of the respondents indicated that this is done "to a moderate degree" and for a "moderate time perspective", whilst 26% indicated it was done "to a low degree" with a "short term time perspective".

When asked to what degree climate planning is integrated in other planning processes in the municipalities, 53% indicated "to a moderate degree" whilst 33% indicated "to a high degree". 13% indicated "do not know". In the additional comments, one respondent noted that such a question can be hard to answer on a general level, whilst other respondents described how this is an ongoing process which might evolve over time.

When asked about how stakeholders are involved in the climate adaptation planning processes, most respondents indicated "to a high degree" (40%) whilst 33% indicated "do not know". When asked about climate mitigation planning process, the answers were quite similar, however, with subtle differences. In the answers to this question, 47% indicated the involvement of stakeholders is done "to a high degree", whilst 20% indicated it is done "to a moderate degree", with only 20% indicating "do not know", highlighting that the planning of climate adaptation and climate mitigation is not necessarily the same process, with involvement of the same actors.

In the final question, answered using the 5-point Likert scale, the respondents were asked to reflect to what degree their municipality have had success in implementing adaptive or mitigative climate solutions. 50% indicated "to a moderate degree", whilst 36% indicated "to a high degree", with 14% indicating "do not know". In the additional comments, one of the respondents noted that their municipality is still

in the start-up phase and wishes to work a little longer with the implementation before making an indication on to what degree. Another respondent described how there is a will to a certain degree but, concerning large-scale farming, the municipality is affected by national initiatives (e.g., climate fees) to succeed. Finally, a respondent described that the ambitions and the will to succeed are widely available in the organisation. However, insufficient finances are a limitation.

The final four questions of the survey were comment-based. The first of those questions focussed on the primary challenges observed regarding climate mitigation. One respondent noted "economy vs. sustainability and climate", whilst another respondent described how the prioritising of climate actions divided into specific disciplines which do not have it as their principal goal is a challenge, because the various disciplines are already tasked with a large task burden. Another respondent explained how the lack of resources is a challenge, both in term of manpower and economy, whilst another respondent mentioned that legislation in some areas is outdated (e.g., with respect to the windmill act). Finally, a respondent noted that the politicians are concerned with multiple or other agendas.

When asked to describe the primary challenges observed with respect to climate adaptation solutions, one respondent answered the same as in the previous question: "economy vs. sustainability and climate". Another respondent simply indicated "nothing significant", whilst another indicated the large costs involved in implementing new solutions. In general, the answers from the various respondents were primarily focused on the economical aspect of implementation, in addition to attaining the right knowledge.

When asked what the primary motivation factor(s) are with respect to achieving efficient results in implementation of climate mitigation, one respondent described that economy is a factor for both the citizens and the industry; image and conscience are then second. Other respondents focused on economy as well, in addition to the development of competences within the municipal workforce, as well as managing the synergies among aspect of the climate action plan.

In the last question, the respondents were asked to describe the most important motivation factors for achieving efficient results in implementing climate adaptive solutions. One respondent answered, "the protection of citizens, values, and nature". Other respondents described more tangible solutions to issues, such as flooding, water in the basement, as well as climate disasters of various kinds. Finally, one respondent answered that the primary motivation factor is that the citizens are able to understand the solutions as long-term investments which protect their properties, to ensure long term use of land (e.g., to store rainwater for use during draught).

Of the 14 respondents who completed the survey, 10 opted for receiving the results of the survey and participate in future studies, whilst 4 opted out from future participation.

The survey was developed to attain a broad and general understanding of climate adaptation and mitigation management in the various municipalities, resulting in general questions allowing for interpretation by the respondents. This was, however, not received well by the respondent, who provided feedback to the questions using the "additional comments" option in the questionnaire. Responders asked for more specific questions, with less ambiguity. Future survey studies should, therefore, rely on more specific questions.

The survey was distributed to only a few selected respondents based on the results of the stakeholder analysis. In future research, more respondents should, nonetheless, be targeted, to ensure a larger quantity of data, to allow for statistical analysis.

3. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

In the following subchapters, barriers are marked by the following categories:

Legislative: barriers in the matter of policies, the regulatory landscape, etc.

Governance: barriers concerning administrative powers, multilevel governance, vertical and horizontal integration.

Finance: barriers related to access to finance, information on financial resources.

Capacity: barriers in terms of institutional capacity, but also in space and time.

Technology: barriers given by the uncertainty of technological advancements.

Data: barriers in the availability, usability and collection of data.

Stakeholder involvement: barriers represented by the (lack of) participation of the civil society, collaborations with private companies, etc.

3.1. Barriers and Potentials in Mitigation

There is a real risk that the goals in the climate strategy cannot be met without legislative changes at national level, including review of relevant laws and regulations, also in relation to incentive structure and financial framework. The central government's influence on the local climate effort, particularly in relation to climate taxes and subsidy as well as to legislation and regulations, is decisive for meeting the targets set by the municipalities (Assens and Varde). The frequent changes in the regulation of subsidy and incentives are considered a barrier for the implementation of the local climate plans. For example, this makes it very uncertain for individuals (e.g. car and home owners), project developers and municipalities to make and implement long term decisions (Vejen). An example is the tax imposed on surplus heat, making its utilization from local cold stores not possible, this hindering the implementation of planed climate actions (Haderslev, Vejle).

It shall be noted that various regulations and energy taxes, which have so far limited the utilization of excess heat, will be most probably changed in the coming years. The municipality's efforts can contribute to overcoming local organizational barriers to the restructuring of the heat supply locally. This can could be achieved also through dissemination of relevant knowledge, coordination of measures and facilitation of processes, including cooperation between citizens and utility companies (Faaborg-Midtfyn).

There are legal limitation in the deployment of district heating, as it is no longer a mandatory requirement (Aabenraa, Svendborg).

The municipality might not have alone the sugfficient means for the conversion of district heating to renewable energy. Although, strategic partnerships and cooperation agreements can support the conversion, as in the case of the three district heating companies in Haderslev, Vojens and Gram (Haderslev).

The municipality cannot easly access apropiate information on current homeowners' consumption level and future forecast, about district heating and supply conditions in residential areas (Varde). Similarly, lack of

systemic update of BBR data is also an obstacle for analyzing and assessing the potential of climate measures. It is the property owner's responsibility that the information is correct, while the municipality is responsible for updating the reported information. This situation could be improved if there was easier access for citizens to update the BBR themselves, and having direct responsiblility for the accuracy of the information they provide (Esbjerg).

Citizens have to finance the replacement of oil and gas boilers themselves, which can be challenging for citizens with low incomes, (Billund, Fredericia, Kolding, Kerteminde, Svendborg, Varde, Tønder). Even though there are subsidy programmes that support conversion from fossil fuels for heating (Billund), incintives seem not to be sufficient (Kerteminde). Furthermore, heating with a heat pump may require additional investments in better insulation of the building envelope. The unwillingness of banks to lend money to owners of older homes in rural areas can also be a barrier (Svendborg).

According to Climate Agreement for Energy and Industry 2020, it will be investigated whether a special loan scheme can be established for citizens with a lack of financing options (Kerteminde). For example, it could be helpful to establish scrap premium, subsidy schemes, higher taxes on oil or lower taxes on electricity (Kolding). Alternative financing options may be made available in the form of subscription solutions; however, this will typically be associated with higher annual operating costs.

Complicated regulations and tax schemes make it less attractive for companies to utilise their roofs for solar panels (Fanø, Fredericia). An example are the regulatory limitations for third parties to own and operate solar panels on buildings owned by others (Kolding).

Solar panels on municipal buildings require an independent company, as municipalities are not allowed to monetise energy production from solar cells. The legislation should be changed so that it becomes profitable to place solar cells on municipal buildings (Nordfyns, Fanø). Copenhagen Municipality is the only one in Denmark to have attempted it, albeit with a financial deficit. They are therefore considering closing the company again, as a municipality is not allowed to run a loss-making business (Vejen).

Odense Municipality is working to improve the possibilities for establishing solar panels on rooftops, for example, by participating in an experiment to try to influence legislation to be less restrictive (Odense).

Creating local support for both wind turbines and solar cells can be difficult, as local citizens often express opposition to the development of energy parks, due to their appearance (e.g., solar cell systems can change the esthetic of a building or a landscape), or noise from wind turbines (Haderslev, Kerteminde, Nordfyns, Nyborg, Svendborg, Tønder).

One way to solve this challenge may be to enter into an early dialogue with the affected citizens, claryfing which benefits the individual and the local area can get from energy installations and giving them the opportunity to become, for example, the investors in the project, so that they also benefit financially from the project (Haderslev, Nordfyns).

Case management and relevant approvals for energy plants can entail long processes from idea to completion of work and operation (Billund).

A relaxation of area restrictions for RE, as described in the Climate Agreement on green power and heat, is likely to alleviate this challenge, ensuring shorter processes and balance between between the nature directives and consideration for the expansion of of renewable energy (Billund).

The development CO_2 capture actions is limited due to the fact that CO_2 allowance prices are relatively low and that it is still relatively cost-free to emit CO_2 in sectors that are not covered by allowances (Kolding, Varde).

It is a prerequisite for CO2 capture that Fortum has been achieving for a number of years tax relief for the upcoming CO2 tax (Nyborg).

The transition to green transport presents major challenges and risks, as it is particularly dependent on legislative frameworks at national and EU level (Sønderborg). Rapid conversion to electric cars requires, for example, possible future legislation to stop the sale of cars based on fossil fuels, as well as changes in taxes and subsidies which promote sales (Middelfart).

One difficulty in promoting private electric vehicles use among citizens is range anxiety, the fear of not reaching the destination in time, as well as the fear of not being able to find a suitable charging station. This fear is estimated to decrease with the expansion of charging infrastructure and the technological development of electric cars (Fanø, Kolding, Nyborg, Varde).

High financial costs to create an optimal public transport system can be a barrier, delaying low-carbon transition of transport (Kolding). For example, electric buses are about two time more expensive than conventional diesel ones. Conversely, electric buses have lower maintenance costs, which is an incentive for the substitution of busess, particoularly busses with higher level of use (Billund, Haderslev).

According to the current legislation, charging stations for electric cars in parking spaces at municipal buildings may only be used by municipal vehicles, and therefore not by citizens, guests or employees (Esbjerg, Vejen). Changes in the current legislation may make advantageous to set up charging stations in several larger parking spaces in different location in the municipality. In a number of these locations, the economic benefits are likely to be so attractive that the charging station operators may be willing to pay to have their charging stations in those locations, while other locations will not currently be profitable to install charging stations without public support (Vejen).

The establishment of charging stations shall be further enabled, but the municipality cannot support private charging operators in setting up charging stations (Esbjerg). Also, limited municipal subsidy options can make it difficult to expand to locations where there is low commercial interest in charging infrastructures, e.g. in rural areas, parking along public roads (Fredericia, Nyborg). It is a barrier that charging operators have not opened up charging options for other than their own subscribers. The electricity system is not is not yet able to support a more distribute electricity consumption, for example incentivizing charging vehicles in non-peak hours (e.g., for battery charging to take place at night) (Fredericia).

Grants are an option for motivate operators that are willing to make an investment, so the municipality becomes a co-financer (Haderslev).

Regarding the electrification of heavy transport, short range and long charging time can be a challenge for some truck types (Billund). Further streghtening of hydrogen and electricity as fuel alternatives must happen (Fredericia), together with apropiate legislation and framework conditions that can support a green transition for heavy transport (Fredericia, Vejle).

Carpooling may require extra time and planning, which can present challenges in a busy everyday life. Some needs, for example, if you have children that need to be acompained somewhere, are more difficult to accommodate through carpooling. Moreover, habits are hard to change (Kolding, Nyborg) and it is estimated that many drivers prioritize flexibility by traveling by themselves (Kolding).

Ways to make carpooling more attractive include greater deductions for providers, a comprehensive overview of trips across platforms that is integrated into the travel plan, the legal possibility for companies and municipalities to subsidise carpooling (Fredericia).

The transition in agriculture may be affected by the fact that there is not enough land in Denmark for all the actions for emissions reductions that are need in agricultural sector (Varde). For example, Kolding Municipality does

not have the opportunity to distribute land if low-carbon projects are planned (Kolding).

The low-carbon transition in agriculture draws heavily on technologies, some of which are not yet fully developed (Billund, Varde); for example, GHG emissions from cultivated land, including those resulting from the use of nitrogen fertilizers, are difficult to limit (Faaborg-Midtfyn). There is also a need for research on the short- and long-term consequences of applying biochar to agricultural land in a Danish context (Svendborg). Major GHG emission reductions, derived by livestock digestion, will be highly dependent from the development of new technologies (Haderslev, Faaborg-Midtfyn), such as the change in livestock feed composition, preventing high-emissions from digestion (Aabenraa).

Testing and development must be done in relation to the animals' digestion, fuel for the large machines, stable systems, etc. The climate partnership between Esbjerg Municipality, DIN Forsyning, Port of Esbjerg and Aalborg University is establishing the Esbjerg Transition Lab, where we would like to invite new technologies to be tested on a 1-1 scale (Esbjerg).

National policies are considered the biggest barrier for low-lying projects (Billund, Langeland, Varde, Vejen): areas set aside for them could be used as fallow areas (ploughed and harrowed but left for a period without being sown in order to restore its fertility or to avoid surplus production). There is no one-off compensation for nature-protected areas in accordance with §3 of the Nature Protection Act (Tønder). Also, when the projects are carried out, it is a requirement to limit the discharge of phosphorus into the aquatic environment. The calculation method prescribed national level, is considered of questionable quality: this means that implementation may risk being stopped based on a possibly faulty calculation (Vejen). Furthermore, the legislation sets a minimum limitation of 10ha to select projects, which is a challenge because many potential areas are under 10ha (Langeland).

The schemes for the set-aside of lowland soil are administered by the Danish Agricultural Agency and the Danish Environmental Protectio Agency. Currently, there are long waiting times for change requests during the construction phase, which can potentially delay project development (Varde).

The climate challenges and changing food habits, as well as agriculture's own transition challenges, may increase the risk of lower demand and thus lower agricultural production. If this happens, the expected biogas plants will be threatened by the necessary supplies from agriculture and food. In the long term, efforts may need to be made to find alternatives to the forms of biomass used today (Haderslev, Sønderborg). Straw that is crushed cannot be used for energy purposes, and thus cannot contribute to meeting the existing demand (Kerteminde). Moreover, plant location must also be close to slurry, and not too far from the national grid, to allow its cost-effective use. In order to achieve good economy in the individual projects and minimise inconvenience during transport, the slurry should not be transported more than 20-25 kilometres from farm to plant (Billund).

Legislation can motivate privates against afforestation or reforestation, since if subsidies are granted, the forest must be established as a protected one and therefore cannot be returned (Aabenraa), for example to be used as a turnover area (Kerteminde, Tønder). For several landowners the financial compensation is not considered adequate, because protected land is poorly valued (Varde). Also, according to current regulations, afforestation is not allowed in areas that are classified as lowland areas, even though a lowland project is not always the most suitable means of taking land, either due to local conditions or the landowner's conviction (Billund, Varde).

Regulations and the fragile natural environments must be respected, but instead of planting trees in the vulnerable areas, a closer look will be given to locally adapted projects, for example with planting in the salt marsh, which will both be good for CO2 uptake and climate

adaptation, as such planting is not oversensitive to flooding (Esbjerg).

Planting a forest is cash intensive (Tønder). There are already many climate accounts from several different players. Creating a municipal climate and nature fund can be in competition with commercial companies such as SEGES and others (Kolding).

Afforestation is most easily spread if it can also be financed in the future via EU funding. State fund for multifunctional land distribution must be maintained (Vejle).

Actions are dependent on the voluntary participation of the landowners (Nyborg, Svendborg, Aabenraa): afforestation and reforestation, where the owner would have to be willing to cede the land (Svendborg), as well as establishing wetlands (Fredericia); reductions at farm in general and extraction of low-lying soils, where it is on farmers to provide for the land; pyrolysis, where CO2 capture and storage can be done by private companies (Nyborg, Aabenraa). Land can only be used for one purpose and there is a battle for farmland - and since the removal of carbon-rich farmland is based on voluntary agreements, the positivity of landowners will be crucial (Kolding). This contributes to maintaining a high price on agricultural land, for example for it to be set aside for solar cells or conversion or use for afforestation and wetlands (Varde). Subsidies for afforestation compete with other schemes for land set-aside, e.g. lowlands (Billund).

Concerning voluntariness in low-lying and wetland projects, history shows that the proportion of voluntary participation increases with the degree of public subsidy. It is therefore very important that the subsidy rates at least correspond to market prices for agricultural land. It should be considered whether expropriation can be an option to implement projects (Vejle).

Within the theme of circular economy, it is difficult to chnage consumption behaviours if there are no financial incentives/disincentives (Billund). Moreover, the behavioral patterns are strongly linked to an unhealthy ownership culture, where the status of owning, versus renting or borrowing, is better considered. We have a "buy new and throw away" culture (Kolding). It is a challenge to change habits and behaviour in the name of the climate, as action also becomes a question of economics (Fanø, Nyborg). This requires changed budgeting procedures and to adopt a life cycle view (Vejle).

The functioning of a new recycling center requires effective citizen-oriented information about sorting and behavior at the recycling centre (Billund, Fredericia). The same goes for sorting within institutions and companies, who have to contribute in making an effort to sort waste correctly and put it in the correct bins. It is a barrier if employees do not take responsibility for proper sorting (Svendborg).

It is a challenge to ensure supply for recyling and reuse of different kind of matter: there must be a clear awareness among consumers of the value of collecting organic waste rather than throwing it away with residual waste to support biogas production from food waste (Fredericia, Vejle); in the case of clothing, it is a challenge to secure a critical mass of suitable textiles for the project, because only particularly solid types of textiles are suitable for being recycled as new work clothes (Fredericia); there are challenges also for wood, plus the market for its upcycling must be expanded (Fredericia).

In the construction area, the requirements in the building regulations can be tightened, and a follow-up on the energy-saving pool after 2024 is needed, for example by introducing tax requirements and support schemes at a national level (Middelfart). Energy-saving measures in construction projects are often deprioritized when project finances are squeezed (Kolding).

Since municipalities are subject to a procurement law, it is difficult to optimize and "hand-pick" items, as the selection depends on the chosen supplier and there is a limit to criteria that each municipality can set (Kolding). There are product groups in the municipality's purchases where it is not yet possible or relevant to ask climate requirements (Nyborg).

Ensuring a continuous green transition in companies requires sharing best practice and openness around processes (Fredericia, Svendborg), which can be a barrier due to competition, for example. Also, potential synergies need to be clarified so that the benefits of participation outweigh the resources (Fredericia).

3.2. Barriers and Potentials in Adaptation

The financing of a large part of the climate projects is the responsibility of the municipality alone. It can often be a challenge to find the financial means in a squeezed municipal budget (Kerteminde, Sønderborg, Svendborg, Varde, Vejen, Vejle). There can also be a barrier in the form of limited resources in the administration if many citizens or many local areas need the municipality's help with climate adaptation at the same time (Faaborg Midtfyn). Also, funds cannot simply be reallocated from damage response to damage prevention, but funds must be prioritized across a wide range of interests (Odense). It can also be a challenge to find funding for projects that private actors are responsible for (Billund).

The lack of legislation regarding the management of the near-surface groundwater is a challenge as, today, it is solely the responsibility of the landowner (Billund, Odense, Nordfyns, Vejen). There are some nationwide barriers in relation to its handling, which is why it would be appropriate to await the framework of the national climate adaptation plan before initiating further measures (Nordfyns).

The free drainage right can present challenges for entire climate adaptation efforts, as there is no set limit on how much each individual landowner on their own property may drain into a watercourse. A watercourse may also include ditches, canals, pipelines and drains as described in section 2 of the Watercourse Act. This means that a drain may be connected to an existing drain and that a catchment area with a drainage system can be "moved over" to another catchment area, which can give an incorrect calculation of the climate action due to incorrect background material. At the same time as the amount of water is incorrectly calculated, the calculation of the velocity of water reaching a given point (e.g., a city) may be flawed and cause the climate action not to have the desired effect (Haderslev). An example is given by Vandløbsloven, that only allows for the examination of existing watercourses and does not consider that watercourses naturally evolve (Odense).

In projects on high water and storm surge protection, a possible division of parties will be a significant risk factor in the project. Here, the progress of the project and the possibility of implementation will depend on being able to create sufficient common understanding of the project itself and of the financial burden distribution in the project. If this to succeed, it is necessary that an early dialogue and reconciliation of expectations take place with the citizens, when a project is started. A financial burden distribution must be experienced as transparent and fair possible. It must also be made clear that the division of parties is complex and will probably always be perceived as fair to everyone (Sønderborg). There are often many landowners in a project area (due to a property structure with smaller and scattered areas), and it can be difficult to get everyone on board (Svendborg).

In addition to floods, there are several other climate risks such as drought, heat wave and storms. These are described in the National Emergency Management Agency's publication "National Risk Picture 2022", which contains 14 incident types that are assessed to be critical for Danish society. The 14 incident types include both those directly climate-related, but also other types such as accidents and illnesses. In general, there is not the same level of knowledge for the climate risks that are not based on floods. This means that a risk mapping cannot be prepared at the same level as for the floods (Kolding, Nyborg, Faaaborg-Midtfyn).

3.3. Cross-cutting Barriers and Potentials

A lack of internal competences and knowledge within climate and sustainability in the municipality has been identified. Therefore, it has been decided that there must be upskilling of our own employees and at the same time the same opportunity is offered externally (Assens, Esbjerg, Odense, Svendborg, Varde), especially in relation to energy optimization of the operation of buildings and energy management (Esbjerg). It is the ambition that climate must be considered in all relevant contexts in the municipality. This means, among other things, that when the municipality's existing plans and strategies have to be revised, it will be done with a targeted climate focus and in accordance with the climate strategy (Assens). Municipality's employees must also be trained to act more sustainably. Some employees may not see the green transition as necessary. These can counteract the effect of the initiatives (Varde).

To this end, the municipality's education and skills development funds will be used (Varde). Also, efforts are being made to offer a leadership course in climate - how to lead employees to work with a climate agenda, which may seem foreign to some (Esbjerg).

The implementation of the climate plan is dependent on the majority of politicians in the local government continuously voting for and supporting the climate plan and related actions, thus ensuring their necessary economic prioritization. Bearing in mind that elections are held every four years. Process transparency and knowledge-based basis for actions can ensure anchoring of actions at the political level (Langeland, Odense, Ærø).

It must be assumed that not all citizens will find the green transition equally relevant or for other reasons do not want to engage in it and a lack of information and reluctance among citizens and businesses can reduce the effect of actions (Billund, Varde, Tønder). But for some of the initiatives, it is crucial that relevant and necessary partners want to enter a binding collaboration on the realization of the individual initiatives (Assens, Kerteminde, Svendborg, Tønder, Ærø).

Local support is important for several initiatives, be it in connection with renewable energy projects, biogas production or afforestation, where it is crucial that the local population can see themselves in the projects. This barrier can be partly overcome through legislation, as legislation can support the prioritization of the green transition, for example by designating specific areas for green projects. Another method to overcome this barrier is to create an incentive structure that provides local value for citizens and businesses in relation to the specific projects and initiatives (Tønder). The initiative concerning the development of a Citizen Climate Council aims to ensure broad representation of citizens in Odense in relation to the development of the climate efforts and the changes to the city that the path to a carbon-neutral city (Odense).

Measures that provide large both CO2 reduction and robust climate protection often cost a lot of money regardless of the size of the municipality, and therefore it is often an obstacle to implementation. This concerns both the municipal economy, but also private funds for private climate projects (Assens, Langeland, Svendborg). There are also efforts that are dependent on obtaining financial support from private or public funds, grant schemes, etc. In many cases, it can also be difficult to calculate the need for financing. Administrative resources are set aside for planning work, feasibility studies, policy development, citizens' arrangements, etc., as well as to support efforts that are expected to be carried out by private, public or semi-public actors (Assens).

Varde Municipality will counter this by articulating this challenge to national legislators and other relevant actors, e.g. banks and foundations (Varde).

3.4. Conclusions and Recommendations

Many municipalities report that DK2020 was the starting point for comprehensive climate plans, gaining political attention and putting the climate agenda under the spotlight for the entire municipality, which was not the case previously.

Regarding GHG emission reduction, the agricultural sector is responsible of the largest share of emissions, both in at present and in future projections. In order to reach climate neutrality by mid-century, this sector would need special attention to prevent and limit emissions. Following is the energy sector, which seems to be the area where action scenarios have the most effective impact, as it is predicted to characterize a very minor part of total emissions in the 2050 projection. Scope 3 emissions, represented by waste, wastewater, and chemical processes, represent the smallest percentage, though not all municipalities calculated them. The building sector is not commonly considered, despite being impactful, if not in terms of energy optimization of the building envelope.

The region is set on a positive path to accomplish the 2030 targe. Action for mitigation within the energy sector include phasing out of fossil powered energy sources that goes in parallel with the increase of clean energy sources, particularly solar cells and wind turbines. At the same time, half of the municipalities rely on carbon capture as a viable option for reducing their emissions, and almost one third on PtX; including Odense Municipality, through which it predicts to have no residual emissions already by 2030. Reduction from the transport sector does not only include electrification of vehicles, but also the promotion of slow mobility (i.e., cycling) through campaigns and improvement of the mobility infrastructure. While this can be seen as a positive aspect, efforts within the agricultural sector make no mention related to organic farming and the potential to lessen the impact of the sector through the avoidance of pesticides and fertilizers – with the exception of Kolding Municipality. Also, as part of scope 3 emissions, chemical processes were considered by less than a half of the municipalities within their emissions inventories and projections and considered even less when formulating mitigation actions. The waste management sector and the construction sector also are not covered by most municipalities. Beyond actions within each sector, by introducing change within their walls, municipal administration can lead the way by example (e.g., introducing a plant-based diets in their canteens).

For assessing climate risks, most municipalities pointed out that they made use of the Klimaatlas to check whether a given hazard would be relevant to assess. The platform provides climate data related to rainfall, drought, water level and storm surge, temperature, wind, solar radiation and evaporation, according to RCP 2.6, RCP 4.5 and RCP 8.5. scenarios. Flooding is the main risk municipalities have been focusing on and is also one of the most complicated to assess, as it can be caused by different kinds of hazards. For instance, there can be different considerations of rainfall together with streams and rivers, as river overflow happens usually due to rainfall. Also, despite being different, flooding caused by sea level rise and storm surges are used interchangeably. Finally, there is a limited knowledge to be able to assess other climate risks to the same extent as floods have been.

The concepts of exposure and vulnerability are key to determine the extent of climate risks, as they can also provide a base for the calculation of loss and damages: these were estimated by less than half of the municipalities but their consideration can help with gaining political willingness for prevention and obtaining funds for implementation. In their adaptation goals, municipalities do not always specify the cause of flooding they intend to protect their territory from, therefore it is challenging to assess whether the adaptation actions respond to the risk accordingly. It is by looking at each specific climate adaptation plan that we could assess whether an appropriate differentiation has been done. Ultimately, there is a large discrepancy between the assessed climate risks and the goals and actions produced. This might be justified by the criteria used to prioritize actions,

which clearly give precedence to projects against flooding.

A listing of different actors, who can be interested in or affected by each action does not automatically translate into actual involvement and engagement in implementation. In a second phase, it would be possible to assess whether there is a match between the mentioned actors and their active involvement and contribution.

A number of municipalities (8) did not indicate KPIs for monitoring, but their elaboration at this stage would be essential to focus implementation according to clear targets from the very start. The use of the indicators developed within the Vores Verdensmål project would represent a potential to align the local action to national and international sustainable goals (2030-Panelet, 2020). This could perhaps contribute to the continuation to the Region of Southern Denmark's sustainable development strategy (2020-2023).

A recurrent cross-cutting issue being mentioned is the lack of competences for the green transition and on climate issues within the municipal workforce, across the different departments. This is a capacity issue that manifests both during the development of policies (e.g., when there is the need to politically align planning themes), and in their implementation (e.g., approval of PtX projects without in-house competentece to evaluate them and translate them into a plan for the city).

Municipalities would rather not engage with consultants, in order to keep the ownership of their knowledge and engagement across various departments.

Across all municipalities there is a concern regarding long-term finance for implementation, as it is strictly dependent on the future budget negotiations, on top of cross municipal and cross regional competition for finance. There seem to be more will to support on climate adaptation than mitigation, as it is easier to get political attention for adaptation projects (e.g., dikes), whilst mitigation efforts are less appealing.

Many actions depend on individuals' behavior: energy renovation of heating and electricity by homeowners, purchase of electric vehicles by citizens for private use and for companies, use of public transport or other green alternatives to private cars such as biking, etc. It is difficult to reach all citizens with information to increase awareness on climate-related issues.

On top of land scarcity, there is also a competition among land uses: agricultural land can be set aside, or can be afforested, or it can be needed for adaptation projects.

Based on the preliminary analysis of the status on climate planning in the selected municipalities, below are some first recommendations for the Region.

<u>Emission reduction: ambitions must be raised.</u>

#1 Several municipalities base the achievement of reduction targets on technological developments and innovations that are questionable in terms of feasibility within a foreseeable number of years. Instead, it is recommended to use known technology, especially in relation to the 2030 target, and be more ambitious in this regard.

#2 It is recommended to focus more than before on synergy effects, also in relation to opportunities for co-financing initiatives, and to account for the costs of no action to a greater extent.

#3 In the coming years, it is recommended to phase in scope-3 emissions in the municipalities' work to realize zero-emission societies and, not least, to create binding collaborations between and across all stakeholders, including municipalities.

Climate adaptation: adapting to more than just flooding.

#4 Municipalities should focus much more on multiple types of hazards, as well as coupled events and multiple risks.

#5 The understanding and evaluation of exposure and vulnerability should be strengthened, including the development of a better set of indicators for local use for dialog and collaboration as well as for assessing (avoided) losses and damages.

#6 High-Impact, Low-Probability and Tipping Points should, to a greater extent than at present, be embedded as part of the municipalities' climate adaptation plans and actions, including as a starting point for a dialogue on mitigation and how this can be seen in a longer-term development perspective.

General: coordination and integration as key parameters.

#7 You are not alone: Develop, share and retain skills through capacity building and training as well as strengthened collaborations and coordinated efforts for plan development and implementation.

#8 Understand and account for financial needs and obligations, seek synergies in terms of financing across actors, and create knowledge, understanding and committed ownership among all stakeholders, not least citizens and the private sector.

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ANNEXES

1. List of municipalities.
2. List of analyzed documents.
3. List of indicators.
4. *Mitigation, adaptation and implementation efforts by each municipality (not publicly available).*

ANNEX 1: List of Municipalities

1. Assens Kommune
2. Billund Kommune
3. Esbjerg Kommune
4. Fanø Kommune
5. Fredericia Kommune
6. Faaborg-Midtfyn Kommune
7. Haderslev Kommune
8. Kerteminde Kommune
9. Kolding Kommune
10. Langeland Kommune
11. Middelfart Kommune
12. Nordfyns Kommune
13. Nyborg Kommune
14. Odense Kommune
15. Svendborg Kommune
16. Sønderborg Kommune
17. Tønder Kommune
18. Varde Kommune
19. Vejen Kommune
20. Vejle Kommune
21. Ærø Kommune
22. Aabenraa Kommune

ANNEX 2: List of analyser documents

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5. Billund Kommune. (2023). *Klimaplan. Virkemiddeloversigt*.
6. Esbjerg Kommune. *Climate Action Planning Framework*.
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9. Esbjerg Kommune. (2021). *Reduktionssti 2021-2030*.
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11. Fanø Kommune. *Virkemiddelkatalog for CO_2e-neutralitet og klimatilpasning*.
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ANNEX 3: List of Indicators

1. Introduction

1.1. Municipality name

1.2. Municipality code

1.3. Reviewer

1.4. Date of document analysis

1.5. Document name(s) and acronym(s)

2. Mitigation challenges

2.1. Base line year

2.3. Base line by sector: Energy

2.4. Base line by sector: Transport

2.5. Base line by sector: AFOLU

2.6. Base line by sector: Waste

2.7. Base line by sector: Chemical processes

2.8. Base line by sector: Other sectors

2.9. Baseline value (total)

3. Mitigation goals

3.1. Values of emission pathways (Y/N)

3.2. GHG reduction by sector: Energy (2030)

3.3. GHG reduction by sector: Transport (2030)

3.4. GHG reduction by sector: AFOLU (2030)

3.5. GHG reduction by sector: Waste (2030)

3.6. GHG reduction by sector: Chemical processes (2030)

3.7. GHG reduction by sector: Other sectors (2030)

3.8. GHG reduction by sector: Energy (2050)

3.9. GHG reduction by sector: Transport (2050)

3.10. GHG reduction by sector: AFOLU (2050)

3.11. GHG reduction by sector: Waste (2050)

3.12. GHG reduction by sector: Chemical processes (2050)

3.13. GHG reduction by sector: Other sectors (2050)

3.14. CO2e neutrality: Base line year

3.15. CO2e neutrality: Target year

3.16. CO2e neutrality: Target value

4. Mitigation actions

4.1. Mitigation by sector: Energy

4.2. Mitigation by sector: Transport

4.3. Mitigation by sector: AFOLU

4.4. Mitigation by sector: Waste

4.5. Mitigation by sector: Chemical processes

4.6. Mitigation by sector: Other sectors

5. Residual emissions

5.1. Expected residual emissions: source text

5.2. Value of total emissions in 1990

5.3. Value of total emissions in 2030

5.4. Value of total emissions in 2050

5.5. Climate neutrality by 2050

6. Adaptation challenges

6.1. Challenges by hazard: Flood

6.2. Challenges by hazard: Drought

6.3. Challenges by hazard: Sea level rise

6.4. Challenges by hazard: Extreme wind

6.5. Challenges by hazard: Temperature rise

6.6. Challenges by hazard: Heat wave

6.7. Challenges by hazard: Land degradation

6.8. Challenges by hazard: Saltwater intrusion

6.9. Challenges by hazard: Water acidification

6.10. Challenges by hazard: Wildfire

6.11. Challenges by hazard: Vector-born disease (air and water)

6.12. Consideration of exposure

6.13. Consideration of vulnerability

6.14. Consideration of loss and damages

7. Adaptation goals

7.1. Adaptation goals: source text

7.2. Adaptation goals: target years

7.3. Goals by hazard: Flood

7.4. Goals by hazard: Drought

7.5. Goals by hazard: Sea level rise

7.6. Goals by hazard: Extreme wind

7.7. Goals by hazard: Temperature rise

7.8. Goals by hazard: Heat wave

7.9. Goals by hazard: Land degradation

7.10. Goals by hazard: Saltwater intrusion

7.11. Goals by hazard: Water acidification

7.12. Goals by hazard: Wildfire

7.13. Goals by hazard: Vector-born disease (air and water)

8. Adaptation actions

8.1. Goals by hazard: Flood

8.2. Goals by hazard: Drought

8.3. Goals by hazard: Sea level rise

8.4. Goals by hazard: Extreme wind

8.5. Goals by hazard: Temperature rise

8.9. Goals by hazard: Heat wave

8.10. Goals by hazard: Land degradation

8.11. Goals by hazard: Saltwater intrusion

8.12. Goals by hazard: Water acidification

8.13. Goals by hazard: Wildfire

8.14. Goals by hazard: Vector-born disease (air and water)

8.15. Consideration of exposure

8.16, Consideration of vulnerability

9. Implementation

9.1. Elements for each action: Identification of responsible parties

9.2. Elements for each action: Implementation timeline

9.3. Elements for each action: Human resources and/or budget for actions

9.4. Criteria for action prioritization

9.5. Co-benefits

9.6. SDGs

10. Monitoring and evaluation

10.1. Key performance indicators

10.2. Implementation monitoring

10.3. Impact assessment

11. Barriers

11.1. Legislation

11.2. Governance

11.3. Capacity

11.4. Finance

11.5. Participation and stakeholder engagement

11.6. Technology

11.7. Data

11.8. Other