Locating net zero emissions: An ethnographic comparison of local approaches to community-scale carbon neutrality

Stephen Gregory Pollard

ORCID: 0000-0001-6627-2373

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Faculty of Architecture, Building and Planning

Melbourne Sustainable Society Institute

University of Melbourne

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Abstract

The concept of global net zero emissions has emerged as a powerful unifying narrative to connect the science and policy of climate change. This thesis examines how policy actors translate the concept of global net zero emissions across different scales and contexts into local goals for, and actions towards, community-scale carbon neutrality. The study is based on an ethnographic comparison of three diverse local jurisdictions with such goals: the City of Copenhagen in Denmark, and the City of Melbourne and Byron Shire in Australia. In establishing these goals, policy actors in each place delineate the boundaries between sources and sinks of emissions using similar methods of municipal carbon accounting, but with distinctive preferences for how and where to balance those emissions. Comparison within and between these places reveals patterns of relations and situated contingencies that shape choices and actions in relation to net zero emissions goals.

The analysis draws together concepts from anthropology and science and technology studies (STS) to examine local goals for community-scale carbon neutrality. Such goals may take hold as **sociotechnical imaginaries** that express collective visions for desirable futures. These goals are anchored to particular localities through spatial and conceptual boundaries that are **co-produced** in relation to objects and scales of climate governance. Enacting carbon neutrality involves reconfiguring open-ended **assemblages** of heterogeneous social and material elements within and across these boundaries. **Friction** enables and constrains these reconfigurations, pulling assemblages in new directions to inflect pathways of sociotechnical change. These concepts are tied together through the thesis to generate insights into how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

The thesis demonstrates common processes and relationships involved in collective efforts to imagine and enact community-scale carbon neutrality, and at the same time shows these to be contingent, unstable and continually unfolding. Ethnographic comparison of local climate governance allows us to learn from and imagine other ways of pursuing low carbon futures in response to climate change. Approaching carbon neutrality as relational and contextually specific reveals multiple pathways and possibilities for ecological, social and technical change. Governing human activities and sociotechnical systems towards carbon neutrality is not only about steering processes of change towards a preconceived ideal but also involves ongoing performances of place and community. These practices require reflexivity towards past histories and current contexts, and flexibility to adjust to shifting circumstances.

Keywords: *Climate change policy, net zero emissions, community-scale carbon neutrality, multilevel climate governance, municipal carbon accounting, sociotechnical imaginaries, co-production, carbon assemblages, friction.*

Declaration page

I declare that:

i. This thesis comprises original work towards a Doctor of Philosophy, except where indicated in the preface;

ii. Due acknowledgement has been made in the text to all other material used; and

iii. The thesis is fewer than the maximum word limit in length, exclusive of tables, maps, bibliographies and appendices.

Stephen Pollard

19 August 2020

Preface

This thesis was carried out under the supervision of Prof John Wiseman and A/Prof Monica Minnegal at the University of Melbourne. Stephen Pollard undertook the fieldwork, solely managing the research process and collecting and analysing the data. Stephen Pollard drafted the chapters in the thesis with feedback and guidance from his supervisors. Early versions and parts of some chapters were also drafted as single-authored academic book chapters, peer-reviewed conference proceedings, and non-peer-reviewed publications. These are described below and with full author-accepted versions included as appendices.

Chapter One

This chapter contains unpublished material not submitted for publication. This chapter is entirely the work of Stephen Pollard.

Chapter Two

An early version of part of this chapter (2.3 Sociotechnical imaginaries) was published in Pollard S. (2020) Imagining the Net Zero Emissions City: Urban Climate Governance in the City of Melbourne, Australia. In: Hoff J, Gausset Q and Lex S (eds) *Building a Sustainable Future: The Role of Non-State Actors in the Green Transition.* Routledge, p211-229. Available at: https://doi.org/10.4324/9780429280399.

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This chapter and those articles are entirely the work of Stephen Pollard.

Chapter Three

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Chapter Four

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Chapter Five

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Chapter Six

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Glossary of acronyms

C40	C40 Cities Leadership Network
CCP	Cities for Climate Protection
CDP	Carbon Disclosure Project
CEDAMIA	Climate Emergency Declaration and Mobilisation in Action
CH2	Council House 2
CO_2-e	Carbon dioxide equivalent
COP	Conference of Parties
CPH	Copenhagen
GCM	Global Circulation Model
GPC	Global Protocol for Community-scale Greenhouse Gas Inventories
HOFOR	HOFOR – Greater Copenhagen Utility
ICLEI	International Council for Local Environmental Initiatives (Local Governments for Sustainability)
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MW	Megawatt
NAZCA	Non-State Actor Zone for Climate Action
OECD	Organisation for Economic Cooperation and Development
UN	United Nations
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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Chapter 1. Imagining and enacting net zero emissions

1.1 Introduction

The concept of global net zero emissions has become a powerful unifying narrative in the science and policy of climate change. The 2015 Paris Agreement marked a moment of consensus between nation states on the need to achieve net zero greenhouse gas emissions by the second half of this Century. While many national governments have been slow to perform actions aligned to this objective, a growing number of sub national and non-state actors – in particular those from the global north – have made voluntary commitments to try and achieve net zero emissions for their own domains of authority and spheres of activity and influence. A certain harmony has emerged around global net zero emissions as an overarching goal in **climate governance** – that is, efforts to govern the human activities, and the social and technical systems and ecologies in which they are embedded, that contribute to climate change. But there is a dissonance between the global scale of this objective and the spread of actors, organisations and institutions that are struggling with its delivery.

The idea of global net zero emissions can be understood, following Tsing (2005), as a **universal** – it transcends localities, moving objects and subjects, but it has not taken over the whole world. The concept is rooted in scientific and technical practices to generate knowledge of the global climate system and the planetary-scale effects of greenhouse gas emissions originating from human activities. In order to move objects and subjects in ways that reduce and remove greenhouse gas emissions, however, this universal concept must take hold in specific places and circumstances. Efforts to implement universals (such as global net zero emissions) produce both abstraction and friction through interactions across difference (Tsing, 2005: 11). It is this tension, between universal and situated, abstract and emplaced, global and local, that this thesis sets out to navigate through a focus on local commitments for net zero emissions.

The central research question addressed in this thesis is: How do policy actors translate the concept of global net zero emissions into local policy goals for, and actions towards, "community-scale carbon neutrality". Consistent with Tsing (2005: 62), I approach **translation** as a recursive and ongoing process that involves the 'drawing of one world-making project into another'. Translation asks us to pay attention to the situated connections through which knowledge is generated, made mobile, and made meaningful. This thesis is focused on the way policy actors draw the abstract universal of global net zero emissions into their situated efforts to remake local worlds as carbon neutral.

Comparison is essential to study relationships between the universal and the particular (Jasanoff and Kim, 2015: 35; Tsing, 2005: 89-90). In this study,

comparison reveals the particular shape and substance of local approaches to community-scale carbon neutrality while generating insights into what is common in these efforts. This study is empirically grounded in an ethnographic comparison of three places. The City of Copenhagen aims to be the first capital city in the world to become carbon neutral by 2025. The City of Melbourne, in 2003, announced its goal to achieve zero net emissions across its municipal area with a target date of 2020 (although in 2018 this strategy was wholly refreshed, and the target date was extended). Byron Shire is striving to become Australia's first regional community to achieve zero emissions by 2025. While all three jurisdictions have clear commitments to carbon neutrality, each is acting in locally specific contexts and circumstances.

Ethnographic comparison of these places supports understandings (rather than explanations) of how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. The study did not seek to pinpoint relationships between variables that will hold as objective truths, but rather to highlight contingencies in these processes that cannot be identified through single case studies or larger multivariate analyses.

The thesis draws together four concepts from STS and anthropology to analyse the common processes and situated contingencies involved in these processes of translation. I apply these concepts, in turn, through the four empirical chapters at the core of this thesis to address the following research sub-questions:

1. What are the conditions of possibility in which particular **sociotechnical imaginaries** of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom)? (Chapter Four)

2. How do practices to define boundaries around community-scale carbon neutrality **co-produce** objects and scales of local climate governance? (Chapter Five)

3. How are efforts to enact carbon neutrality negotiated and contested as policy actors attempt to **assemble** new connections between people, technologies, and nature? (Chapter Six)

4. What **frictions** emerge in processes to enact community-scale carbon neutrality and how do these enable, constrain and inflect processes of sociotechnical change? (Chapter Seven)

First, I approach local goals for community-scale carbon neutrality as **sociotechnical imaginaries**, collectively held and performed visions of social life and social order mirrored in the design and enactment of scientific and technological projects (Jasanoff and Kim, 2009: 2; Jasanoff, 2015: 4). Second, I examine the processes of boundary making that hold these imaginaries in place through the idiom of **co-production** (Jasanoff, 2004), to highlight symmetries between knowledge of

greenhouse gases and actions to govern the human activities and sociotechnical systems and ecologies that emit and absorb those gases. Third, I trace the **assemblages** of social and material elements (Blok and Farías, 2016; Tsing, 2015) that are focused on and reconfigured around carbon within and across these boundaries in order to reduce and neutralise emissions. Fourth, I consider the **frictions** (Tsing, 2005) that shape, inflect, and destabilise these processes of sociotechnical change, to highlight situated contingencies and draw attention to strategies that policy actors use to adjust and stabilise local goals for community-scale carbon neutrality in response to shifting circumstances.

Each of these sub-questions and concepts distils an essential part of situated processes to imagine and enact community-scale carbon neutrality that are at the core of this thesis. The final chapter draws these concepts together as an analytic scaffold to address the central research question of this thesis. It is this heuristic framework, rather than explanatory variables, that can be transferred to generate insights into processes and practices related to net zero emissions in other places and at other levels of climate governance.

In this chapter I outline the overall direction of the thesis and the key points necessary for orientation. First, I frame the goal of global net zero emissions as a scientific and technical project of planetary proportions, yet one that can only be realised through changes to sources and sinks of greenhouse gases in particular locations. Next, I summarise each of the analytic framing devices outlined above and their application in the thesis and give a brief account of the contributions to knowledge generated through this study. Then, I give an overview of the methodological considerations that informed the design of this study; its empirical grounding in ethnographic comparison, the selection of localities at its core, and the ethnographic style of writing used to generate and convey understandings. I conclude this opening chapter with an overview of the thesis as a whole.

1.2 Locating net zero emissions

The concept of global net zero emissions represents the desired outcome of collective action on climate change at a planetary scale. It signals a future where concentrations of greenhouse gases in the Earth's atmosphere stabilise in order to limit humanity's impacts on the global climate system. The international Paris Agreement on climate change contains a central objective to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C (UNFCCC, 2015: Article 2, clause 1a). To achieve this long-term temperature goal, global emissions must peak as soon as possible and then rapidly reduce 'so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of the Century' (UNFCCC, 2015: Article 4, clause 1). This clause is widely understood to mean that global net zero emissions must be achieved no later than 2050.

Achieving net zero emissions will require deep and lasting transformations to the human activities that release greenhouse gas emissions and the sociotechnical systems in which these activities are embedded. Yet these activities and systems are not "global", unlike the atmosphere and oceans that they impact. They are situated in particular places and connected in complex ways. Sophisticated models that abstract the global climate system are important, as are innovative technologies that could be applied around the globe to generate, store, and manage flows of renewable energy or, conversely, to draw carbon dioxide out of the air. Equally important are familiar technologies embedded in everyday life such as the bicycle, and cycles of organic growth that sequester carbon in plants, soils and seabeds. Enacting net zero emissions involves negotiation and contestation over how and where sources and sinks of greenhouse gases ought to be balanced, what forms of knowledge should inform these decisions, and which technological innovations, ecological configurations and societal alterations ought to be redirected towards this goal.

To speak of "net zero" emissions is to draw attention to the boundary between emissions and removals of greenhouse gases. In this respect, the problem of global climate change could be likened to a bathtub where the atmosphere (the tub) is filling up with greenhouse gases (the water), and overflow signals disaster (Guy et al., 2013). The concept of global net zero emissions stands for a state of equilibrium. In principle, this could be a static equilibrium where the taps are turned off before the tub overflows, or a dynamic equilibrium where the taps remain on, but the tub is drained as fast as the water flows in. The calculation is made more difficult by not knowing exactly how big the tub is to begin with (whether 1.5°C or 2°C are considered a "safe" temperature limit), how quickly the growth of global greenhouse gas emissions could be turned around, and at what volumes and rates could greenhouse gases be removed from the atmosphere given that plants take time to grow and new technologies take time to develop. Of course, the climate system is far more complex than a bathtub in terms of feedback loops, tipping elements, uncertainties and indeterminacies, not to mention risks. In terms of balancing greenhouse gases, there are multiple interconnected taps and plugs to manage.

Defining goals for net zero emissions become more complicated at less-than-global scales and in a context of multilevel climate governance. With national pledges and policies falling far short of the Paris Agreement goals (UNEP, 2019b), many non-state actors have established their own voluntary commitments to reduce emissions in response to climate change. In that context, cities have been receiving substantial attention as key sites, and local governments and transnational municipal networks as key actors, in the efforts required to achieve the Paris Agreement targets (see for instance Acuto and Parnell, 2016; Bulkeley, 2015). Within this cohort, a growing number of local governments and local communities are putting forward their own commitments for net zero emissions in the form of "community-scale carbon neutrality" (C40 Cities and Arup, 2016; Tozer and Klenk, 2018; Kenis and Lievens, 2017; Pollard, 2020). Broadly defined, this refers to a situation where greenhouse

gases emitted within a specified local territory, and resulting from activities that occur in that territory, are reduced as much as possible and any remainder is "offset" by removing (or avoiding emissions of) an equivalent amount of carbon dioxide elsewhere. Amongst the dozens of local governments with goals for community-scale carbon neutrality, there are potentially significant variations in how these goals are defined in terms of the boundaries delineated around these policy objectives and the approaches taken to balance emissions across these boundaries. Such differences include methods to equate sources and sinks of greenhouse gases across extended geographies and timescales, such as emissions saved by generating wind energy in one place being credited with displacing energy that would have been produced by burning coal elsewhere, and carbon emitted from transport being equated with carbon taken up by forests.

There are winners and losers in projects to alter (and to resist alterations of) human activities and the sociotechnical and ecological systems in which those activities are embedded, highlighting that power is an important dynamic in climate governance. Relationships of knowledge and power shape the ways in which climate change, and possibilities to respond to climate change, are understood, communicated and acted upon. While power is one of the elements at play in how policy actors envision and seek to implement goals for net zero emissions, the research presented here is not primarily a study of how power dynamics shape multilevel climate governance. Instead, this study foregrounds the situated contexts, processes and relationships through which discourses and practices play out to delineate boundaries around net zero emissions and manage greenhouse gases within and across these edges.

Focusing on local climate governance throws interactions related to net zero emissions into relief because the geographic territories overseen by local governments encompass only portions of the human activities and sociotechnical systems that emit greenhouse gases, or the ecological systems that absorb them. Defining and seeking to implement local goals for community-scale carbon neutrality therefore involves explicit work to delineate boundaries around complex and extended systems and between sources and sinks of greenhouse gases. Applying a place-based perspective to processes of climate governance draws attention to how these boundaries are stabilised and adjusted. This, in turn, highlights that efforts to govern human activities and sociotechnical systems in response to climate change are situated in, and at the same time cut across, complex and variegated social and material worlds. Thus, the narrative of global net zero emissions becomes differentiated at less-than-global scales as the meanings of what counts as net zero emissions, the changes to ecological and sociotechnical systems seen as appropriate and necessary to support this outcome, and the actors responsible for these changes, emerge differently in different contexts and places.

To bring these boundary making processes further into focus, consider how policy actors in the three field sites at the core of this dissertation had each planned a different approach to reduce and then neutralise emissions their local emissions. In its

inaugural strategy for zero net emissions by 2020, the City of Melbourne's preferred approach was to use market-based carbon offsets alongside measures to reduce emissions within the city (City of Melbourne, 2003). The City of Copenhagen has employed a carbon accounting method where exports of surplus wind energy offset emissions from other sources such as transportation (City of Copenhagen, 2009; 2017b). In Byron Shire the goal expressed was for net zero emissions within the geographic boundaries of the municipality through a combination of reducing emissions and sequestering carbon locally through reforestation and regenerative agriculture (Byron Shire Council, 2015; Milman, 2015; Zero Emissions Byron, 2016). In-depth investigation and comparison of these local approaches to community-scale carbon neutrality provide insights into the shared features and situated contingencies that shape discourses and practices related to net zero emissions.

1.3 Key concepts

The central research question addressed in this thesis is: How do policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality? I approach this central research question through four sub-questions, expressed earlier, that apply, in turn, the concepts of sociotechnical imaginaries, co-production, assemblages and frictions.

Each of the four sub-questions focus on a key part of processes through which policy actors translate the concept of net zero emissions from a global abstract to locally emplaced targets and visions, policies and actions. Below, I briefly sketch each of these analytic framing devices and their application in the thesis, with this summary more fully developed in Chapter Two. Distilling these mutually interconnected processes to imagine and enact community-scale carbon neutrality helps draw attention to what stays the same, and what changes, as the analysis in this thesis moves between different contexts and situations.

Sociotechnical imaginaries are defined as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (Jasanoff, 2015: 4). Put another way, policy goals for global net zero emissions and community-scale carbon neutrality can coalesce as sociotechnical imaginaries that take up scientific knowledge, technological innovations, and conceptions of social and natural order in particular ways. Viewing local policies, strategies, and interventions for community-scale carbon neutrality in this way draws attention to who is doing the imagining and what pathways of sociotechnical change are involved in their enactment, as well as relationships of knowledge and power that are implicit in these imaginings. The focus in Chapter Four is on how the viability and desirability of collectively imagined carbon neutral futures change as local histories and conditions change, and in

relation to the constellations of actors involved in framing imaginaries within these contexts.

Objectives for community-scale carbon neutrality are held in place by delineating spatial and conceptual boundaries around greenhouse gases, and the human activities and sociotechnical systems associated with the emission and removal of those gases. In Chapter Five, the focus shifts to the practices of municipal carbon accounting used to define boundaries in each of the field sites in order that greenhouse gases can be measured and managed within and across those delineations. The idiom of **co-production** (Jasanoff, 2004), helps to draw out the symmetrical processes through which knowledge of the world and action in the world are produced in relation to each other. The focus in Chapter Five is on how practices of municipal carbon accounting generate knowledge through interaction between actors, institutions, and material realities. These practices render greenhouse gases as legible objects that can be governed at local scales, helping to stabilise objects and scales of climate governance, and shaping possibilities to reduce and remove greenhouse gases. Comparison reveals how these processes of boundary making align to institutional systems of climate governance in other places and across other levels and, equally, must attend and conform, to some extent, to local specificities.

Whereas boundaries fix commitments for community-scale carbon neutrality to specific places, enacting changes to achieve these goals involves efforts to alter human activities, reconfigure sociotechnical systems and ecologies, and remake lived experiences and meanings. Achieving carbon neutrality thus require relationships between society, technologies and ecologies to be modified and transformed. Thinking through **assemblages** (Blok and Farías, 2016; Tsing, 2015) helps to trace these processes of reconfiguration as open-ended encounters between social and material elements that are focused around carbon to reduce and offset greenhouse gases. Chapter Six is focused on the ways that efforts to assemble carbon neutrality are negotiated and contested in each field site in relation to concrete urban development projects. Carbon assemblages rest on practices that establish and maintain carbon dioxide equivalent as an object that can be governed in these projects, but always unfold in different ways because of the indeterminacy of encounters between people, technologies and natures.

Processes to imagine and enact community-scale carbon neutrality emerge from locally specific conditions of possibility, creation and stabilisation of objects and scales of climate governance, and the indeterminacy of encounters between people, technologies and natures. The concept of **friction** (Tsing, 2005) helps to draw out the dynamic interactions that shape and inflect these local responses to global climate change. Friction – 'awkward, unequal, unstable, and creative qualities of interconnection across difference' (Tsing 2005: 4) – is inherent in encounters across difference that grip and may pull assemblages in unexpected directions. Thinking through friction helps to identify situated interactions where alternative ways of imagining and enacting community-scale carbon neutrality may emerge. The focus in

Chapter Seven is on tracing these encounters to show that, while similar points of friction emerge in each locality, processes of sociotechnical change follow different trajectories as a result.

While these four focal concepts are interrelated, different bodies of literature have foregrounded one or other of them in varied ways, as I discuss further in the next chapter. In-depth analysis through each of these conceptual lenses, in three different field sites, generates insights into the common processes through which policy actors envision and enact goals for net zero emissions. Equally, this analytic approach reveals the ways in which different contexts and relationships may shape these processes, highlighting locally situated contingencies in processes of sociotechnical change. This includes which constellations of actors and institutions are prominent in negotiating policy goals for, and actions to realise, community-scale carbon neutrality; how and where boundaries are stabilised and adjusted around these objectives; and what options are available to policy actors to adjust actions and goals in response to shifting circumstances. Thus, while it is possible to better understand these processes, they are not reducible to explanation by way of determining variables, and nor is it possible to think of any particular approach to community-scale carbon neutrality as being strictly reproducible or scalable.

1.4 Contributions to knowledge

This thesis makes a substantive empirical and conceptual contribution to social scientific literature on climate governance, including in the fields of anthropology, science and technology studies (STS), and multilevel climate governance. It develops an in-depth, ethnographically informed account of how processes to imagine and enact low carbon futures unfold in particular places. The study highlights that negotiation and contestation over what counts as net zero emissions and how to get there play out at less-than-global scales, reinforcing that local contexts and actions must be taken seriously in studies of global issues. From a pragmatic point of view, telling stories about local policy actors who are ambitious, but not always successful, in the face of shifting circumstances, is a way to acknowledge their creativity and inventiveness and draw attention to the messy realities of imagining and enacting local responses to global climate change.

Ethnographic comparison between these places amplifies patterns of action and interaction and, by doing so, helps to make sense of complex realities. Ethnographically locating efforts to realise net zero emissions highlights processes of translation involved in moving between abstract global to situated local, and the institutions and dialogues through which both local and global agendas are shaped (Tsing, 2005: 279). Doing so helps us to imagine low-carbon futures in other ways and to reflect on how, and for whom, policy goals for community-scale carbon neutrality are made meaningful. Through this comparative approach (outlined below and discussed in detail in Chapter Three), the thesis adds to ongoing methodological discussions concerning comparative approaches in social scientific inquiry.

The principal theoretical contribution of this thesis is to advance the analytic scaffold of interconnected concepts outlined above. Drawing these concepts together highlights and strengthens shared strands of scholarship between STS, anthropology, and multilevel climate governance. This scaffold structures the thesis and establishes an empirically grounded heuristic framework that can be transferred to other places, contexts and scales of climate governance. Approaching discourses and practices related to net zero emissions through this framework, as relational and locally specific, allows us to imagine other ways of pursuing low carbon futures in response to climate change. Thus, the thesis generates new ways of understanding the concept of net zero emissions as situated, contingent, and open-ended, involving ongoing negotiation and stabilisation across varied contexts and scales.

The analysis developed through this thesis is not comprehensive, and a key limitation is its engagement on socioecological dimensions of efforts to imagine and enact low carbon futures. Multispecies entanglements do not tend to be a strong feature of research on sociotechnical imaginaries, which is most often focused on scientific and technological projects framed within positive visions of the future. Even the concept of co-production, which helps to articulate relationships between knowledge of the world and action in the world, is focused on how the world comes to be known by human actors. Thinking through assemblages and friction opens up possibilities to engage with more-than-human relations, however my analysis of carbon assemblages and frictions does not pursue these possibilities in depth. Reflection in the concluding chapter about the radical reshaping of social and material relations through the COVID-19 pandemic, which is unfolding as I write this in mid-2020, underscores the importance of research that engages with more-than-human relations in efforts to imagine and enact low carbon futures.

Most importantly, this thesis has been shaped through ongoing engagement with the places and actors at its heart. I am grateful to the people who participated in my research for receiving me in their worlds and sharing their knowledge, experiences and reflections. In return, the narratives and analysis contained in these chapters are a way to share the stories and meanings that have been shared with me. Additionally, I hope the concepts, narratives, and interpretations developed through this study offer a resource for policy actors engaged in their own efforts to imagine and enact low carbon futures in response to global climate change.

1.4 Research methodology

Addressing how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality raises a set of methodological issues about how, and where, to study discourses and practices of multilevel climate governance. Viewing goals for community-scale carbon neutrality as sociotechnical imaginaries requires an appreciation of the local contexts in which these collective visions are shaped. Understanding how boundaries are delineated around the "community-scale" as a site for climate governance involves situating

localities and communities in relation to wider contexts. Tracing efforts to reconfigure social and material elements into carbon neutral assemblages, and the frictions that emerge through these processes, involves carefully observing and describing complex interactions. In this section, I provide an outline of my methodological framing, research design and research methods, with a more detailed discussion to follow in Chapter Three.

Jasanoff (2015) describes comparison across social and political structures as an indispensable method for studying sociotechnical imaginaries. Comparison 'not only helps to identify the content and contours of sociotechnical imaginaries but also avoid the intellectual trap of taking as universal epistemic and ethical assumption that turn out, on investigation, to be situated and particular' (Jasanoff and Kim, 2015: 35). My empirical investigation was designed to ethnographically compare local approaches to community-scale carbon neutrality. In-depth ethnographic field work was designed to reveal locally specific social, economic and political landscapes. Comparison between these places and over time was designed to highlight these specificities and, at the same time, amplify patterns of relations that are common to processes of sociotechnical change directed towards net zero emissions.

1.4.1 Scoping research and selection of field sites

I began this inquiry with scoping research into the responses of local governments to global climate change, and in particular commitments to reduce emissions and contribute to goals for global net zero emissions. Through a desktop review of the emissions reduction commitments of local governments, I identified 26 that were reporting goals for community-scale carbon neutrality, expressed in various ways.[1] Close review of policy documents produced by these entities about their commitments revealed variations between definitions of community-scale carbon neutrality, pointing to the instability of this as a discursive category (with similar findings made by Tozer (2018) in a study of discourses generated by members of the Carbon Neutral Cities Alliance).

From the subset of jurisdictions identified through the desktop review, I selected three localities for ethnographic comparison on the basis of four considerations summarised below. First, I chose to investigate localities with near-term targets on the basis that policy and decision-making processes would be underway during the research period, and thus accessible through ethnographic fieldwork. Second, I elected to focus on jurisdictions that had expressed clear boundaries around their carbon neutral goals, as noted earlier. The third consideration was to engage with different social, economic and political landscapes rather than attempting to "control" variables or smooth out differences by selecting places that seemed alike through

[1] At that time, 24 of the 26 cities identified through the desktop review were located in the global north, signalling a potentially worrying gap with the majority of urban emissions growth expected to come from the development and expansion of cities in the global south (UN Habitat, 2016).

research design. This comparison across difference was devised to reveal how contexts may shape different approaches, and what remains common despite situated differences. Finally, I considered the practicality of the research design, with a focus on three localities (as opposed to four, or nine, or 26) to give sufficient time for in-depth ethnographic fieldwork in each place while pushing comparison beyond a two-case study.

1.4.2 Ethnographic comparison

Comparison across the three different field sites presented a methodological challenge, but also an opportunity to explore how the concept of net zero emissions moves between global and local scales as discourses and practices circulate between scientific observation and understandings, computer generated climate models, international political agreements, national politics and policies, and locally situated commitments and actions.

I approached the three field sites as ethnographic places, rather than as representing pre-configured categories of city, municipality or shire. The intention of comparing these places is not to develop generalisable explanations of factors that cause processes of sociotechnical change to unfold one way or another (thus offering law-like predictions of how to direct such processes). Nor is it to offer interpretations of how these processes have unfolded based on reasons that are entirely specific to a time, place, and set of actors. Rather, I used ethnographic comparison to generate understandings of patterns of relations that remain the same as these processes play out in different contexts, while highlighting the situated contingencies that shape particular processes.

The places at the core of this inquiry are both locally situated and part of globally connected networks. The spatial and conceptual boundaries delineated around these places in relation to their policy goals are a key focus of my analysis. But the study also sought to uncover the connections to other places that distinguish these localities (Tsing, 2005: 127). To evoke the significance of these situated connections, this investigation brings together a series of local perspectives on global issues while making explicit the situations and relationships that shape these perspectives (Ingold, 2000: 209-218; Milton, 1993).

1.4.3 Ethnographic methods

While it is impossible to comprehend all the complex variables that shape processes of sociotechnical change, it is feasible to explore the relationships between variables and how these change over time. Tools of ethnographic research assist in these efforts to amplify patterns of relations and render them intelligible (Law, 2004: 14). The methods used in this study comprised analysis of discourses contained in written documents, and techniques of participant-observation and in-depth interviews that

included carefully recording and describing in field notes what was seen, heard, and done during these interactions.

A distinguishing feature of ethnographic research compared to other modes of social inquiry is the degree of reflexivity on the part of the researcher about the practices through which the objects of research inquiry are produced (Law, 2004). #1715}. The practice of generating fieldnotes about interactions within field sites, and reflections upon those interactions, are an essential part of the ethnographic toolkit and the iterative process of careful observation and description used to generate situated understandings of human actions and meanings.

In a similar vein, ethnographic comparison requires reflexivity about how comparability is produced through research processes. Scheffer and Niewö (2010) argue for "thick comparison", resembling Geertz' (1973) method of *thick description* to situate a particular gesture or social fact within its own mode of production in order to make sense of it. They contend that objects of comparison are not found "out there" but, rather, are produced as comparable objects through research methods. Thick comparison recognises this process of meaning-production and engages the ambition to compare as fruitful and instructive' (Scheffer and Niewöhner, 2010: 4).

The three localities at the focus of this inquiry were constructed as comparable objects through the research process. This included by identifying discursively comparable targets and timeframes for community-scale carbon neutrality, taken to reflect that policy actors in these places were actively engaged in efforts to enact these goals. Comparability was produced by situating myself, the researcher, in each place to observe, discuss, and describe these efforts. Variations between the boundaries delineated around local goals for carbon neutrality, and between local contexts and constellations of actors, were not isolated as explanatory variables. Instead, comparison across these different places was designed to generate understandings of what things change, and what remains the same, as the contexts in which policy actors pursue community-scale carbon neutrality change.

As mentioned above, observation and description are fundamental to ethnographic methods. Ethnographic writing is a technique to thickly describe, and thus situate, human actions and associated meanings within their social contexts. This style of writing is intentionally crafted with interwoven details and messages to evoke the reader's recognition of complex, yet consensible and intelligible, patterns of intersubjective meaning (Carrithers, 1990: 266). Accordingly, many of the descriptions of places, people, objects and events within the dissertation are descriptive and evocative rather than explanatory and analytic, to convey contexts and meanings while at the same time reflexively situating the researcher within the frame of analysis. Throughout the thesis, short vignettes drawn from field notes and refined through analysis and reflection are presented to knit together detailed information, convey narrative flows of events, and highlight patterns of human action and interaction that, while specific to social and material contexts, are also intelligible

across contexts (Roth, 1989). As with any knowledge, the understandings generated and communicated through these methods are not absolute but are, nonetheless, reliable within recognisable limits (Carrithers, 1990).

1.5 Thesis overview

This thesis addresses how policy actors translate the concept of global net zero emissions into local goals for community-scale carbon neutrality, through an ethnographic comparison of three localities where these processes are actively underway. By doing so, it generates understandings of how low carbon futures are collectively imagined, how boundaries are defined around net zero emissions, and how processes of sociotechnical change are enacted and inflected in relation to these goals. This chapter has sketched the context of this research inquiry, the key research questions and analytic scaffold that structure the dissertation, and the methodological considerations that have shaped the investigation. In the next two chapters, I give a more detailed description of the conceptual and methodological framing of this study, after which, I move on to the empirical substance of the thesis.

In Chapter Two, I develop the conceptual framing of the thesis in relation to scholarly engagement with local responses to climate change and reducing greenhouse gas emissions. In particular, literature on multilevel climate governance highlights cities and urban areas as important sites in which to mitigate the effects of climate change. Actors that speak on behalf of cities – local governments and transnational municipal networks – have become prominent in these efforts. Yet research into these phenomena must contend with ambiguous and blurred boundaries around what the city is, and who speaks (or claims to speak) on behalf of the city. Cities and urban areas can be understood on the one hand as parts of complex and interconnected global systems, and on the other hand as heterogeneous entanglements of social and material elements. In order to engage with the processes through which these ensembles are categorised, I advance four concepts of imaginaries, co-production, assemblages and friction, and sketch the interconnections between these concepts that are developed further through the thesis.

Chapter Three builds upon the methodological overview given beforehand with a more detailed rationale for the methodology, research design and research methods employed in this investigation. This includes articulating the theoretical and methodological considerations that have shaped key decisions in this investigation and that situate it within the fields of anthropology and STS. The research design, with its focus on in-depth ethnographic comparison, follows directly from these methodological concerns. I provide a fuller description of the scoping research that informed the design of this study and the selection of field sites at its empirical core. I then give an account of the fieldwork methods used to generate empirical data, and offer some reflections on the key elements that shaped these research encounters.

In the four empirical chapters that follow, I weave together observations, descriptions, and analysis from the empirical research to examine and compare how policy actors in each field site translate the concept of global net zero emissions into local goals for community-scale carbon neutrality. Each of these chapters, in turn, addresses one of the four research questions stated earlier through engagement with one of the key analytic concepts – sociotechnical imaginaries, co-production, carbon assemblages, and friction. Through ethnographic comparison, different elements of local climate governance emerge as salient in each place. From one chapter to the next, I alter the sequence in which I present the field sites with intent; to interrupt assumptions about orders of priority or significance while drawing attention to alignments and contrasts between the different localities.

Chapter Four examines the conditions of possibility in which particular **sociotechnical imaginaries** of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom) in each field site. The description and analysis in this chapter situates future-oriented goals for net zero emissions within historic, social, and material contexts. Exploring policy commitments and strategies for carbon neutrality as sociotechnical imaginaries draws attention to the unique confluence of circumstances, discourses, and alliances from which visions for low carbon futures emerge. Each of the three collectively imagined pathways of sociotechnical change examined in this chapter impart a sense of opportunity and agency in responding to planetary scale threats while being grounded in local contexts. The viability and desirability of each of these imaginaries is shaped in relation to global and local scales, drawing attention to circulations of knowledge, relations of power, and deep-seated assumptions about social and natural orders that are further examined in subsequent chapters.

Chapter Five addresses how processes to define boundaries around community-scale carbon neutrality **co-produce** objects and scales of local climate governance. The analysis steps back to situate these boundary making practices in relation to institutions, discourses, and practices of climate governance across local, national and international levels. Standardised principles and techniques of carbon accounting render greenhouse gases as a stable and governable object in the form of carbon dioxide equivalent (CO_2-e). At the same time, these practices contribute to the production of the "local" as a discrete and abstracted scale of climate governance. While these practices stabilise objects and scales across levels of climate governance, processes to negotiate boundaries around the community-scale must always, to some extent, attend to local specificities. Thus, boundaries defined around community-scale carbon neutrality are always contingent and must be continually renegotiated and maintained in response to shifting circumstances.

Chapter Six turns to processes of enacting change to address how carbon neutrality is negotiated and contested. Achieving community-scale carbon neutrality requires efforts to redirect and reconfigure human activities, sociotechnical systems and ecologies in ways that reduce emissions into, and remove greenhouse gases from, the

Earth's atmosphere. The analysis narrows in on a specific sustainable building project within each of the field sites; projects that reflect important elements of wider municipal goals for community-scale carbon neutrality. Each project is aimed at disassembling and reassembling relations between people, technologies and natures in order to achieve (or contribute to) carbon neutrality. Locally situated concerns and controversies emerge in relation to these reconfigurations, not only where efforts are underway to reduce emissions, but also beyond the spatial and conceptual boundaries that hold imaginaries of community-scale carbon neutrality in place. The analysis highlights that, although objects of climate governance are stabilised through administrative practices, the "**carbon assemblages**" brought together through these projects are open ended and contingent, unfolding in uncertain directions as people, technologies and nature encounter and connect in new ways.

Chapter Seven examines the frictions that emerge in processes of enacting community-scale carbon neutrality and how these inflect imagined and actual processes of sociotechnical change. **Friction** holds assemblages of social and material elements together, shaping interactions, and inflecting processes of sociotechnical change. The analysis in this chapter examines shifting circumstances within each of the field sites – dynamic and contingent conditions of possibility that destabilise sociotechnical imaginaries for community-scale carbon neutrality in each place. It traces the creative and inventive ways that policy actors in each of the three field sites respond to those shifts by reimagining low carbon futures and re-defining boundaries around their policy goals. Comparison across the three field sites highlights that, while similar points of friction emerge in each locality, processes of sociotechnical change follow different trajectories as a result.

In the final chapter, I conclude the dissertation by addressing the abstractions and frictions produced as policy actors translate the universal concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. I summarise key contributions to knowledge with respect to interconnected methodological, empirical and conceptual, and theoretical concerns. Through ethnographic comparison, the thesis highlights common processes and patterns of relations involved in efforts to collectively imagine and enact community-scale carbon neutrality. The thesis develops the foundations for a place-based approach to climate governance and net zero emissions by identifying ongoing dialogues between global and local, abstraction and emplacement. The analytic scaffold developed through this thesis helps with understanding the interconnections between abstracted boundaries and emplaced assemblages that shape, from both outside and inside, efforts to imagine and enact net zero emissions. These understandings will be important as we grapple with the complexities and indeterminacies of sociotechnical change towards low carbon futures.

Chapter 2. Literature review and conceptual framing

2.1 Introduction

This thesis examines how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. This chapter will situate the thesis in relation to key areas of scholarship concerned with local responses to climate change and reducing greenhouse gas emissions. I look first at multilevel climate governance literature and its focus on structures of climate governance, and the position of actors within those structures, in order to highlight how the approach taken in this study differs. Then, I draw on literature from the fields of STS and anthropology to discuss four analytic concepts that will be applied though the thesis to help analyse and compare processes of sociotechnical change in the three field sites at the core of this study.

The multilevel climate governance literature draws attention to the role of local governments and transnational municipal networks in responses to climate change. Research in this field (overlapping with political science, critical urban theory, and sustainability transitions) engages with the roles played by these actors to effect changes to the many-layered structures of climate governance, and to the human activities and sociotechnical systems that produce greenhouse emissions. Cities have been framed by many authors as key sites, and local governments as key actors, in multilevel climate governance.[2] Yet, what constitutes a "city" as distinct from other local arenas of action is not always clearly defined, and the extent to which cities, however defined, are contributing to problems of, or solutions to, climate change is unclear. Cities and city-networks are also commonly referred to as actors in the literature on climate governance, raising further questions about who speaks (or claims to speak) on behalf of cities.

A key to understanding these ambiguities is to recognise that cities are concentrated nodes within globally connected matrices. All cities are necessarily local, while at the same time being situated within global networks in varied ways. Climate change is a global phenomenon, but its effects are experienced locally. Cities and urban areas concentrate many of the human activities and sociotechnical systems that produce greenhouse gases, but these activities and systems also extend beyond urban boundaries. Processes of globalisation and urbanisation connect locally situated activities and sociotechnical systems to global climate change, yet these connections are not everywhere the same. Methodological and analytic approaches that naturalise scales such as "global", "local", and categories such as "cities" and "urban" may

[2] In this chapter, I follow the style of the multilevel governance literature by referring to "cities" and "city networks" but do so to open up discussion about the ambiguity of these concepts.

overlook practices of cultural production through which these scales and categories are established, maintained and contested.

The empirical and analytic approach that I develop through this study differs from, and adds to, that taken in much of the literature on multilevel climate governance. An important point of difference is the extent to which the structures and agents of climate governance, and the objects that are sought to be governed, are taken as stable or are understood to be continually performed. I draw on literature from anthropology and STS that is engaged with the processes through which boundaries and categories are interposed across complex and interconnected systems and scales, and how these are shaped by, and in turn shape, situated experiences, meanings and possibilities for action. Building on this literature, I lay the foundations for an analytic scaffold comprising four interconnected concepts – sociotechnical imaginaries, co-production, assemblages, and friction – through which to generate understandings of how low carbon futures are collectively imagined, how boundaries are defined around net zero emissions, and how processes of sociotechnical change are enacted and inflected in relation to these goals.

2.2 Multilevel climate governance

The relationship between cities and climate change is often portrayed in contradictory ways, with the former seen as both unsustainable in the face of global climate change but also the locus of hope for responding to that change. By some accounts, we are in a new geological epoch of the Anthropocene, defined by the planetary scale at which human activities are impacting the environment (Crutzen, 2006; Lewis and Maslin, 2015). Climate change is an acute indication of these impacts, but so too are trends of urbanisation (Christoff and Eckersley, 2013; Eriksen and Schober, 2017).

More than half of the world's population now lives in urban areas, and this trend is expected to continue (United Nations, 2018). The UN Habitat program (2016) highlights that existing models of urbanisation are highly unsustainable while at the same time placing urbanisation at the fulcrum of positive social, political, economic and environmental transformations (see also Gleeson, 2014). Decisions on urban development and infrastructure made now will have long-lasting implications for the emissions intensity of urban activities into the future (Rosenzweig et al., 2018). Concentrations of people, built assets and economic activities make urban areas especially vulnerable to climate impacts such as sea level rise and storm surge, coastal and inland flooding, drought and heat stress, water scarcity and increased aridity (Revi et al., 2014).

Urban opportunities both shape, and are deeply disturbed by, planetary-scale threats to human and natural systems (Beck, 2009). Processes of urbanisation stretch far beyond urban areas with supply chains, sociotechnical infrastructures, and political economies shaping flows of resources and wastes far beyond urban environments

(Tsing, 2015; Marvin and Hodson, 2010; Gleeson, 2010; 2014; Merrifield, 2013). Just as the epoch of the Anthropocene, upon closer inspection, is revealed as patchy rather than homogeneous (Tsing et al., 2019), the interconnections between cities and climate change are not everywhere the same. Climate change is entangled with the urban, but the connections are complex and difficult to trace with certainty.

2.2.1 Networked cities

Attention to the role of local actors (and in particular local governments) in global environmental change and environmental policy is not new. Research into multilevel environmental governance emerged alongside sustainable development discourses of the 1992 Rio Earth Summit and Local Agenda 21 campaigns that established the popular expression to "think global, act local" (Lafferty and Eckerberg, 2013). These kinds of campaigns have been termed "new localism" because they identified wide-ranging environmental problems as stemming from actions that are local and argued that cities are places where efficient solutions can be found (Bulkeley and Betsill, 2003: 25). Such arguments accorded with views that environmental sustainability is best enacted and maintained at local levels by citizens and communities empowered to take care of their local environment. From this perspective, local governments play a key role in the requisite devolved structures of authority and decision-making because they are situated closest to the community (Dryzek, 1987; Eckersley, 1992; Goodin, 2013). Critical urban scholarship reinforces the promise of local governance as supporting qualities of cultural diversity, through ideas such as the public right to the city and the city as a locus of deliberative democracy. At the same time, it emphasises that these qualities are fragile and contested (Fincher and Jacobs, 1998; Magnusson, 2010; Marcuse, 2009).

From the perspective of international relations, the management of global environmental issues such as climate change has been framed as a "transboundary" problem, because although the origins of change are located within sovereign national territories the impacts of change spill over these borders. International institutions comprised of nation states were thought necessary to manage these spill over effects (Hoel, 1997; Hoel, 2002). Drawing on critical perspectives from fields of geography and political economy, multilevel climate governance scholarship has helped to challenge assumptions that nation states are the primary arena of political power with sovereign territories as the demarcation of this power (Brenner et al., 2003; Bulkeley, 2005). It has also helped to disrupt hierarchical conceptions of scale, where global and national policy solutions are expected to cascade downwards and shape sub-national and local actions (Bulkeley and Betsill, 2003: 15-16). Bulkeley (2005: 879) describes,

> This naturalization of the "global" as the arena in which designated global environmental problems take place effectively serves to disembody the causes and consequences of such problems, and their construction as such, from practices and politics taking place at a multitude of sites and scales of governance.

The multilevel governance literature reveals flexible relations and elastic boundaries between state and non-state actors, and between formal politics and more informal "spheres of authority" in the governance of complex, interconnected and transboundary issues. It draws out how governing the environment involves political processes to rescale objects and agents of climate governance, creating new "hybrid" entities and "networked" spaces of climate governance that do not easily conform to the conceptions of national governments and sovereign territories through which global environmental governance had previously been understood (Bulkeley, 2005; Okereke et al., 2009).

Many of the theoretical insights into how, where, and by whom climate governance is performed have been drawn together through empirical research on local governments and transnational municipal networks engaged in environmental and climate policy work. The International Council for Local Environmental Initiatives (ICLEI) and their Cities for Climate Protection (CCP) program was a key focus of early inquiries into the processes and politics of designing and implementing climate policies at local levels (Betsill and Bulkeley, 2004; 2006; 2007; Bulkeley, 2000; 2005; Hoff, 2010; Lindseth, 2004). Subsequently, numerous municipal networks have emerged to interconnect and amplify efforts by local governments to address the causes and impacts of climate change (Keiner and Kim, 2007). These networks are not directed only towards finding solutions to problems in local settings and in relation to local publics. They have also shifted towards more strategic forms of diplomacy, advocacy and regulation aimed at shaping national and international policy and politics around transboundary and global issues (Toly, 2008; Bulkeley, 2013).

Despite the emergence of these new forms of trans-local diplomacy in tackling global environmental problems, however, cities continue to be the primary domain of political-economic and strongly material path-dependencies (Acuto and Rayner, 2016: 1150; Marvin and Hodson, 2010). With some of the most prominent transnational municipal networks financed and supported through private philanthropy, several authors have expressed discomfort with the political and economic agendas that underpin much city-led diplomacy (Davidson and Gleeson, 2015; Davidson et al., 2019). Potential inequalities in the spread and influence of city-networks are evident in the differential participation of cities in the global south compared to the global north (Bouteligier, 2013). Marvin and Hodson (2010) illustrate this unease with their contention that the emblematic responses of many prominent "world cities" to compounding pressures of global ecological change, resource constraints, and insecurity can also be read as efforts to secure their continued reproduction and reinforce existing power structures. They have suggested that the prominence of world cities in multilevel climate governance is due to their power as concentrated nodes within other matrices (and I turn to consider these concentrations next). Material and social infrastructures such as international airports, financial capital, green-tech industries, and political power enable and

maintain the movement of sustainability professionals, technologies, and ideas (Blok, 2012; Marvin and Hodson, 2010). Of course, circulations between world cities are not the only circulations at play, but they do tend to be a focus of academic and professional discourses about the role of cities in addressing climate change.

2.2.2 Cities as nodes

In relation to human activities that generate greenhouse gases, cities are concentrated nodes within wider networks of extended sociotechnical systems and resource flows. Because of their concentration, cities and urban areas are identified as promising places to transition human behaviours and sociotechnical systems onto sustainable and low carbon footings, especially in relation to energy, built environments and transport (Bulkeley et al., 2010; Bulkeley et al., 2013; Broto and Bulkeley, 2013). This has been an important point of engagement between the multilevel governance literature and the field of sustainability transitions. Within this latter field, the multilevel perspective is put forward as a key analytic framework to explain (and thus predict and direct) processes of sociotechnical change. This construct identifies key actors in such processes as occupying three levels (Geels, 2010; 2011; Smith et al., 2010). Incumbent "regime" level actors seek to maintain and extend their power. Emerging "niche" level actors seek to supplant the incumbent regime. Beyond these socio-institutional dynamics, external shocks from the "landscape" level can disrupt the dominant regime and create space for niches to expand. The sustainability transitions literature has its foundations in innovation studies and emphasises technological change as a key driver for social and institutional change.

From this conceptual framing, governing low carbon transitions is often framed as "experimental", as can be seen, for example, in the proliferation of "urban living labs" in cities around the world (Bulkeley et al., 2016; Broto et al., 2014; Evans and Karvonen, 2014; Steen and van Bueren, 2017; Marvin et al., 2018; Voytenko et al., 2016). Technological change is assumed to be a powerful determining force in these processes of sociotechnical change, with "path dependencies" and "system lock-ins" that presuppose the stability of sociotechnical systems and regimes unless they are, in some way, dislodged by some other force. The focus is on cities as places with potential for radical sociotechnical transformation, yet there are critical questions about the spatial and social elements that shape these potentials (Coenen et al., 2012; Shove and Walker, 2010), and how we might go about evaluating the success, or otherwise, of interventions to steer processes of sociotechnical change (Hodson and Marvin, 2010). Furthermore (and a key point where my slant differs) such approaches seem to overlook the cultural and material contexts in which these systems are situated, and the practices through which such systems are continually performed and maintained, destabilised and destroyed.

Taking stock for a moment, the networked structures that sustain and reproduce cities are locally concentrated but extend globally. The obverse of this situation is true for climate change, which is a global phenomenon experienced locally.

Methodological and analytic inquiry into the relationships between cities and climate can tend to foreground either one perspective or the other in what Blok (2019) has described as methodological city-ism and methodological globalism. Such tendencies may cause important connections between these scales to be overlooked, not to mention the social and political processes through which scales themselves are produced and stabilised (Wilbanks and Kates, 1999; Meadowcroft, 2002; Delaney and Leitner, 1997; Marston et al., 2005). These tendencies may also have implications for agency, with respect to who speaks (claims to speak) on behalf of the city in relation to the global climate. As certain cities become increasingly connected through city networks, they speak not only for their own locality, but potentially also for a web of linked localities where shared alliance and commonality are emphasised over diversity and difference. One area in which homogenising views of cities are especially evident is in calculations of, and discourses about, the portion of greenhouse gases that can be attributed to cities.

2.2.3 Attributing greenhouse gases

Although widely cited, figures about cities' majority contribution to greenhouse gas emissions (as much as 80 per cent) are not unquestioned. Satterthwaite (2008) has argued, based on statistics from the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), that emissions generated within urban areas amount to less than half of all global greenhouse emissions, but are often overstated because emissions that arise outside of cities – such as from agriculture and deforestation, heavy industries and fossil fuelled power stations, and high consumption households in regional locations – are allocated elsewhere. Satterthwaite concedes that assigning emissions from power stations and industries to the location of the person or organisation that consumes them, as is common practice in many municipal carbon accounts, raises the proportional contribution by cities. However, it is misleading to attribute these emissions to cities in general, because grouping cities together in relation to greenhouse emissions overlooks substantial differences and unevenness within and between urban areas. For example, per capita emissions can vary 10-fold from highest to lowest per capita emissions within a city, and perhaps by 100-fold between high- and low-income cities (Satterthwaite, 2008: 543). Dodman's (2009) analysis of greenhouse emissions produced by a number of European, North American and Asian cities reveals that industrial sector emissions from Asian cities are much higher than in cities elsewhere, reflecting shifts in Europe and North America towards more service-based economies with their manufacturing and industry being moved to Asia and elsewhere (Dodman, 2009; Chen et al., 2016; Croft, 2017).

Despite these complexities in attribution, Bulkeley (2013: 46) concludes that assessments of cities' contribution to greenhouse gas emissions underscores their importance as places to address climate change, including through the efforts of local governments and transnational municipal networks. Knowledge of the urban activities that produce emissions is important to guide emissions reduction activities,

but also to gain access to increasing amounts of finance and resources being directed towards mitigating the effects of climate change. In short, there are political economies at play in shaping the formation and ongoing reproduction of cities and urban areas. Assessments and calculations that link greenhouse gas emissions to specific cities and urban territories are part of these processes of accumulation and distribution. The political ecology perspective put forward by Rice (2010) likewise proposes that municipal carbon accounts establish "carbon territories" that relate the production of greenhouse gases to specific urban activities and to local government jurisdictional capacities. Lövbrand and Stripple (2011: 191) argue that the "spatial grammar" of carbon, has gained authority 'only to the extent that assessments of local emissions have been underpinned by credible carbon accounting techniques that have stabilised carbon as something knowable and operable'.

It follows from these politically attuned perspectives that knowledge of greenhouse gas emissions is a key part of negotiations over who has the power to shape processes of sociotechnical change in relation to urban areas and human activities. The highly technical methods used to trace and attribute greenhouse gas emissions to specific sources can be seen to simplify and elide complex and ambiguous relationships between cities, the urban and wider processes of urbanisation. Homogenising views of the city can overlook important differences within and between these material sites, the historic responsibilities of actors towards the climate crisis, and the capacities of local actors to effect changes. Variations between places and circumstances raise further questions about the possibilities and appropriateness of climate solutions in one setting being made mobile and replicable in another; the appropriate scale of climate solutions (and whether bigger is always better); and the relationships between knowledge and power in envisioning desirable urban futures.

Put another way, 'Rather than an explicit conflict over political aims what we have now is a confrontation between imaginations of the city' (Massey, 2005; in Marvin and Hodson, 2010: 34). Thus, while cities are recognised as strategic arenas for climate change action, they are also sites of political struggle over processes of sociotechnical change. For example, Kenis and Lievens (2017) argue that pursuing climate neutrality through urban policy requires the conceptual boundaries of the city to be reimagined in ways that are deeply political, but that these processes to delineate boundaries are often ignored in sustainability projects. Tozer (2018) highlights a range of storylines used to frame carbon neutral objectives in her analysis of discourses in the Carbon Neutral Cities Alliance, a network of local governments that are pioneering approaches to decarbonise their local areas.

So far, I have touched on some key ambiguities in how cities have been framed as important sites, and local governments as important actors, in the multilevel governance of climate change. This includes who speaks (claims to speak) on behalf of the city in multilevel climate governance, how spatial and conceptual boundaries are delineated around local territories and urban systems, and how local efforts

towards net zero emissions might be understood given the specific cultural and material contexts in which these efforts are situated.

In the rest of this chapter, I approach these ambiguities through scholarship from STS and anthropology and advance the conceptual framework that underpins the thesis, addressing sociotechnical imaginaries, co-production through boundary making, assemblages and friction in turn. The first of these concepts addresses who speaks (claims to speak) on behalf of the city by generating understandings of how low carbon futures are collectively imagined. The second concept of co-production generates insights into processes through which boundaries are delineated around the global and the local with respect to climate governance. The latter concepts of assemblages and friction offer ways to understand the ways in which processes of sociotechnical change are shaped, without being determined, by local contexts and global connections, circulations of knowledge and power, and situated contingencies.

2.3 Sociotechnical imaginaries[3]

Science and technology play central roles in the ways that climate change is understood, in terms of knowledge about changes to earth systems and their causes and implications, as well as framing and enacting appropriate responses to these changes. Yet understanding and responding to climate change are not solely the result of scientific facts guiding rational policy decisions. These responses also evoke and are informed by powerful political and moral perspectives and interpretations, and their entanglements with material worlds. This calls attention to the importance of social and material relationships, not only individual psychologies, to appraise how, and for whom, climate change comes to matter (Callison, 2014; Crate, 2011; Fiske et al., 2014; Hoff et al., 2020; Hulme, 2009; Verweij et al., 2006).

The concept of sociotechnical imaginaries (Jasanoff and Kim, 2009; 2013: 190; 2015) relates to collective visions of what is and what ought to be, tying imaginative capacity to visions of social and technical progress. Jasanoff and Kim define sociotechnical imaginaries as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (Jasanoff and Kim, 2015: 6). These shared desires for the future can also be seen to reflect shared fears and harms about the consequences of failing to progress in favoured directions.

Although originally conceived in relation to the socio-political role of science and technology in shaping national identity (Jasanoff and Kim, 2009), sociotechnical imaginaries can be discerned across multiple scales in collectively held accounts of

[3] An early version of this section has been published in Pollard S. (2020) Imagining the Net Zero Emissions City: Urban Climate Governance in the City of Melbourne, Australia. In: Hoff J, Gausset Q and Lex S (eds) *Building a Sustainable Future: The Role of Non-State Actors in the Green Transition.* Routledge, p211-229. Available at: https://doi.org/10.4324/9780429280399.

potential futures. They can emerge from the visions of single individuals, growing and gathering adherents through exertions of power or persistent efforts to build coalitions, until they are communally adopted (Jasanoff and Kim, 2015: 5). Multiple sociotechnical imaginaries can exist and interact within a society, and it can fall to powerful institutions such as governments, courts, and the media to elevate one imaginary above others.

With respect to multilevel climate governance, there are processes and institutions that operate at and between scales and encompass a wide range of actors with varying levels of authority. The goal of global net zero emissions displays key qualities of a sociotechnical imaginary, expressed through the institutional architecture of the Paris Agreement as a collective desire for a safe climate future, and gathering a wide array of adherents in scientific, political, corporate and civic realms. At the same time, multiple sociotechnical imaginaries of net zero emissions have emerged that differ on key points of how this planetary state of equilibrium should be achieved, by when, concerning whom, involving what social, technological and ecological changes, and in which places.

As an analytic device, sociotechnical imaginaries are advanced in studies 'to investigate how, through the imaginative work of varied social actors, science and technology become enmeshed in performing and producing diverse visions of the collective good, at expanding scales of governance from communities to nation states to the planet' (Jasanoff and Kim, 2015: 15). Though sociotechnical imaginaries do not determine policy outcomes, Jasanoff and Kim argue that they are potent cultural resources that help to shape social responses to technological innovations (Jasanoff and Kim, 2013: 190). Analysing sociotechnical imaginaries can generate insights into why scientific and technological advances and controversies are perceived and responded to differently across varied social contexts and political regimes. The concept is put forward to accommodate the indeterminacy of history and avoid simplified causalities that tend to underpin grand narratives of scientific and technological progress. This is because the concept engages with the ways in which people's shared hopes for the future are entangled with their past histories and achievements. To think through sociotechnical imaginaries is to examine how normative understandings of time, space and social order are brought into being, stabilised, and destabilised, through the spread and circulation of ideas, practices and ideologies (Jasanoff and Kim, 2015: 31-32).

The roots of the concept of sociotechnical imaginaries within social theory are partly drawn from Anderson's (1983: 6) influential book on nationalism, in which he argued that 'nations emerge imaginatively as a result of particular practices, such as the diffusion of maps and the printed press […] but can be investigated empirically as processes that, though always present in social life, may have variable characteristics'. It has also been developed from Appadurai's (1990) exposition of overlapping and disjointed flows or "scapes" – of people, technology, money, communication, and ideas – in the context of globalisation. Taylor's (2004) conception of modern social

imaginaries has also been influential for thinking about the ways people imagine and perform their social existence, and the deeper normative ideas and philosophies that underpin these expectations and experiences.

Engaging with the development of these ideas within anthropology, Sneath et al. (2009) submit that the concept of imagination has, in several ways, been spread too thin. Firstly, that imagination may play the role of "culture" in new clothes, serving as a holistic horizon of meanings (see also Strauss, 2006: 322). Taylor (2004), for example, can be read as substituting the concept of culture (as a fixed totality of explicit meanings) with social imaginaries as a fluid totality of implicit meanings (Sneath et al., 2009: 7). Further, imagination is often presented in instrumental terms, with its analytic value based on demonstrating that it serves a specific function in people's lives (Sneath et al., 2009: 5). In this regard, imagination is often fashioned as something purposeful such as making sense of the world. Finally, there is a tendency to attribute positive connotations to imagination, as is aptly demonstrated with the inference of progressive modernity that underlie Jasanoff and Kim's sociotechnical imaginaries.

Against these tendencies, Sneath et al. suggest that the concept ought to be refocussed on the social and material means by which particular imaginings are generated: 'a more refined, contingent appraisal of social processes of shared mental life, where imagination is not a holistic horizon but a set of emergent effects' (Sneath et al., 2009: 6). They see imagination as a social and cultural phenomenon that can be empirically investigated (Sneath et al.; see also Crapanzano, 2004). Their proposition for "technologies of the imagination" marks a shift from substantive heuristics to anthropological analytics (Sneath et al., 2009: 8). Attending to the social and material means through which particular imaginings are generated allows imagination to be defined in terms of the indeterminate relationships and processes that give rise to it (Sneath et al., 2009: 6). Such a view separates out, and binds together, individual psychology (phenomenology of perception) and collective imagining (culture, imagined communities, sociotechnical imaginaries). Put another way, 'imagination is immanent in perception itself, recalling the generative potential of a world that is not so much ready-made as continually on the brink of formation' (Janowski and Ingold, 2012: 1).

In a similar fashion, the concepts of sociotechnical imaginaries and technologies of the imagination are intended to open up this "brink" of generative potential as a space of indeterminate encounter between social and material elements, with a particular focus on technologies. For both Jasanoff and Sneath et al., a key point is that technologies involve, but cannot be reduced to, material tools or artefacts. The development of material technologies cannot be understood apart from its social contexts, and a key area of overlap between STS and anthropological inquiry has been to bring social depth and complexity into the appreciation of technological systems.

A foundational premise in STS is that science and technology do not exist in a vacuum apart from society, but are actively constituted within, and in turn shape, society (Law, 2004: 12). Jasanoff describes how technologies are 'thoroughly enmeshed in society, as integral components of social order' (Jasanoff, 2015: 3). Illustrating this point, she describes that,

> In popular discourse the word "technology" tends to be equated with machine or invention, something solid, engineered, black-boxed, and these days most likely an instrument of electronic communication. Yet cars as we know them would never have taken to the roads without myriad social roles, institutions, and practices spawned by modernity […] who ultimately gave cars their utility, appeal, and meaning (Jasanoff, 2015: 2).

Sneath et al. express a similar point about the symmetrical relationships between technological and social developments:

> Technological systems cannot be identified independently of the knowledge that people bring to bear upon them, which itself is socially constituted. Conversely, the development of society includes changes in people's skilful engagement with tools and can therefore only be articulated in relation to the possibilities that tools allow for (Sneath et al.: 21).

These perspectives direct attention to intersections between the material and the social, and towards technology as an integral aspect of the social rather than something that is independent from it (Sneath et al.: 16; Pfaffenberger, 1992; Latour, 2005). In other words, the role of technology in processes of social change is not intrinsic to the technology but, rather, a function of what that technology "affords" to its users, recognising the multiple uses and valences to which a material technology, or technological system, might lend themselves in different social contexts (Ingold, 2000: 168; Gibson, 1977).

Building on these considerations, processes to reconfigure sociotechnical systems are not only about re-engineering technologies but also entail reconfiguring social systems. Articulating this point with respect to energy technologies, Jasanoff and Kim reason that:

> New energy futures will need to reconfigure the physical deep structures of civilisation—grids and pipelines, seashores and pastoral landscapes, and suburbs and cities—that were shaped by the energy choices of the past. […] Radical changes in the fuel supply are likely to transform social infrastructures, changing established patterns of life and work and allocating benefits and burdens differently from before. Accordingly, analysts should pay greater attention to the social dimensions of energy transitions, complementing more conventional analyses of economic and engineering issues (Jasanoff and Kim, 2013: 189).

Such fundamental processes of sociotechnical change have potential to both challenge and reinforce existing relations of knowledge and power relations (Jasanoff and Kim, 2015; Stirling, 2014). Recognising that it takes power to demarcate and simplify a world of hybridity, a key role for the social sciences is to

attend to multiple forms of agency, pathways of change and narratives of causation involved in sociotechnical change (Jasanoff and Kim, 2015: 24).

In the context of this thesis, the concept of sociotechnical imaginaries provides a lens to examine local commitments for community-scale carbon neutrality, the social and material dynamics from which they emerged, and the social and technological futures they point towards. Bringing this concept into dialogue with the earlier discussion of multilevel climate governance may offer insights into the social and material worlds in which policy goals for low carbon futures are being envisioned and enacted. I take up this analytic lens in Chapter Four to examine, in the context of each field site, the conditions of possibility in which particular sociotechnical imaginaries of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom).

2.4 Co-production

Sociotechnical imaginaries are understood to emerge through processes of co-production between actors, institutions and material realities (Jasanoff, 2004). The concept draws attention to symmetries between the ways that people organise and govern themselves and the ways that nature and society are perceived and understood:

> Co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiments are at once products of social work and constitutive of forms of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports (Jasanoff, 2004: 2).

The concept of co-production shares some roots in theories of social constructivism, including Douglas' work on the way social relations shape perceptions of environmental risk (Douglas and Wildavsky, 1982; Douglas, 1986) and its development into a more dynamic neo-institutionalist theory (Thompson et al., 1990; Thompson, 2008). However, Jasanoff defines co-production as an "idiom", rather than a theory or a rule to steer away from constructivist tendencies to over-determine relationships between social arrangements and ways of perceiving and acting in the world.

To understand social and political responses to the phenomenon of global climate change, it helps to recognise the ways in which this global threat is perceived and experienced. The climate is not something that can be perceived directly through the senses. Rather, knowledge of the climate and climate change is built up over time by aggregating and extrapolating measurements of particular things from particular places (Callison, 2014; Hulme, 2009). Most people, however, do not experience climate change in the manner put forth by the dominant climate science paradigm (Fiske et al., 2014: 11; Hulme, 2009). Climate change is a global phenomenon with locally experienced effects. Human activities and sociotechnical systems that are

locally situated are driving processes of change at planetary scales, including climate change, globalisation and urbanisation. Eriksen's concept of overheating captures well the acceleration and intensification of these global processes in the sense that 'change now takes place faster and with more wide-ranging consequences than before [...] marked by crises which are increasingly perceived as being global in character, but which remain local in their effects" (Eriksen and Schober, 2017: 7). There is a disjuncture between the global scale of climate change and the situated contexts in which knowledge of these dynamics are pieced together and the effect of these dynamics are experienced.

Viewing this disjuncture from an STS perspective, Miller (2004) has charted how knowledge and meanings of the climate shifted from an aggregation of local weather conditions over various spatial areas and timeframes—a statistical artefact—to a representation of an integrated, global system based on computer models of the general circulation of the atmosphere, called General Circulation Models (GCM's). He uses the concept of co-production in his analysis of the relationships between knowledge of the world (generated through such models) and action in the world. In this regard, co-production is not applied to explain these relationships in terms of causality, but rather as: 'a way of interpreting and accounting for complex phenomenon [...] by calling attention to symmetrical relations between social dimensions of cognitive commitments and understandings, while underscoring the epistemic and material correlates of social formations' (Jasanoff, 2004: 3). Put another way, knowledge of the world and action in the world can be seen as mutually constitutive. Paying attention to these relationships helps to analyse and interpret complex phenomenon without recourse to oversimplified accounts or over determined causalities.

The World Meteorological Organisation and the United Nations Environment Program established the IPCC to provide policymakers with regular scientific assessments of the current state of knowledge about climate change. The IPCC derived much of its understanding of climate from GCM's developed by climate modellers through the 1980s and 1990s and adopted the climate system as their central metaphor, while largely eschewing concern with local weather and climates (Miller, 2004; Beck and Forsyth, 2015; Howe, 2014; Miller and Edwards, 2001). Miller argues that re-imagining the Earth's climate as a *global* system brought views of the atmosphere into line with assumptions about the jurisdiction of international institutions, and aligned claims about global climate change with debates about international politics (Miller, 2004: 51). By reinforcing a global, systemic understanding of climate and climate change, the IPCC contributed to the co-production of a natural order (that is, a new understanding of how the natural world is) that both necessitated, and opened up possibilities for, a global politics of climate. The shift to perceiving and understanding the global climate as a set of interconnected physical systems represented not just a change in the conditions of knowledge about the climate, but a change in humanity's relationship with the

climate as conceived through these powerful institutions. The IPCC articulated a model of global politics in which expertise was framed as politically neutral and accorded significant power to define problems of global policy.

In Miller's analysis, the concept of co-production is used to draw attention to boundaries and interactions between the domains of science and policy. It does not imply that science and policy produce each other but, rather, that interactions between these domains can, at times, constitute something else entirely. In this case, circumscribing the climate as a global system supported the legitimacy of claims for a global system of governance. Seen through this recursive lens, the scientific representation of the global climate system shaped the need for a global political order through which to manage that system. At the same time, new global political institutions provided the legitimacy for global sciences. What is less clear in Miller's analysis are the implications and role of sub-national and regional institutions of governance and political arrangements in this political imaginary. Submitting that the global climate system can be addressed *only* through global political cooperation differs from suggesting it cannot be managed *without* global political cooperation – that global cooperation is necessary but not sufficient in itself. Some further context from Tsing's work can help shed light on these connections across scales.

Resonant with Miller's account, Tsing (2005) puts forward a broader argument that the representation of universal Nature and of the globe have helped to make each other. Much of Tsing's research is positioned at the interface between local and global frames of analysis, moving between situated "local" controversies and widely circulating "global" issues of knowledge and power. This reticulation between frames of analysis helps to develop understandings of the institutions and dialogues through which local and global agendas are shaped (Tsing, 1994: 279). In tracing these circulations of knowledge, Tsing is concerned with processes of generalisation in which 'small details support great visions and the universal is discovered in particularities' (Tsing, 2005: 89). For this to occur requires a large space of compatibility among disparate particular facts and observations: 'As long as facts are apples and oranges, one cannot generalise across them; one must first see facts as "fruit" to make general claims' (Tsing, 2005: 89). This is a two-step process through which particularities are first pieced together to make generalisations, and then the collaborations through which these inferences have been made are erased:

> Collaborations create convincingly agreed upon observations and facts that then appear to support generalisations *directly*, that is, without the proper mediation of the collaboration. The contingency of the collaboration, and its exclusions, no longer seem relevant because the facts come to "speak for themselves" (Tsing, 2005: 89).

These processes might be considered similar to what Star describes as "invisible work" in the gap between formal representations of scientific experiments and the magnitude of backstage work that is carefully tailored out of the picture (Star and Griesemer, 1989; Star, 2010).

The global climate as represented through GCM's serves as one of Tsing's examples of processes of generalisation at work in defining the global scale and universal Nature. These models used geophysical laws to generate a 'self-conscious representation' of a simplified social and natural world. In the process, they portray a specific, even peculiar, kind of globe that is unified, neutral and understandable through the collection and manipulation of information. Through these models, the global scale becomes the locus of understanding and prediction. In Tsing's words, 'Local data may adjust the global model but never defy it' (2005: 101). Tsing maintains, like Miller, that the global commitments of the model are attuned to stimulate international dialogue. But she also shows the collaborations across differences that are erased through reference to the unified globe of the climate model. From these analyses, we can begin to see the global climate as an object that is co-produced through collaborations and erasures across difference. While only the agreed-upon object remains in view, it is shaped by those collaborations across difference and subsequent erasure of those collaborative processes. Tsing's account thus opens up inquiry into the ongoing processes and dialogues through which the abstracted boundaries and scales of global climate governance are brought into being, stabilised, and destabilised.

Models and representations of the global climate delineate a system that is holistic, interconnected and whole, but also observable, able to be modelled and known, and able to be governed. These models also delineate a human system that interacts with the climate system through certain activities – the release of greenhouse emissions, clearing or protecting forests, agricultural practices and so on. Viewed from a co-production perspective, these boundaries are not given but must be continually enacted. Asking whose nature is being represented, and what the material effects of such representations are, helps to denaturalise the privileged gaze of science and open up alternative ways of knowing and experiencing nature. Such a view casts new light on the dynamic social processes that underpin stable accounts of environmental change (Lövbrand et al., 2015; Tsing, 2015).

A key input into models of the global climate system is the concentration of greenhouse gases in the atmosphere. But first, the category of greenhouse gases must be specified, and this requires different types of gases, and different modes of emission and absorption, to be made compatible. The first international climate agreement, the Kyoto Protocol, established equivalences in the effects of six different types of greenhouse gases on global warming so that quantities of these could be reduced to a single measure of carbon dioxide equivalent (CO_2-e). This measure allows changes to the composition of the atmosphere to be observed, discussed and modelled using a simplified metric. Representative concentrations of CO_2-e in the atmosphere, in turn, have been translated into probabilistic carbon budgets that specify the greenhouse gas emissions targets needed to limit global average temperature increases to a particular temperature thresholds of 2°C (Meinshausen et al., 2009; McKibben, 2012) and 1.5°C (IPCC, 2018). These temperature targets and

cumulative carbon budgets have been identified as planetary boundaries (Rockström et al., 2009), beyond which lie threats of irreversible change to "tipping elements" in Earth systems.[4] These delineations interpose between greenhouse gases, global average temperature thresholds and other planetary boundaries and, by so doing, frame greenhouse gases into objects that can be governed in relation to these planetary systems. Just as global models of the climate portray a unified, neutral and understandable global scale, methods to account for greenhouse gases contribute to the production of a unified category of CO_2-e (as with Tsing's apples and oranges classified as fruit).

Practices of municipal carbon accounting delineate the edges of local spaces and sociotechnical systems in relation to carbon emissions. These are boundary making processes, and the carbon inscribed within these accounts differs depending on the boundaries used to demarcate these local territories such as the core or central city, the metropolitan area, the contiguous built up area or the extended planning region (Satterthwaite, 2008: 541). These boundaries have important social and political implications. Lövbrand and Stripple (2011) argue that carbon accounting is one of the primary techniques used to turn carbon into a coherent object that can be governed, most often by framing it in relation to accepted economic and political categories such as the state, the market and the individual. Rice (2010: 935) argues that work by local government institutions to incorporate greenhouse emissions into territorial space also enrols urban citizens into the process with expectations that they will reduce their own individual carbon footprints. Callon's description of framing helps to articulate the work these boundaries perform to separate 'the relations which the agents will take into account and which will serve in their calculations and those which will be thrown out of the calculation' (Callon, 1998: 16). Through this exact positioning of the boundary, framing 'puts the outside world in brackets, as it were, but does not actually abolish all links with it' (Callon, 1998: 249).

These are issues about how the world is rendered legible in order to be governed (Scott, 1998). From the perspective of the authors discussed above, the boundaries defined around greenhouse gases so that they might be made governable can often be seen to align with and reinforce dominant political and economic categories and structures. Yet it is also important to consider how delineating boundaries around greenhouse gases might serve to destabilise, disrupt and transform dominant structures and categories of climate governance, and the possibilities for agency that these constructions enable and constrain.

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[4] Tipping elements are defined as very large components within Earth systems characterised by a threshold behaviour in relation to background climate that, when functioning near that threshold, can be tipped into a qualitatively different state – such as melting of the Greenland ice sheet, dieback of Amazon rainforest and shifts in the West African monsoon (Lenton et al., 2008).

I take up the concept of co-production in Chapter Five to examine how practices to define boundaries around community-scale carbon neutrality co-produce objects and scales of local climate governance. The analysis focuses on the way boundaries are delineated around community-scale carbon neutrality in the three field sites, and situates these practices in relation to local specificities, national policy contexts, and key phases of international climate governance. These boundaries contribute to the production of CO_2-e as a stable object, and the "local" as a distinct gradation, in multilevel climate governance. At the same time, boundaries delineated around the community-scale must always attend, to some extent, to locally specific contexts and circumstances.

2.5 Assemblages[5]

Enacting of sociotechnical imaginaries involves efforts to reconfigure sociotechnical systems and human activities within and across spatial and conceptual boundaries. I examine these efforts at altering social and material elements through the concept of assemblages. The idea of an assemblage differs from other ways of thinking about social and material elements and their interconnections, such as by conceptualising networks and groups. A network is a grid of interconnected elements, but these connections lack focus. A group is defined by its edges, or the limit between what is within the group and what remains outside the group. The former directs attention to linkages, the latter to nodes. Assemblages combine these qualities; they come together around some focal point but extend open-endedly. In this sense they are always contingent but never bounded.

Earlier in this chapter, I touched on how transnational city-networks are helping to propel common narratives around cities (and in particular "world-cities") as important sites for climate action. These widely circulating discourses, technologies and practices of sustainable and low-carbon urban development also intersect with situated places and public concerns, such as at the site of a particular building, precinct, city, or region. One way to apprehend the processes of translation and contestation that emerge at these intersections is through the lens of assemblage urbanism. From this perspective, cities can be understood as enormous sociotechnical artefacts, heterogeneously engineered by a range of competing actors and institutions (Aibar and Bijker, 1997; Cronon, 2009). Most of these ensembles of urban ecology – collections of elements that work together to form something greater than the sum of their parts – are largely unnoticed in everyday life, shaped by inflexible socio-material infrastructures of buildings, electricity, water, transportation and waste (Star, 1999; Hommels, 2005). Under certain conditions, however, these socio-material relations are re-articulated as local "matters-of-concern" involving new

[5] An earlier version of this section has been published in Pollard S. (2019) Cities as Forerunners: Local Climate Governance and the Carbon Neutral City. In: Maginn P and MacCallum D (eds) *9th State of Australian Cities National Conference 30 November - 5 December 2019.* Perth, WA. Available at: https://apo.org.au/node/305270.

sociotechnical innovations and new constellations of actors (Latour, 2004; see also Latour and Porter, 1996: 72). Thinking through assemblages draws attention to processes of bringing elements together around a new focal point, and to what is produced and stabilised (and conversely what is destabilised and destroyed) through these processes.

Blok argues that discourses and practices of urban sustainability are 'an important domain to observe the large-scale reassembling of nature, technology and society, and to invite new ways of thinking about sustainable urbanism as a particular mode of knowledge production' (Blok, 2013: 5). To this end, Blok puts forward the notion of urban green assemblages as a 'new ontology of city metabolisms', in order to articulate the ways in which urban green knowledge is produced, translated and contested across specific urban sites, scales and relations (Blok, 2013: 6). He defines urban green assemblages as: 'ensembles of heterogeneous actors, human and non-human, which orient themselves to the gradual redesign of urban eco-sociotechnical relations in "green" (or "sustainable") directions' (Blok, 2013: 10). These assemblages emerge as actors forge urban ecological connections, often entailing issues of knowledge and power, and opening new spaces of democratic experimentation around ecological "matters of concern" (Blok, 2013: 10). Viewed through the lens of assemblages, green architectural practices and their concrete manifestations – green walls, zero carbon buildings, eco-districts, urban forests, cycle ways, and so on – are not seen as static objects but as movable projects that emerge through a complex ecology of contention between different types of knowledge, material practices, and value commitments. The situated negotiations and controversies that emerge in relation to these projects, shaped by and reshaping their physical construction and social meaning, illustrate the material ways that social relations of knowledge and power manifest (Blok, 2013: 13-14; following Latour and Yaneva, 2008).

This approach to conceptualising the city, inspired by actor-network theory (ANT), is a way to engage with nodal concentrations and networked connections while discarding the taken-for-granted categories that designate which actors, objects and structures are important in social and historic analysis. In Latour's (1993) seminal ANT exploration of the "Pasteurization of France", microbes were given as central a role in the reconfiguration of public health practices as the scientists and public officials that are ordinarily at the centre of grand narratives of sociotechnical change. Re-appraising these narratives of change through the lens of assemblages brings into view non-human action, indeterminacy and open-ended encounters. (Such considerations are highly relevant given the profound changes to social life and sociotechnical systems flowing from responses to the COVID-19 pandemic at the time of finalising this thesis in early 2020.) At the same time, when lodged too heavily in an ontological standpoint of "naïve objectivism", the concept has been criticized by some for failing to engage with extant social arrangements and power structures (Brenner et al., 2011; Jasanoff and Kim, 2015: 32). The contention over how ANT perspectives treat power relations can be summarised thus. On the one hand, an

objective or "flattened" view of assemblages encourages analysis of actors and relationships that may otherwise be taken for granted – naturalised – and thus overlooked. On the other hand, a flattened perspective may underplay existing topologies of power – such as why some institutions and actors have a stronger voice in framing issues and shaping processes of change, and (recalling earlier discussion of sociotechnical imaginaries) how existing social and material infrastructures shape and constrain agency.

With respect to local climate change policies and actions, paying attention to dynamics of knowledge and power is important because of unequal historic and contemporary contributions to greenhouse gas emissions, unequal distribution of climate change impacts, and uneven capacities and affordances to reduce emissions and manage impacts. This includes recognising places that are being destroyed in order for other places to be protected, across multiple scales from communities shouldering more than their fair share of environmental harms in "sacrifice zones" (Lerner, 2010; Scott and Smith, 2017), to entire urban metabolisms that rely on regional and global supply chains for continued existence (Merrifield, 2013). Attending to these power inequalities demands thinking about places as part of a structured world, and how structures of knowledge and power produce and maintain structural inequalities between places (Tsing, 2017).

One way to resolve the difficulties of thinking through assemblages while remaining sensitive to structures of power is with careful attention to analytic placement. In Tsing's ethnographically informed approach to assemblages, she describes "margins" as placements from which to observe circulations of knowledge and power by questioning social categories: 'zones of unpredictability at the edge of discursive stability, where contradictory discourses overlap, or where discrepant kinds of meaning-making converge' (Tsing, 1994: 279). In later work, she identifies "gaps" (Tsing, 2005: 202) in the seams of universal projects where the universals have not been successful in setting all the terms, and "patches" (Tsing, 2015), places and actors, both human and non-human, that fall outside or are cast outside of global commodity chains. Positioning analysis with respect to these kinds of edges and openings makes it possible to trace the limits of hegemonic power (Tsing, 2005: 202). As Latour (2012) reminds us, hegemony is as much at play in the naturalisation of categories taken for granted in social sciences. The treatment of power relations in studies that apply the concept of assemblages can be partly addressed as a methodological issue (and one that I consider in the next chapter) about the placement of analytic frames.

From an analytic perspective, Tsing's (2005: 127) concept of "contingent lineages" highlights relationships between structure and agency in processes of change, merging existing social and material arrangements and structures of power with indeterminate encounters and open-ended connections. To illustrate this concept, she traces the interconnections between local and global in shaping of urban development over time, and how those connections come together through the city as both a

situated and a cosmopolitan space. For this reason, it is worth quoting her observations at length:

> A city…can be appreciated as the hub of many roads, stretching out to other places in every direction; it can also be experienced as an unforgettable and distinctive style, a pace, an outlook, a peculiar arrangement of neighbourhoods and markets and parks and crime zones, a manifestation of a particular history that can never be exactly replicated. The closer one looks at any idiosyncratic feature of the city, the more one sees the tracks that lead to other cities in conjoined pasts and presents; the more carefully one follows these links, the more one is startled by the unique features they have given to the city (Tsing, 2005: 121).

This perspective encompasses the city as simultaneously local and global, nodal and networked. Tsing discusses how urban development and change takes shape over time at the confluence of node and network, becoming most specific as it brings together influences from many places. Yet the history of this confluence can be difficult to grasp, 'Roads have been rerouted, and neighbourhoods have changed. The form of the confluence exists only because it is a node of articulation of varied historical trajectories' (Tsing, 2005: 121). She suggests:

> Looking back from the confluence as we know it today, we might call these shifting urban histories "lineages", that is, shards of genealogies through which present forms have emerged. Occasionally these lineages result directly from urban planning policies; most of the time, however, they come into existence through some haphazard combination of varied and contradictory planning, unpredictable negotiation, rebellious refusal, and unavoidable confusion. We might speak of "contingent lineages" through which the current form of the city has come into being. The city makes cosmopolitanism its own through these contingent lineages (Tsing, 2005: 121).

Contingent lineages are a form of assemblage that draw attention to the way in which social and material elements are brought together across space and time in processes of sociotechnical change. Social structures and power relations can be traced through contingent lineages, even while the encounters are indeterminate. Contingent lineages are at play in shaping cities, the politics of urban design, and pathways of imagined and actual low carbon transition, as they emerge through negotiation, struggle and compromise.

Bringing these perspectives to bear around local imaginaries and practices of carbon reduction and carbon-neutrality, I put forward the notion of "carbon assemblages" (Pollard, 2019) oriented towards the redesign of ecological and sociotechnical relations specifically around carbon. I apply this concept in Chapter Six to address how efforts to enact carbon neutrality are negotiated and contested as policy actors attempt to assemble new connections between people, technologies, and nature.

2.6 Friction

Efforts to enact community-scale carbon neutrality are directed towards reconfiguring social and material relations and reshaping sociotechnical systems.

These efforts are entangled in extended networks of actors, infrastructures, and resources flows. Eriksen's terminology of overheating signals the rapidly warming of the earth due to industrial activities releasing greenhouse gases, but it also conveys the points of connection that brush against each other in complex and uneven processes of change. The concept of friction proposed by Tsing (2005: 4) – that is, 'awkward, unequal, unstable, and creative qualities of interconnection across difference' – helps to unravel these interconnections and interactions between local and global. Friction enables and constrains circulations of actors, flows of information, and movements of resources and commodities, just as it enables and constrains Newtonian motion. It holds assemblages together, gripping social and material elements as they move past each other, inflecting these movements through interaction and resulting in new trajectories.

Tsing's study of how abstract claims about the globe operate in the world teases out frictions in unexpected alliances that remake global possibilities (Tsing, 2005: 12). She proposes the concept of friction as a counterpoint to popular stories of globalisation that took hold in the 1990s and the presumption in those stories that the imagined flow of goods, ideas, money and people would be pervasive and unimpeded.

> The experts imagine the perfect market, pure as one of Plato's universal forms. Yet markets are made in the friction of political and cultural circumstance. Local conditions for the enforcement of property rights […] shape market economies, whose universals cannot transcend politically managed questions of access (Tsing, 2005: 21-22).

In an era of globalisation, the experts foretold, motion would proceed entirely without friction: 'Motion itself would be experienced as self-actualisation, and self-actualisation without restraint would oil the machinery of the economy, science and society' (Tsing, 2005: 5). Yet motion does not proceed this way. The concept of friction serves as a reminder that, just as interactions define movement, they also define social structure, cultural form, and agency. Thus, friction is not only about slowing things down but also about holding things together and enabling movement and change.

Tsing uses the image of roads as an example of how friction works, establishing pathways to make motion easier, while at the same time limiting where we go. Friction works in the same way to inflect historic trajectories by enabling, excluding and particularising (Tsing, 2005: 6). Attention to the frictions through which universals are made and unmade opens up room for ethnographic inquiry into global connection, and possibilities to regard universals not as truths that "speak from themselves", but as "sticky engagements". Knowledge claims emerge in relation to concrete problems and possibilities for dialogue: the productive features of friction.

Tsing argues that drawing binary distinctions between local and global scales are unhelpful because they perpetuate assumptions that, in contrast to the diversity of the local, the global is unified and universal. By allowing the global to appear

homogenous compared to the heterogeneity of locality, we are more likely to accept its predictability and evolutionary status as the latest stage in macro-narratives (Tsing, 2005: 58). This can be seen, for example, in the global models of earth systems considered earlier that contribute to co-producing the global scale as the locus for understanding and predicting processes of ecological and sociotechnical change. The construction of a universal Nature, or a global climate, omits the frictions that underpin these processes of cultural production. Tsing argues, however, that we can address these dilemmas by paying attention to the way scale is made. 'Scale is not just a neutral frame for viewing the world; scale must be brought into being: proposed, practiced, and evaded, as well as taken for granted. Scales are claimed and contested in cultural and political projects' (2005: 58).

From this perspective, we could consider goals for global net zero emissions a universal project – in the sense of its all-encompassing planetary scale, with models of the global climate systems as the locus for understanding and prediction. Sociotechnical imaginaries for community-scale carbon neutrality can be seen as concretely situated knowledge claims that offer possibilities for dialogue. The different boundaries that are interposed around these situated imaginaries hint at margins and gaps at the edges of seemingly stable discourses of net zero emissions. Attention to friction generates insights into how knowledge of global climate change is translated across scales, including to situated local goals for community-scale carbon neutrality. In Chapter Seven I examine the frictions that emerge in processes to enact community-scale carbon neutrality, and the ways in which these frictions enable, constrain, and inflect processes of sociotechnical change. Frictions are at play in each of the three field sites at the core of this study as actors struggle to assemble carbon neutrality by forging new connections between technologies, people and nature. Frictions shape and alter these encounters, creating unanticipated outcomes and inflecting processes of change with new possibilities.

2.7 Conclusion

Scholarship on the multilevel governance of climate change alerts us to relationships between cities as locally situated nodes within globally connected networks. A paradox of cities is that they are geographically local and at the same time enmeshed in extended social and material webs of interconnection. Analyses that foreground networks of climate governance can overlook unevenness within and between the places and actors that constitute these networks. Analyses that foreground cities as concentrated nodes of people and infrastructures can divert attention from the wider social and material networks in which they are situated.

Terms such as "local", "global", "carbon neutral" and "community-scale" do not designate firm categories but enactments of fluid relationships. This is not to imply that the scales and objects so designated do not really exist, or that they can mean anything we want them to mean. Rather, the meanings of these things are negotiated

and stabilised through shared sets of social practices that operate across multiple levels, and these meanings are plural and malleable.

The concept of sociotechnical imaginaries opens up discussion of what is being imagined, and by whom, as policy actors pursue transitions towards low carbon futures in response to global climate change. The idiom of co-production helps to articulate relationships between knowledge and action in practices to define boundaries around carbon neutrality and the local scale. Enacting change to reduce and remove greenhouse gas emissions requires efforts to reconfigure assemblages of social and material elements focused around the abstracted object of CO_2-e. Frictions are inherent in these processes to enact sociotechnical change, not necessarily impeding movement but certainly shaping and inflecting pathways of change.

In this thesis, I focus on these four concepts – sociotechnical imaginaries, co-production, assemblages, and friction – to examine how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. These are not separate lenses applied to separate objects of research but comprise an interconnected analytic scaffold through which to examine the same sets of phenomena from different perspectives. In the next chapter, I discuss the methodological implications of this analytic framing and describe the research methods that follow from these considerations.

Chapter 3. Research methodology

3.1 Introduction

Sociotechnical imaginaries of community-scale carbon neutrality must be negotiated in relation to specific contexts and circumstances. Boundaries are delineated to hold these imaginaries in specific places, at the same time stabilising (through processes of co-production) objects and scales of climate governance. Enacting carbon neutrality involves efforts to reconfigure social and material elements in assemblages focused around carbon dioxide equivalent (CO_2-e). Friction holds these assemblages together and inflects processes of sociotechnical change. Investigating the way community-scale carbon neutrality is imagined and enacted thus calls for research methods that engage with contexts, processes and relationships in all their complexity.

With the analytic framing of this dissertation mapped out in the previous chapter, it is worth momentarily stepping back to clarify the ontological and epistemological coordinates of this study. This thesis is built upon the recognition that knowledge is always situated, while appreciating that traditions of scientific and social science inquiry are divided on questions of how it is situated, what factors shape knowledge in different situations, and the extent to which we can come to know what these factors are. I have applied a critical realist perspective (Archer et al., 2016) that, while things of the world are not "made up", we can only know the world through the connections to which we pay attention. Framed in relation to this inquiry, processes of global climate change, greenhouse gas emissions, and their anthropogenic causes do exist. The ways in which these things come to be known and responded to, however, are historic, contingent, and changing.

Critical realism is an alternative approach to scientific forms of positivism that are concerned with regularities and the quest for law-like formulations of how the world is. It is also an alternative to strong interpretivist or postmodern perspectives that favour interpretation over explanation by focusing on hermeneutics rather than causation. Archer et al. (2016) describe critical realism as a meta-theoretical position intended to provide a philosophically informed account of science and social science to guide empirical investigations. Forsyth (2001: 146) contends the significance of this approach for research into issues of environmental degradation because it stresses that 'scientific explanations of environmental change provide only partial insights into complex biophysical processes, and that existing models of explanation reflect the agendas of the societies that created them'. Forsyth's viewpoint broadly illustrates the idiom of co-production, because it highlights the ways in which explanatory models of environmental and sociotechnical changes are shaped by, and in turn may also reinforce, existing social and political structures and agendas.

From this theoretical stance, the key methodological decisions that have shaped this dissertation were to: focus on how goals for community-scale carbon neutrality are

made meaningful and enacted in particular localities; pursue a methodology based on ethnographic comparison that situates knowledge and action while being attuned to wider interconnections; and employ ethnographic writing to convey detailed descriptions, evoke feeling and engage with complexity. Consistent with a critical realist standpoint, my empirical investigation did not seek to uncover definitive stories of my field sites or make unequivocal claims to knowledge regarding local climate governance, community-scale carbon neutrality or global net zero emissions. Rather, I set out to explore how policy actors engage with, and what they think about, processes and patterns of relations through which low carbon futures are collectively imagined and enacted.

In this chapter, I expand upon the methodological considerations presented in Chapter One to lay out the key decisions that have shaped this investigation and fill in the detail of my research methods. First, I report on my scoping research into local commitments for community-scale carbon neutrality and my review of discourses contained within policy documents about these goals. Next, I describe how the findings from this exploratory investigation informed my research design, selection of case studies, and application of research methods. Then to set the scene for the empirical chapters that follow, I give a brief account of my research in each of the three field sites including the recruitment of research participants, design of semi-structured interviews, and details about methods of participant-observation.

3.2 Scoping research

3.2.1 Desktop review of local emissions reduction commitments

The scoping stage of research was conducted between July and December 2016 and involved a desktop review of voluntary commitments by local governments from around the world to reduce emissions at the "community-scale" – that is, across their local territories and not limited to their own corporate operations (Greenhouse Gas Protocol, 2016). The purpose of the desktop review was to find out which local governments had established commitments for community-scale carbon neutrality as a first step towards addressing how policy actors translate the concept of global net zero emissions into these local goals. The intention was not to establish a definitive comparison or benchmark of local government commitments on climate mitigation. Rather, the review was undertaken to inform my selection of case studies for ethnographic comparison, sharpen the focus of key research questions, and guide the design of research methods.

Surveying local level emissions reduction targets can help to reveal the rough contours of "moral geography" (Blok, 2012: 233) that are emerging in multilevel

climate governance.[6] Emissions reduction targets can be compared with respect to the size and speed of proposed emissions cuts. These commitments can be read as something of a "race to the top" to reduce emissions as fast and as far as possible, while at the same time adding weight to any efforts to advocate and persuade other actors to do more to reduce emissions (see for instance Mouritsen, 2019). At the same time, many details are difficult to ascertain from these high-level targets. The different historic, social and material contexts of a country, a region, a local jurisdiction, or an organisation, shape what their emissions are at a given point in time and can also be expected to shape opportunities and constraints to reduce emissions from that point. It is not always easy to ascertain how a particular jurisdiction has defined boundaries around sources and removals of greenhouse gas emissions, what actions they have elected to take to change their emissions, and how successful these actions are.

The review concentrated on three of the largest reporting platforms used by local governments to report on their climate-related commitments and actions: the UN Non-State Actor Zone for Climate Action (NAZCA), the Carbon*n* Climate Registry, and the CDP (formerly Carbon Disclosure Program) platform. Transnational network organisations promote these platforms as a way for local governments and other sub-national policy actors to share their commitments and actions on climate change. I cross-referenced information from these platforms with the several prominent transnational municipal networks (the Global Covenant of Mayors on Climate and Energy, C40 Cities, the Carbon Neutral Cities Alliance, and the Under 2 MOU) as well as council websites, non-government organisations and media reports identified through broader web-based searches. From these searches I compiled a dataset of jurisdictions and their emissions reduction targets along with other obtainable data including land area and population size. I also identified, where available, strategy and policy documents for those local governments targeting carbon neutrality across their local area.

While the desktop review was designed to be as comprehensive as possible, it was not intended to be, nor could it be, exhaustive. Local governments report their emissions reduction commitments and become members of transnational networks on a voluntary basis, and no platform claims to have comprehensive information. Information about each jurisdiction was presented in a variety of ways across

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[6] While the desktop review was limited to voluntary commitments by local government, a wide range of actors are establishing targets to reduce emissions and achieve carbon neutrality in the context of the international Paris Agreement. For example, Bhutan aims to maintain carbon neutrality by ensuring that carbon sequestration from its forests exceeds greenhouse gas emissions from other sectors (Climate Action Tracker, 2020). The Microsoft corporation, in January 2020, announced its intention to become carbon negative by 2030, and by 2050 remove from the environment all the carbon the company has emitted from electricity consumption or directly since its establishment in 1975 (Microsoft News Centre, 2020).

different platforms, with a mix of qualitative and quantitative data. The amount of detail that each jurisdiction reported about their targets and policies was mixed, with some reporting only their high-level commitment, while others provided emissions profiles, descriptions of actions being taken to reduce emissions, and links to policy documents. Cross-referencing data across multiple sources helped to fill in some missing details, but this process was time-consuming and, in some cases, inconclusive. For example, one jurisdiction located in China was reported as having a commitment to climate neutrality by one source, but further research did not identify any additional sources of information to corroborate this report. In addition, new pledges and actions continued to be made throughout the review period. For example, as part of the December 2016 international climate conference held in Morocco, 22 local and state governments joined the "2050 Pathways Platform" that involved a commitment to achieve net zero emissions by 2050 (UNFCCC, 2016). For some jurisdictions, joining this platform built upon pre-existing commitments, while for others joining this platform marked a new commitment. Notwithstanding some information gaps and uncertainties, the review fulfilled its purpose to generate a rough layout of local government commitments on climate mitigation.

Through the review, I identified 144 local jurisdictions with targets to reduce community-scale greenhouse gas emissions. Of these, 89 jurisdictions reported emissions reduction targets of 80 per cent or more; these were located in countries including Australia, Austria, Canada, Denmark, Finland, Germany, Italy, Japan, Mexico, New Zealand, Norway, Senegal, Sweden, Switzerland, and the United States. A subset of 26 local governments was identified as reporting commitments for community-scale carbon neutrality (broadly defined, as outlined below).[7] Within this subset of 26 local jurisdictions, eleven were located in the Nordic countries of Denmark, Finland, Norway and Sweden, seven were located in Australia, five were located in the United States, two were located in Belgium and one was located in the United Kingdom.

There were significant differences between those jurisdictions reporting commitments for community-scale carbon neutrality. Target years by which to achieve these commitments ranged from 2020 to 2050. Local populations ranged from 3,027 in Queenscliff Shire, Australia to 1,246,611 in Copenhagen, Denmark. The area of these jurisdictions ranged from 862 ha in Queenscliff Shire to 4,934,100 ha in Jämtland, Sweden. In terms of details about their emissions reduction targets, only 14 jurisdictions were identified as reporting an emissions baseline against which to assess progress towards their goal. These ranged from 263,199 tonnes of CO_2-e in Byron Shire, Australia (measured in 2016) to 4.94 million tonnes CO_2-e in

[7] Appendix 1a provides a full list of local jurisdictions that were identified through the review as reporting emissions reduction of 80 per cent or more. Appendix 1b presents a table summarising key information about the 26 jurisdictions identified as reporting commitments for community-scale carbon neutrality.

Melbourne, Australia (measured in 2008). Of those jurisdictions that had reported an emissions baseline, only eight were identified as having updated their emissions profiles to track progress. Exactly half of the 26 jurisdictions were identified as having published policy documents to frame their targets and to outline strategies for achieving them. In some instances, the lack of information on emissions profiles and policies may have reflected that commitments were newly made and, as such, supporting material had not yet been developed or made public. Finally, the commitments reported by some jurisdictions appeared not to have been updated for several years, suggesting that emissions reduction targets identified through the review might not necessarily reflect current policy objectives.

Perhaps the most significant finding from the desktop review was the extent of variation in how local jurisdictions define and report their emissions reduction commitments, particularly their goals for community-scale carbon neutrality. This policy goal was expressed in 15 different ways, as: "net zero emissions", "net zero greenhouse gas emissions", "zero greenhouse gas emissions", "zero net greenhouse gas emissions", "net zero carbon", "zero net carbon emissions", "carbon neutral", "CO_2 neutral", "community carbon neutral", "city-wide carbon neutrality", "climate neutrality", "100 per cent greenhouse gas reduction", "reduce CO_2 emissions from the community by 100 per cent", "reduce community-wide CO_2-e emissions by 100 per cent", and "100 per cent CO_2 reduction". These differences highlight that while the concept of global net zero emissions appears fairly stable (notwithstanding earlier discussion about the different ways to balance emissions sources and sinks to achieve this outcome), ways of expressing the concept at less-than-global scales are far from settled. Based on the desktop review, community-scale carbon neutrality appeared to be undergoing a process of formation as a discursive category. Recalling how Tsing (1994: 279) has positioned her analysis of universal concepts at the margins of discursive stability, the desktop review identified a group of localities and networks through which to investigate the indistinct and potentially contradictory ways that discourses and practices of community-wide carbon neutrality may overlap and where potentially discrepant kinds of meaning-making may converge.

3.2.2 Analysis of policy discourses for community-scale carbon neutrality

To further investigate discourses of community-scale carbon neutrality, I conducted an analysis of those policy materials produced by local governments and network organisations that were identified through the review. The analysis examined 29 documents published by local jurisdictions (in three instances prepared by consultants for local governments) about their policies for reducing emissions and community-scale carbon neutrality. It also examined 14 documents published by transnational network organisations and reporting platforms about their roles, objectives and operations. The earliest publications dated from 2003 (the City of Melbourne, Australia), and the latest from 2016 (draft strategies from Byron Shire and the City of Bendigo, Australia).

The informal content analysis involved close reading of documents to identify the discourses contained within them, without counting the specific number of times that discourses appeared (Gorman and Clayton, 2005). Some jurisdictions had published multiple strategies and updates, while others had produced only limited materials, so it seemed more useful to focus on the substance of discourses on community-scale carbon neutrality rather than the volume and frequency at which particular content appeared. The purpose was to identify, from a grounded perspective, key themes contained within policy discourses and points where these themes converged and diverged across different jurisdictions. The analysis identified high-level themes of policy rationales and objectives, models of participation, choice of policy instruments and timeframes in which to act. I coded this content using Nvivo software under the headings *why act, what end, how, who,* and *when*. Table 1 lists the variations on these themes identified within the policy discourses, expanded in the discussion below.

Table 1: Variations in local climate policy emerging through discourse analysis

Themes	*Variations in policy discourses*
Why act?	Reduce risks / Create opportunities / Contribute to collective efforts
What end?	Public good / "Green" growth / Common good
Who?	Experts / Entrepreneurs / Everyone
How?	Regulations / Markets and price signals / Changing values
When?	Slow and steady / Ahead of competition / Urgently

The main finding from the analysis was that, although the local governments shared broadly related commitments for community-scale carbon neutrality, they were not all talking about doing so in the same way, by the same means, or for the same ends. All of the strategies contained similar themes: outlining climate change as a problem involving the production of greenhouse gases; reporting on the potential risks of climate change in general terms and, in some instances, specific to the locality; describing the rationale for their goals for community-scale carbon neutrality; and setting out the key policy actions towards these targets. Beyond these thematic similarities, the most pronounced variations between policy discourses were in relation to climate change risks and responses, timeframes for action, preferred policy actions to reduce emissions, and preferred approaches to balancing sources and sinks of emissions in order achieve carbon neutrality.

In terms of climate change risks and responses, all the policy discourses framed global climate change as a threat and local actions to reduce emissions and achieve carbon neutrality as also providing positive opportunities. Amongst these, jurisdictions consistently expressed their intentions as "contributing to global efforts", "playing a part", and "doing our fair share", highlighting their local commitments and efforts to reduce emissions as part of a much larger movement of collective action, but also pointing towards issues of equity in addressing global climate risks.

Alongside these framings of thinking globally and acting locally, jurisdictions emphasised different kinds of positive opportunities, often described as "co-benefits". The desirable outcomes of local action to reduce emissions included local economic opportunities through "green" economic growth (such as by attracting investment in new industries), opportunities to improve public goods (such as by safeguarding and improving public infrastructure and social institutions), and opportunities to protect and enhance common-pool resources (such as by improving air and water quality).

Regarding timeframes for action, all the jurisdictions considered in the analysis presented a target year by which they planned to realise their carbon neutral objective, spanning from 2020 to 2050. The policy rationales that underpinned these proposed timetables varied. Some discourses emphasised the need to act quickly in order to secure competitive advantages against other cities, while other jurisdictions emphasised carefully managed emissions reduction pathways along a planned trajectory. Still others emphasised the need for urgent action due to the perception that global warming had already exceeded "safe" temperature thresholds. Such calls for urgent action are now often framed in terms of climate emergency. However, this discourse was only just starting to emerge at the time of conducting the desktop review.[8]

With respect to policy actions to reduce emissions, the policy documents examined in the desktop analysis emphasised a range of approaches, including "nudging" individual consumer preferences such as through price signals, introducing or tightening regulations to require certain activities to comply with specifications, and influencing people's values in order to motivate changes to behaviour. Preferences also varied for the kinds of technological changes that were coupled with these approaches to directing social changes, from discretely adopting new technologies where they would lead to cost savings (such as installing solar panels and energy efficient lighting), to broader restructuring of sociotechnical systems (such as investing in large renewable energy projects or integrating networks of bicycle lanes into city streets), and in some instances favouring low-tech solutions (such as encouraging walking and cycling and reducing emissions from waste by composting).

All the policy documents defined community-scale carbon neutrality as reducing greenhouse gas emissions from local activities as much as possible and then offsetting any remaining emissions through activities to avoid or sequester greenhouse gases in other locations. Within these policy documents, most jurisdictions provided some details about the boundaries defined around their goal (that is, the greenhouse gases included in their municipal carbon accounts) and thus their specific delineation of the "community-scale". However, very few documents contained details about the

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[8] To illustrate this point, the first local government in the world to declare a Climate Emergency was Darebin City Council, on 5 December 2016. By 2 April 2020, 1,482 jurisdictions are reported to have declared a climate emergency (CEDAMIA, 2020; Climate Emergency Declaration, 2020).

activities that would be undertaken to offset emissions. This general lack of specificity was contrasted by three jurisdictions – those three places at the empirical core of this thesis – that drew my attention because of their more detailed proposals for how and where residual emissions would be offset in order to achieve their carbon neutral objectives.

Alongside this analysis of discourses contained in policy documents, my attention to the way boundaries were defined around community-scale carbon neutrality was also informed by preliminary fieldwork in my home town of Melbourne. A conference titled the Community Energy Congress, held at the City of Melbourne Town Hall in February 2017, brought me into contact with policy actors involved in local climate governance. This included a small contingent of people from Byron Shire who had made the journey to learn what other communities were doing to develop community owned renewable energy projects and to share their own work on renewable energy and the Zero Emissions Byron project. In conversation, I learned more about the aspiration underpinning their local emissions reduction goals, which was to become self-sufficient in carbon within the boundaries of the Shire. This notion of being self-contained with respect to greenhouse gas emissions sharpened my curiosity with the local contexts and values that shape local goals for community-scale carbon and the processes through which these goals are envisaged and pursued. It also focused my attention on the City of Melbourne and the City of Copenhagen as jurisdictions with similarly ambitious commitments for community-scale carbon neutrality, but distinctly different preferences for how to balance greenhouse gases within and beyond their local territories.

To summarise the scoping research, the desktop review and analysis of policy discourses help to illustrate how the narrative of global net zero emissions becomes differentiated at less-than-global scales. In a context of multilevel climate governance, this finding raises questions about how objectives for local emissions reductions and community-scale carbon neutrality might "add up" towards global net zero emissions, especially when policy framings, objectives and mechanisms overlap and contradict in varied ways. The discursive themes identified through the desktop analysis converge and diverge from each other in patterns that indicate multiple ways in which policy actors are making sense of what global climate change means at local levels, and what the appropriate responses ought to be (Thompson, 2003; Verweij et al., 2006). Of course, while analysing policy discourses helps to illuminate patterns of variation at a point in time, policy processes are dynamic rather than static, and they unfold socially and materially as well as discursively (Howlett et al., 1995; Jasanoff et al., 1997). Rather than approaching policy discourses as static objects that could be situated in relation to each other in order to, say, compare a league table of progress towards ambitious goals and evaluate a "best practice" approach, I chose to focus on the dynamic and situated processes through which local approaches to community-scale carbon neutrality are being envisioned and enacted. This brings us to the design of the empirical research on which this thesis is based.

3.3 Ethnographic research design

The introductory chapter contained an overview of the research design and methods that underpin this dissertation, but it is important to provide a detailed context for the empirical chapters to come and reflexively situate the processes of knowledge production that I engaged in as a researcher. In this section, I further develop my introductory discussion of ethnographic fieldwork and research design, and then give a detailed account of my research methods.

3.3.1 Ethnographic fieldwork

Ethnographic research is fundamentally concerned with the negotiation of meaning, not only between people but also with the material world. It is ideally suited to a study concerned with investigating flux and change rather than identifying stable essences. It is based on the view from anthropology that how people behave, and the ways they construct and make meaning of their worlds, are highly variable and locally specific (LeCompte and Schensul, 1999). A basic principle of ethnographic research is to understand what people do and the reasons they give for doing it before offering interpretations of their actions and associated meanings. At the same time, a key intuition is the existence of universal qualities of human experience and condition. Through its close attention to contexts, and comparison across contexts, ethnographic research helps to account for social and cultural variation in the world while also conceptualising and understanding similarities between social systems and human relationships (Eriksen, 2001: 1).

To gain insights into locally situated actions and meanings, ethnographic methods include a combination of structured research tools such as surveys and interviews, and unstructured research in the form of participant-observation. The latter is a loosely defined research technique based on the ideal of the researcher immersing themselves in the life of the locals being studied, but without being noticed too much and thus disrupting how that local life proceeds (Eriksen, 2001). At the same time, the dynamic potential of ethnography is recognised as residing in the way it changes its object through the process of studying it (Hastrup, 1997). Ethnographic research is thus a reflexive methodology, requiring considered and continual appraisal and reflection about the relationships between what is being studied and the process of studying it (Law, 2004). This is a key point in ethnographic comparison (discussed in Chapter One) that recognises the way objects of comparison are produced as comparable objects through research methods (Scheffer and Niewöhner, 2010: 4).

The origins of ethnographic research lie with the discipline of anthropology, which at a basic level is the comparative study of society and culture and the connections between various aspects of human existence. While culture and society are both terms with many varied and ambiguous meanings, Eriksen (2001: 4) offers a concise summary: 'culture refers to the acquired, cognitive and symbolic aspects of existence, whereas society refers to the social organisation of human life, patterns of interaction

and power relationships'. Processes to negotiate meaning cut across cultural and social dimensions, and in the context of this investigation I am not overly concerned with disentangling one from the other. The analytic concepts that frame this thesis engage with the organisation of social life at the juncture between institutional structures of knowledge and power, infrastructural contexts of material and technological interaction, and cultural aspects of existence that shape patterns of relations and constructions of meaning at those junctures.

Whereas anthropology as a discipline was traditionally distinguished by its focus on (seemingly) bounded localities and cultures, the discipline has shifted to recognise that social and cultural milieus are also unbounded, dispersed and connected in complex ways. Tsing (2005: 121) argues that 'cultures are always *both* wide-ranging and situated, whether participants imagine them as global or local, modern or traditional, futuristic or backward looking. The challenge of cultural analysis is to address both the spreading interconnections and the locatedness of culture'. In his seminal essay, Marcus (1995) explains the methodological shift from the study of particular social groups contextualised within constructions of a larger social order (such as capitalist political economy), to studies of the construction of larger social orders through ethnographic research in multiple sites. Multi-sited ethnography allows observation that cut across dichotomies such as the "local" and the "global", the "lifeworld" and the "system"' (Marcus, 1995: 95), and in doing so, draws attention to the processes through which objects of research inquiry are produced (Law, 2004).

From its origins in anthropological study of (what were considered at the time to be) discrete societies in distinct locations, ethnographic methods have become common in many social sciences, including in STS to engage with the ways in which science and technology are embedded and enacted within social contexts (Law, 2004: 12). Seminal research in this field has drawn on ethnographic research to understand, close up, phenomena such as how science is practiced in laboratories (Latour and Woolgar, 2013), how practices of medical diagnosis and treatment enact the objects with which they are concerned (Mol, 2002), and how experiences of material technology change shape and become more or less definite (De Laet and Mol, 2000). Law (2004: 14) argues that social science 'should also be trying to make and know realities that are vague and indefinite *because much of the world is enacted in that way'* (emphasis given). Ethnographic research offers one set of tools to do so, because it helps researchers to detect, resonate and amplify particular patterns of relations through which complex realities come to be known and made meaningful (Law, 2004: 14).

3.3.2 Selection of field sites

For the purpose of this investigation, I designed a comparative ethnography across multiple sites in order to investigate the situated processes through which discourses and practices of community-scale carbon neutrality are taking shape. I approach my

research questions through ethnographic comparison between three localities where policy actors have been (and continue to be) engaged in translating the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

Four considerations underpinned my selection of Byron Shire, the City of Melbourne, and the City of Copenhagen as the sites for my comparative ethnographic study. I have briefly sketched the reasons for this selection in Chapter One and through my discussion of scoping research. Empirical research in these places forms the substantive empirical contribution of this dissertation, so I now lay out this rationale in full.

First, amongst the subset of local jurisdictions with policy materials about their goals for community-scale carbon neutrality, these three jurisdictions were amongst those with the nearest term targets. This suggested processes to implement, adjust, and evaluate policy actions would be actively underway during fieldwork rather than being seen as long-term issues (as may be the case with longer term targets such as for the year 2050). Thinking of these timeframes for action as "temporal boundaries" links decisions about timing and speed to the next point.

Second, these three jurisdictions expressed distinctive preferences for how they planned to balance greenhouse gases across spatial and conceptual boundaries at the community-scale. Preferences for trading carbon through market mechanisms in the City of Melbourne's early strategies contrasted against preferences expressed in Byron Shire to sequester carbon within the local area, and against the City of Copenhagen's approach of generating surplus renewable energy by investing in large wind farms. As I have already mentioned, the clarity of these proposed approaches to managing greenhouse gases across spatial and conceptual boundaries stood out amongst the policy discourses examined through the desktop review. These clearly delineated preferences for how to manage greenhouse gases across the spatial and conceptual boundaries of the community-scale resonated through other parts of their policy documents. The three jurisdictions emphasised different factors in their respective rationales for responding to climate change, their framing of benefits envisaged to result from these actions, and their preferences for policy mechanisms and technologies to enact sociotechnical changes to achieve carbon neutrality.

Third, the localities chosen for empirical investigation were situated in different social and material contexts. The plural discourses and distinctive boundaries described above raised questions about the social and material factors that have shaped these approaches to community-scale carbon neutrality, and how actions taken towards these goals have unfolded in practice. Recalling earlier discussion, the goal of global net zero emissions requires changes to sources and sinks of emissions in particular localities to be pieced together into a general claim of global net zero emissions. This reflects Tsing's two-step process of piecing together particularities to make generalisations, and then erasing those collaborations through which inferences have

been made (Tsing, 2005: 89). The purpose of comparing different approaches to community-scale carbon neutrality was to help reveal those collaborations across difference and dialogues through which both local and global agendas are shaped.

Briefly highlighting some key differences between the field sites, the City of Copenhagen is a powerful city-state within Denmark's two-tiered system of government, while the City of Melbourne and Byron Shire sit within Australia's three-tiered system of government. The City of Melbourne is one of 32 municipalities within the greater metropolis of Melbourne, the state capital of Victoria. Byron Shire is an even smaller regional council on the far north coast of New South Wales. In each place, different constellations of actors are involved in processes to negotiate and contest, enact and resist, goals for community-scale carbon neutrality. This includes politicians and bureaucrats, publicly- and privately-owned companies, civil society organisations, local, state and national governments, regional and international networks organisations, community groups, and local publics.

In the context of multilevel climate governance, a further variable that differentiates these places is the contrasting approach to national climate change policy in Denmark and Australia. Each year since 2005, the Climate Change Performance Index has assessed countries on their overall performance with respect to greenhouse gas emissions, renewable energy, energy use, and climate policy. In 2016, Denmark, at position four, was ranked ahead of every other nation for the fifth year in a row (no country achieved positions one to three, because none is considered to be doing enough to prevent dangerous climate change), while Australia was ranked at position 56 of the 58 countries assessed (Burck et al., 2016). Despite these contrasting contexts of national policy, actors in the three localities at the focus of this study were all attempting to go beyond national responses to climate change and reducing emissions.

Fourth, the selection of case studies was considered pragmatically to ensure the study could be achieved within the time and resource constraints of doctoral research. As stated earlier, I selected three case studies to allow for in-depth ethnographic research while at the same time encouraging comparison and analysis to go beyond binary distinctions.[9] The selection enabled comparison across Australian and Danish contexts, between large and small jurisdictions, between metropolitan and rural settings, between bureaucratic and grassroots organisation, between voluntary, regulatory and market driven approaches, while appreciating that the significance and meanings of these categories are not fixed but are negotiated. On that point, I

[9] The scoping research guided my selection of case studies, but also pointed towards a range of other possibilities for investigation that are beyond the scope of this study. For example, although the review identified several jurisdictions in the United States with (longer-term) targets and strategies for community-scale carbon neutrality (Austin, Texas by 2050, Santa Fe, New Mexico by 2040, and Seattle, Oregon by 2050), I considered a doctoral research program across three countries would be stretched too thin to allow for in-depth ethnographic fieldwork.

turn now to give an account of the ethnographic research at the core of this dissertation.

3.4 Conducting ethnographic fieldwork

I conducted ethnographic research between March 2017 and June 2019. This included extensive periods of fieldwork in the City of Melbourne in Spring 2017 and Spring 2019, in Byron Shire in Summer 2018 and Autumn 2019, and in the City of Copenhagen in Spring and Summer 2018. The fieldwork was spatially situated within the City of Melbourne and the municipalities that surround it, the towns and hinterlands of Byron Shire, and the City of Copenhagen and its surrounds. It also extended to other places to speak with actors who were involved in local climate governance relevant to my field sites, including the C40 Cities office in London and the Samsø Energy Academy on Samsø Renewable Energy Island (see Papazu, 2016b). The research extended beyond the three field sites through analysis of policy discourses and practices and by evoking responses through semi-structured interviews. This was in order to trace how policy actors measured and inscribed flows of greenhouse gas emissions through techniques such as municipal carbon accounting, and to gain insights into potential social and material implications of these practices. My investigation was temporally oriented towards future policy objectives for community-scale carbon neutrality, while also attending closely to the past histories and present circumstances in which these goals were being framed.

I commenced ethnographic fieldwork with a set of open-ended questions and propositions to be explored, informed by findings from my scoping research. The investigation was designed to explore how and why different approaches to community-scale carbon neutrality emerge, how these approaches are entangled across other sites, scales and institutions, and the possible implications of the different approaches being taken in each of the field sites across the wider landscape of climate governance. The research questions and interwoven analytic concepts that frame this dissertation are the result of a reflexive and iterative research process, shaped and refined through interaction and reflection, rather than pre-defined hypotheses to be tested. Comparison between the three field sites gave the study momentum because discovering something significant in one place always prompted questions about its significance in other places. Comparing local approaches to community-scale carbon neutrality across different contexts and circumstances required engagement with processes that were complex, dynamic and messy rather than clear and certain. The discovery and analysis continued through writing and analysing field notes, drafting research papers, presenting at seminars and conferences, preparing the chapters of this thesis, and sharing drafts with research participants.

Reflecting on these comparisons here, my fieldwork in the City of Melbourne became a template for my research as a whole – tracing the conditions of possibility from which pathways to a carbon neutral future had been imagined, how these pathways had been inflected at various points, and how local policy actors had responded to

these shifting circumstances. My fieldwork in Byron Shire sharpened my focus on the presentation of the "community-scale" as a pre-configured category in local goals for carbon neutrality. Yet community actors are only partially and differentially involved in processes to imagine and enact these low carbon futures. My fieldwork in Copenhagen felt like a turning point in the research because it drew my attention to the sociotechnical fabric of the city – with its wind turbines, combined heat and power plants, and bicycle lanes interwoven through the experience of daily life – in shaping possibilities for a carbon neutral future. Tracing efforts to enact these futures in each place drew attention to contingencies, indeterminacies and shifting circumstances as common threads in these processes of sociotechnical change.

3.4.1 Research methods

My research methods included semi-structured interviews with policy actors involved in local climate governance in each of the field sites, and participant-observation to discern the social and material contexts in which these efforts are situated and how they have played out over time. These fieldwork methods were supported by continued analysis of discourses contained in documents relevant to climate governance in each of the field sites. My engagement took the form of dissecting climate action plans, policy documents, annual reports and minutes from council meetings. I also analysed technical documents such as greenhouse gas inventories, international standards and guidelines, and national regulations to understand the wider structures and institutions that shape local approaches to measuring, managing and reporting greenhouse gases.

I conducted semi-structured interviews with policy practitioners, councillors, consultants, and community activists involved in shaping policies and actions in relation to goals for community-scale carbon neutrality, in order to provide a range of experiences and perspectives on local climate governance. Research participants were recruited from local councils in each of the field sites and from organisations connected with local climate governance in those places. I identified potential research participants through existing networks, by searching council records and policy documents, and through media articles. I reached out to potential participants with an introductory email to outline the study and invite their involvement, following up with a plain language statement and a consent form. I used a snowball approach to extend recruitment by asking participants to suggest others who may be willing to contribute to the research.

Research participants were asked about their knowledge and experience of climate change and emissions reduction policy and practices. I asked a series of open-ended questions related to key areas of local climate policy and governance, processes of negotiating, implementing and adjusting policy objectives and actions, and

interactions between people and organisations in relation to these processes.[10] These questions were designed to explore the diversity of views and approaches brought to bear on the design and implementation of policy goals for community-scale carbon neutrality, and how policy decisions and processes of sociotechnical changes are entangled across other sites, scales and institutions. The semi-structured and open-ended format of interviews was designed to elicit detailed responses, allow for follow-up questions and enable excursions into other topics and themes as guided by research participants.

In total, I conducted a total of 48 interviews distributed fairly evenly across the three field sites. The interviews lasted between 35 minutes and 1.5 hours with an average duration of 50 minutes. Half the interviews were audio-recorded (with permission from participants), where the setting allowed. All but one were conducted face-to-face, and usually at a meeting place familiar to my research participant such as their workplace, home or a local cafe.[11] I took hand-written notes during both the recorded and unrecorded interviews to capture key points of discussion, quick reflections, interesting phrases and expressions, and questions or issues to follow up. I typed these up into more detailed field notes as soon as possible after each event (with reference to any audio recording) to also capture contextual details and preliminary reflections alongside key details from the conversations. In finalising this thesis, I shared draft chapters with research participants and highlighted those excerpts and quotes drawn from our interactions in order to confirm their earlier consent, check details, and encourage ongoing dialogue.

Alongside interviews, I engaged in participant observation in each field site to learn about the situated contexts in which local approaches to carbon neutrality have taken shape. This involved getting to know each place by participating in and critically observing daily life, reading local news articles to understand local issues and controversies and their intersections with climate governance, attending events and public consultations related to local climate policy and action, and engaging people in conversation about my research and about their lives. Field notes generated from these encounters and the interviews described above lay the empirical groundwork for my analysis. I drew on these field notes for the ethnographic writing and descriptive vignettes of people and places within this dissertation, using thick description and thick comparison to evoke feeling, convey complexity, and highlight processes and patterns of relations. In the next section, I introduce my encounters with each of these places.

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[10] Key themes and prompts to guide these interviews are included in Appendix 1c.

[11] The exception was an interview conducted via Skype with a Regional Director in the C40 Cities organisation.

3.4.2 Encountering the field

Although broadly commensurable, my encounters with the field took shape differently in each place. As my own place of residence for almost 10 years, the City of Melbourne offered a familiar setting. Against this familiarity was the challenge of seeing things with new eyes through ethnographic encounter. At the time of my research, the council was undertaking a wholesale review of its climate policies under a pilot initiative by C40 Cities, called Deadline 2020, which aims to align the climate policies of its (then) 90 member cities with the Paris Agreement goals (C40 Cities and Arup, 2016). Through the fieldwork period, the City of Melbourne developed a new climate strategy that resulted in revisions to the framing and timing for community-scale carbon neutrality, from 2020 to 2050 (Pollard, 2020). This process presented an opportunity to observe the dynamics of policy formation within the organisation and in relation to other levels of climate governance.

My initial inquiries into carbon accounting and offsetting were met with caution, with many in the organisation not wishing to discuss these issues with an outside researcher while the new strategy was being developed. Negotiating the terms of engagement has been an ongoing process. It was not possible to sit in on internal meetings, as I had hoped in my research proposal, either at the City of Melbourne or at my other field sites. However, there were also several outward facing forums in which to observe the process of developing the new climate strategy, including public consultations and council meetings. Semi-structured interviews and informal conversations with those involved in the process contributed substantially to my understanding. Participants included current and past employees and councillors at the City of Melbourne and people who had worked closely with the council on issues related to climate change, in their roles with C40 Cities, Ironbark Sustainability and the Northern Alliance for Greenhouse Action. These conversations also sharpened my attention to the contexts in which the original strategy and its subsequent updates were developed.

My fieldwork in Byron Shire added up to a total of five weeks, carried out over two separate occasions. Although of shorter duration, the depth of fieldwork here was comparable to the other two sites because of the jurisdiction's smaller size and the flexibility and generosity of research participants. Whereas scheduling an interview with staff in a municipal administration might sometimes require weeks of forward planning, research participants in Byron Shire were willing to meet with me at short notice (perhaps illustrating the laid-back lifestyle for which the area is famous). Most research participants in Byron Shire were involved in community-based organisations rather than the local Shire council, reflecting a different constellation of actors and organisations involved in local climate governance here compared to Melbourne and Copenhagen. Although written materials on the Shire's climate policies were not as numerous as those from the City of Melbourne and City of Copenhagen, people in the Shire are just as passionate about storytelling. There was

abundant material from which to learn about place, identity and community that speak to issues at the very core of local climate governance.

The connections I made through research at the City of Melbourne snowballed into contact with staff at the City of Copenhagen's Technical and Environmental Administration and the C40 Cities Copenhagen office. In 2018, I conducted four months of fieldwork in the City of Copenhagen from late February through to the end of June. The language barrier posed few challenges for fieldwork in Copenhagen. The City of Copenhagen publishes English language versions of many of its climate strategy and policy documents, as part of campaigns to promote Copenhagen and Denmark as offering climate solutions to the world. Many Danes are fluent in English, and all my research participants seemed comfortable corresponding and conversing in English. My inability to speak and read Danish did limit access to newspapers, popular media, advertising and so on, which added to the difficulty of learning about local issues and debates. The four-month duration of my fieldwork helped to make up for these deficits, and my outsider perspective on life in Copenhagen, and the ethnographic strangeness I experienced, provided insights that might not be available to local residents. The generosity of colleagues and friends at the University of Copenhagen who were willing to explain local customs and controversies to a puzzled observer also proved invaluable.

Although my encounters with policy actors and organisations in each of the field sites unfolded in different ways, it is important to reflect on these processes of interaction and collaboration as integral to the production of knowledge. That is also why, in the empirical chapters that follow, I use stories, vignettes, and thick descriptions and comparisons to reflexively situate the processes of knowledge production on which this dissertation is based.

3.6 Conclusion

This study presumes that its objects of inquiry – sociotechnical imaginaries and assemblages of community-scale carbon neutrality – are stabilised and destabilised through ongoing processes of translation, through which policy actors draw the abstract universal of global net zero emissions into their situated efforts to remake local worlds as carbon neutral. The objectives of this study can only be addressed through ethnographic comparison that engages with contexts, processes and relationships.

Scoping research drew attention to variations in the expression of local goals for community-scale carbon neutrality, in particular the spatial and conceptual boundaries defined around these goals and the preferences for policies and technologies to enact them. The discursive instability of community-scale carbon neutrality indicated margins to the universal concept of global net zero emissions – analytic placements from which to explore the dialogues through which both local and global agendas are shaped.

The three case studies were selected to investigate how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. Byron Shire, the City of Melbourne, and the City of Copenhagen were chosen on the basis of their near-term targets and the distinctive boundaries and preferences they had defined around their carbon neutral goals. Taken together with other variations in policy discourse and differences between social and material contexts, fieldwork in these places was designed to ethnographically compare processes of translation across difference. Contrasting and juxtaposing local policy goals, institutional arrangements, sociotechnical systems, and envisaged and actual pathways of sociotechnical change highlighted processes and patterns of relations that were common across these places. At the same time, these comparisons revealed situated contingencies and inescapable indeterminacies involved in local efforts to reduce and neutralise emissions in response to climate change.

The research sub-questions that are the focus of the next four chapters emerged through this process of inquiry. Ethnographic comparison between the three field sites draws attention to the social and material contexts in which policy actors translate the concept of global net zero emissions into local goals for community-wide carbon neutrality. This helps to reveal (in Chapter Four) the conditions of possibility in which particular **sociotechnical imaginaries** of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom). Comparing the way boundaries are defined around community-scale carbon neutrality highlights the elements that are excluded, and entanglements created, through the calculative processes of municipal carbon accounting. This supports examination (in Chapter Five) of how practices to define boundaries around community-scale carbon neutrality **co-produce** objects and scales of local climate governance. Comparing particular projects to reduce and offset greenhouse gas emissions reveals patterns of relations as well as indeterminacies in processes of sociotechnical change. This underpins analysis (in Chapter Six) of how efforts to enact carbon neutrality negotiated and contested as policy actors attempt to reconfigure **assemblages** of people, technologies, and nature. Comparing shifting circumstances in each field site reveals the efforts of policy actors to adjust and stabilise their sociotechnical imaginaries in response to these shift. This helps to identify (in Chapter Seven) the **frictions** that emerge in processes to enact community-scale carbon neutrality and how these enable, constrain and inflect processes of sociotechnical change.

Much like the production and enactment of objects that the study was investigating, the research was itself a process of negotiation. Each phase of fieldwork added new layers of understanding, directing attention back to previously unseen aspects of fieldwork elsewhere. The process of writing and revising this thesis was an iterative one, with empirical material and conceptual framings coming into focus through successive drafts. This ongoing and reflexive process of knowledge production underpins the substantive analysis that I turn to in the rest of the thesis.

Chapter 4. Sociotechnical imaginaries of community-scale carbon neutrality

4.1 Introduction

This thesis examines how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. This chapter is focused on the conditions of possibility, in each of the three field sites at the core of this study, in which particular sociotechnical imaginaries of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom).

Sociotechnical imaginaries are collective visions of what is and what ought to be; tying imaginative capacity to visions for, and actions towards, processes of sociotechnical change (Jasanoff and Kim, 2015: 6). These future-oriented visions emerge and take hold within a set of existent social and material contexts and circumstances. They map out a pathway of sociotechnical change from a situated present to an abstracted future state. The purpose of this chapter is to generate insights into what these starting points are in each of the field sites – the historic, social and material contexts and relationships in which goals for community-scale carbon neutrality originate and take hold as collective imaginaries. I apply the concept of sociotechnical imaginaries to generate insights into how these future-oriented visions for carbon neutrality come into being, and by which constellations of actors.

Comparison across the three field sites reveals differences with respect to the social and material contexts in which visions for community-scale carbon neutrality emerge, the means by which policy actors imagine their vision might be achieved, and the arrangements of people, technologies, and nature that these envisaged futures entail. These visions, and the sociotechnical projects through which they are to be achieved, must be seen as viable and desirable by actors within, and in relation to, a given locality. That is, these visions must be perceived as possible and worthwhile in terms of technical, political, economic, and / or moral registers and valences. In this sense, visions of local carbon neutral futures are not fanciful speculation but, rather, reflect and embody the imaginative capacity of policy actors to envision processes of sociotechnical change. Policy actors must frame their visons in such a way that they become communally adopted as sociotechnical imaginaries, if not by all, then at least by a constellation of actors and institutions that is powerful enough to sustain the imaginary so that others may be swept along by it.

Policy goals for community-scale carbon neutrality draw on scientific evidence to frame knowledge of climate impacts, inform methods of measuring greenhouse gases, and plot targets and trajectories for reducing those emissions. These goals are also informed by a wide range of possibilities to change human activities and

sociotechnical systems by way of technological, regulatory, economic, and cultural projects. Sociotechnical systems, in this context, are broadly defined. They can be high-tech, but do not need to be. They could include installing or investing in renewable energy to reduce reliance on fossil fuels in electricity generation, retrofitting buildings to make them more energy efficient, improving bicycle lanes and walking paths, and substituting cars and buses for vehicles powered by renewable electricity or zero emissions fuels. They could also involve technologies to absorb greenhouse gases, such as by planting trees or managing land differently, capturing biogas from sewage treatment or compost, or drawing carbon dioxide directly out of the air. Such projects are always situated within wider matrices of legal and regulatory institutions, flows of finance and incentives to modify investment decisions, and behavioural changes to accompany technological shifts. These projects are always, ultimately, embedded in places and shaped by what those settings afford. They include social and ecological as well as scientific and technological dimensions.

Processes to collectively define and enact sociotechnical imaginaries of community-scale carbon neutrality emerge through relationships, so it is important to consider how policy actors organise themselves around, and are shaped by, these imaginaries. Viewing local policy commitments and strategies for net zero emissions as sociotechnical imaginaries draws attention to the different meanings given to key framing concepts, such as how "community" is constituted and made meaningful in relation to the "community-scale" to which these policy goals refer. The outcome of negotiation over meanings is influenced by the range of actors and institutions contributing to the imagining, noting that it is not only local governments. While local councils play important roles in establishing such policy goals, they are involved with different constellations of policy actors and organisations in each of the places examined in this study. Comparison between Byron Shire, Copenhagen, and Melbourne highlights the different contexts and contingencies through which local communities come to be collectively defined, and what social and natural orders are reproduced or must be reconfigured to realise these futures. Differences between these sites lead to different engagements.

I now move to piece together the conditions of possibility from which particular sociotechnical imaginaries for community-scale carbon neutrality emerge. I begin with Byron Shire, move next to the City of Copenhagen, and then to the City of Melbourne. For each field site, I evoke the social and material contexts and relationships of each place through descriptive vignettes of histories, places and people. I examine how the vision for community-scale carbon neutrality builds on existing preferences for social and natural order. And I consider the constellations and actors through which these future imaginaries are stabilised and foreshadow some key dynamics that upset that stability. Comparison between the field sites reveals shared features and processes while also highlighting particular conditions of possibility in which each of these sociotechnical imaginaries for community-scale carbon neutrality take hold.

4.2 Byron Shire and the vision for Zero Emissions Byron

The theme of belonging evokes questions about who belongs in a place, and who is responsible for making decisions about that place. These questions are never simple to address, but they offer an entry point to begin thinking about who is empowered to imagine the future of their local community.

4.2.1 Belonging[12]

Byron Shire is an idyllic place on the far north coast of New South Wales where the eastern-most point of Australia folds into the sea. The largest town is Byron Bay, a full day drive from Sydney but less than two hours from Brisbane and a mere 40 minutes from the Queensland border and the towering glass and steel of the Gold Coast. The original inhabitants of the land, the Arakwal people of the Bundjalung Nation, call Byron Bay "Cavanbah", which means meeting place (Duke, 2010: 12). The eruption of Mount Warning some 60 million years ago created a caldera that spreads up to the Tweed River and seaward past the Byron headland to Nguthungulli (also called Julian Rocks). The volcano spewed basalt and rich volcanic ash across the Northern Rivers area, up to seven metres deep in places such as Bangalow. The area is a productive food bowl and a hot spot for biodiversity (Department of Agriculture Water and the Environment, 2020). Australian author Di Morrissey (in Duke, 2010: 5) describes:

> Byron Bay is a place which, if it didn't exist, one would have to create. A landscape of stunning beauty with a rich and colourful history, where one is caught in the magical and creative cusp between Mount Warning, the Byron headland and the hinterland.

The recent history of Byron Shire can be read, in part, as a struggle over who and what belongs, and who gets to decide; a struggle that continues to shape collective imaginings of future possibility. By tracing these complex histories of belonging, we can begin to grasp the overlapping social and material contexts in which *this* imaginary of community-scale carbon neutrality, in *this* place, has taken shape.

Timber cutters first came to the area in the 1800s via the Brunswick River. Where the dense sub-tropical forests were felled for cedar, settlers started farms and dairies. On the coast, Byron Bay boomed with shipping, whaling and sand mining. As these industries declined, surfers discovered the waves offshore and waves of new settlers established intentional communities in the hinterlands, each practicing lifestyles and espousing values alternative to the mainstream. Tourism and population growth promised social and economic renewal, but urban expansion was kept in check through the 1990s and early 2000s by a "deep green" council, and a moratorium on development because of an underperforming sewerage treatment plant (Graham and

[12] An earlier version of this section was published in Pollard S. (2020) Resistance and Change in Byron Shire. *Rusty's Byron Guide.* Byron Bay: Rusty Miller and Tricia Shantz, 50-51. Available at: http://rustymillersurf.com/byron-guide/.

Prior, in Miller and Shantz, 2018: 14-15). Recent years have seen visitors and development surge, putting pressure on housing and living costs, damaging roads, threatening fragile ecologies and, at least in the view of some, eroding values of community and place.

Against external pressures, the local community has fought for what its members believe in. Former mayor Jan Barham holds that 'Byron is beautiful because of the people that fight daily to keep it that way' (in Miller and Shantz, 2018). The anti-logging protest at Terania Creek in 1979 was Australia's first rainforest preservation campaign, forming the model for subsequent protest actions like the iconic Franklin River blockade (Duke, 2010: 76). When Club Med proposed an $85 million mega-resort at North Beach in 1991, its plans were met with concerted resistance from local businesses and environmentalists against unlimited development, corporate takeover of local commerce, and threats to ecologically sensitive areas and species. The proposal was finally overturned in the NSW land and environment court with the endangered comb-crested jacana given precedence over the development (Duke, 2010: 88).

Resisting the incursion of Gold Coast property developers, known locally as the "white shoe brigade" – as in flashy white leather and business suits, according to local architect Dominic Finlay-Jones – continues to bring people together (field notes, 18 January 2018). Plans to develop a new housing estate in the West Byron wetlands, rezoned by the NSW government without consultation, were voted in 2019 down after sustained community resistance on the basis of ecological impacts (Jeffrey, 2019).

Unwanted urban development is not the only incursion being resisted. With the threat of coal seam gas extraction projects appearing in the region in 2010, people also came together against a common enemy. Innovative community surveys verified near-total opposition to the proposed fracking across the Northern Rivers. Placards fixed by the roadside declare the results of this survey for every town in the region, for instance: "Byron Bay 98% declared Gas field free". When local and state governments disregarded this message, the people behind those voices blockaded the drill sites, culminating at Bentley in 2015 where 10,000 protesters halted the rigs and their 800-strong escort of NSW police (Shoebridge, 2016). These contests over what belongs, and who gets to decide, highlight the power of a common enemy to forge a collective sense of identity and place. This has important implications for how, and for whom, the sociotechnical imaginary of a zero emissions Byron Shire has been framed.

Out of the aversion to coal seam gas, and to distant state and corporate power, a constellation of local organisations has emerged in Byron Shire charting new pathways for energy, climate and community. Mullumbimby local Dave Rawlins described to me how resisting coal seam gas catalysed Community Owned Renewable Energy Mullumbimby (COREM) to imagine a desirable energy future

with profits and benefits recirculating locally (interview, 9 January 2018). Co-founder Ella Rose Goninan recounted the contradiction she felt defending the Northern Rivers and Bentley from coal seam gas in the blockade while going home and using that same material in her everyday life. She described a choice to either keep living on the front lines fighting these extractive industries, or else find a way that we don't need them anymore (interview, 15 April 2019).

In a similar vein, Alison Crook described to an audience at the monthly Mullumbimby "Stories in the Club" the origins of Australia's first community owned energy retailer, Enova Energy (of which she is CEO). She told how, on the last day of the Bentley blockade, she was dressed in her business attire ready to sit in the front row of the blockade (in anticipation that police dragging away the well-heeled could make news headlines). At the last minute, the NSW government revoked the exploration license 'because they didn't have social license' (field notes, 14 April 2019). Alison's feeling was that, even though this battle was won, they needed to prove that not only is gas not wanted, it is not needed; that regions can be self-sufficient in energy. Community owned renewable energy offers the alternative, and Alison described it as a "multiplier" that 'builds local economies because it circulates through local transactions multiple times, supporting more economic goods in the local area' (field notes, 14 April 2019). Now, with Enova well established in the Northern Rivers and expanding its model of community owned electricity retail to other parts of Australia, Alison expressed the view that she would like to retire soon. But at the same time, she knows we are in a climate emergency and there is no time to waste. 'The ice caps are melting, seas are rising, species are becoming extinct', and she feels anger and fear. 'Enova gives me actions to take every day so that I don't despair' (field notes, 14 April 2019).

The sociotechnical imaginary for a Zero Emissions Byron is one of local autonomy and independence, strong ecological values, encapsulated by and reflected in a powerful sense of place and belonging. Byron Shire's imaginary for zero emissions focuses on using the sun, wind and water to generate community owned renewable energy. A strong history of community alliances to protect local environmental values has led to an imaginary with a strong focus on environmentally benign technologies and local structures of ownership and control. Elemental forces are reformulated as collective resources that reshape flows of power in multiple senses of the word. COREM has established a revolving fund to pay for solar photovoltaics on community facilities. The money saved on electricity bills is used to repay the initial cost and replenish the fund for the next project, with further savings supporting the financial position of these local organisations (COREM, 2018). There are also plans to revive the Mullumbimby hydroelectric power station (Hydro-Electric Corporation, 2018). Built by Mullumbimby Council in the 1920s, it provided electricity to the town, and revenue to the council, until it was decommissioned in 1990.

Extractive industries such as coal seam gas pose threats that are planetary in scale through greenhouse gas emissions, but they also threaten local values of environmental protection and community autonomy. Community owned renewable energy is a direct response to both of these threats because it endows the local community with the power – politically, economically, and materially – to reject extractive industries and to reduce the environmental harms of daily life. The idea of becoming self-sufficient in carbon within the Shire, while not central in all of the discourse that emerged in relation to the zero emissions imaginary, formed a powerful connection with the area's social and material histories. The rich volcanic soil and extensive hinterland – cleared by timber cutters and occupied by successive waves of settlers – established the social and material conditions of possibility in which to imagine an ecological resurgence that could sequester any local emissions that remain.

4.2.2 Imagining change

From these slender threads, the possibilities to envision a carbon neutral community coalesced around reducing emissions through renewable energies, responsible lifestyles and regenerative practices within the municipal boundaries. These possibilities grew from the collective imaginaries that constitute and reproduce understandings of identity and place.

The Zero Emissions Byron project is built upon and manifests through these grassroots imperatives for local circulations of autonomy, energy and wealth. These attributes, however, also intersected with wider circulations. Sociotechnical imaginaries of community-scale carbon neutrality are collective visions of what the future ought to be and how to get there. Group dynamics are important, in terms of who has a say in deciding what the future ought to be. The meanings of the imaginary for a zero emissions Byron Shire have been negotiated in the grip of local and global connections, grounded in place and identity but also in relation to other layers of climate governance. I turn to trace the negotiations of meaning that underpin the form in which Byron Shire's imaginary emerged.

In early 2015 in the lead up to the much-anticipated COP21 international climate negotiations in Paris, Mayor Simon Richardson announced the goal for Byron Shire to achieve net zero emissions within ten years as a joint project between the local government, the local community, Beyond Zero Emissions and the Centre for Social Change (Byron Shire Council, 2015; Milman, 2015). Mayor Richardson's leadership tapped into a powerful desire within parts of the local community to confront the climate emergency they saw unfolding before their eyes. With this announcement Byron Shire joined a coalition of hundreds of local mayors pledging ambitious climate action to spur international climate negotiations and to inspire other local governments and communities.

The contribution of Beyond Zero Emissions was significant because of its technical expertise in low carbon transitions. A not-for-profit organisation coordinating input from (at times) hundreds of volunteers, it had developed a series of strategies to take key sectors of the Australian economy to zero emissions over ten-year timeframes (Beyond Zero Emissions, 2020; Parkinson, 2015a). The organisation's CEO Stephen Bygraves promised that their technical support would help to rescale these national blueprints to the level of Byron Shire (Byron Shire Council, 2015). Coupling this technical expertise with community mobilisation added potency to this commitment. Director of the Centre for Social Change, Dr Amanda Cahill, was invited to lead the community engagement and help channel the powerful local currents of environmental and social activism (interview, 12 January 2018).

Several community members who had contributed to Beyond Zero Emissions projects as volunteers encouraged the partnership with Byron Shire. One of these people was John Sparks, a retired architect and university lecturer, and a self-described activist with the look of a veteran surfer, a tie-dyed t-shirt hanging on his tanned and wiry frame. He moved to the region in 2011 and talked with enthusiasm about the great community that he found here. John had developed conceptual master plans for several locations within the Shire, including Byron Bay, Bangalow and West Byron, based on making these precincts and towns self-sufficient in energy, water, waste, food and emissions (Sparks, 2015). His design principles are based on producing more renewable energy than is consumed, balancing water consumption with rainfall, using waste as a resource, linking food and organic waste through community gardens, and planting trees and protecting rainforest and wetlands to draw down carbon dioxide. In our conversation, John described how he had done this already on his own property. These individual actions, he assured me, are not that hard to do (interview, 15 January 2018).

These concepts, already practiced by John and others throughout the region, express the feasibility of self-sufficient – and thus self-reliant, independent, and autonomous – homes, precincts and towns. Moreover, the plans evoke a future way of living together (holding echoes of those intentional communities established by new settlers with their own visions for the future) that may appear highly desirable – strengthening social cohesion by building on positive qualities of human nature and minimising environmental harms by carefully balancing natural processes.

When John was working on his plan for Byron Bay, he contacted the head of Beyond Zero Emissions, Stephen Bygraves, to suggest that the town should become zero carbon and operate as self-contained across all of those sectors outlined above. John reported that Stephen was very interested and arranged to meet with the Mayor of Byron Shire, Simon Richardson. At that meeting, Simon was enthusiastic and wanted to extend the vision to encompass all the other towns in the Shire, including Brunswick Heads, Bangalow, and Mullumbimby. Simon proposed a goal to make the whole of Byron Shire zero carbon (interview, 15 January 2018). When that goal was formally announced, it drastically ramped up the Shire's existing

commitments to reduce community-scale emissions by 30 per cent (Byron Shire Council, 2008). However, not everyone within the local area, or the local government, accepted this vision. The Mayor's announcement created tensions within the Shire council because he hadn't consulted with other councillors or sought advice from council staff and executives. There were differing levels of support within the organisation. Some staff had reservations about how the commitment would be delivered, as well as with the Mayor's unilateral approach to making the announcement (field notes, 16 January 2018).

The vision for Zero Emissions Byron was developed in dialogue with other actors, institutions, and places. Visions in one place build upon what has been done in other places and, equally, can grab hold of actors in other places as they frame their own possibilities for change. Reflecting on her involvement during the strategy's inception, Dr Amanda Cahill considered the prospects for achieving zero emissions in Byron Shire. She said that it is definitely possible, and she hopes it is achieved: 'I need it to happen so that I can showcase it and inspire the other communities that I am working with' (interview, 12 January 2018).

Even so, a future imaginary that is framed in relation to the community – in the form of community-scale carbon neutrality – implies some form of collective decision making by the community. Byron Shire is defined by a strong sense of community and place, but as with any community it also encompasses diverse viewpoints and opinions. The meanings negotiated in relation to the vision for Byron Shire to achieve carbon neutrality are never uncontested or final. These negotiations are expressed, to some extent, through struggles over who belongs inside and outside of the local community and, thus, who is empowered to imagine change.

4.2.3 Collective action

It is challenging to envisage Byron Shire as self-sufficient when there are more than two million visitors to the region each year (Byron Shire Council, 2017a: 4), highlighting just one domain where flows of people, patterns of consumption and systems of infrastructure traverse geographic boundaries. The sociotechnical imaginary for a zero emissions Shire, powered by community owned renewable energy, speaks to a desire shared by many in the region to keep resources and wealth that are generated locally within the local area rather than see them siphoned off to other places. At the same time, the region generates significant wealth by opening up and sharing local resources with others through tourism – including beaches, surf breaks, rivers, rainforests, music, food, and good vibes. A sign on Ewingsdale Road on the way into Byron Bay reads "Cheer up, Slow down, Chill out", signalling the relaxed atmosphere, beautiful surroundings, and friendly people that have made the area a famous holiday spot for both domestic and international tourists. Fault lines appear between imperatives to share these local qualities and efforts to prevent their erosion.

The long-standing moratorium on development and constrained urban expansion described earlier may have protected the "real Byron", but it also had a downside, as local architect Dominic Findlay-Jones explained, of tightening supply and pushing up housing costs (field notes, 18 January 2018). The white shoe brigade bought up land, biding time. Tourism and development around the beaches brought economic growth but not in uniform ways. Dominic reflected, 'It's hard for the locals because tourism pushes the prices high and puts a lot of pressure on scarce resources. It's the opposite of community' (field notes, 8 January 2018). He told me of a double garage in a beachside suburb being rented as a dwelling for $550 per week. A report on Australian property values from May 2019 identified that Byron Bay had overtaken Sydney as Australia's most expensive city for real estate, with median house prices increasing by 64 per cent over five years and continuing to rise (Pressley, 2019). As prices rise, many locals have moved from the coast to surrounding towns in the hinterlands.

Traffic gridlock on the streets of Byron Bay is becoming a harsh reality, particularly in the peak summer tourist season. Potholes in the local roads reflect an area heavily dependent on car-based transport. These roads bear the pressure of visits from tourists, but the cost of their maintenance is borne by local ratepayers (field notes, 18 January 2018). One method of easing these impacts, as I discovered after a winding drive to Federal to conduct an interview, is that road signs are oriented to send tourists the long way between towns (field notes, 10 January 2018). Despite the economic promises, the money spent by visitors in local shops and pubs does not trickle down to pay for basic infrastructure and services. Talk of introducing a "bed tax" on visitors to recover some costs has been going on for 20 years, but only the state government has that power. In the meantime, paid parking was introduced in Byron Bay ahead of possible roll out in other towns, but revenue is thin given the high costs of managing the scheme (Morrow, 2018). Opposition to inappropriate urban development, and corporate incursion into local economic transactions, are threats to treasured values and ways of life. A common refrain in Byron Shire is that the community is good at opposing things, but that it can be harder to come together in favour of something. Issues around housing and living costs, potholes in local roads, traffic congestion and parking, evoke some of the problematic relationships that emerge between locals and visitors within the Shire. While struggles of resistance expose the power of a common enemy to define collective identity, imagining change generates tensions and frictions between multiple, often conflicting, perspectives and values.

It is into these shifting social and material histories that the sociotechnical imaginary for Zero Emissions Byron seeks to not only build on existing community values, but also to bring a community into being in relation to a low carbon future. The imaginary of community-scale carbon neutrality for Byron Shire is stretched between grassroots desire to transform social systems and the promise of technical solutions through the expertise of Beyond Zero Emissions. The local community envisioned a

carbon neutral future that was informed by the social and material affordances of *this* place – an enlightened community and a resurgent ecology. The vision took shape and gained momentum through the alliance formed between Beyond Zero Emissions and the Shire mayor. The imaginary was premised on existing and emergent grassroots initiatives joining up into a larger vision, helped along by technical expertise to redesign existing infrastructures and systems of energy, transportation, waste, land management and the like. The ambitious ten-year timeframe was based on a view, reflected in all of Beyond Zero Emissions' decarbonisation strategies, that the technological solutions are in our hands and have only to be implemented. This was bolstered by the view that if this kind of project could be made to work anywhere it would be in Byron Shire, because the strength of the local community had been forged and tested in its resolve to protect local ecologies and resist corporate take overs. If Byron Shire is able to demonstrate these possibilities, then other regional Australian communities may be able to follow. The imaginary was been underpinned by sentiments that individuals and small collectives in the local area must hold government and corporate interests back in order for the local community to implement approaches that have already been proven. At the same time, achieving the vision would require visitors and newcomers to the Shire to also raise their consciousness and take personal responsibility for their greenhouse emissions.

4.3 Carbon Neutral Copenhagen by 2025

The City of Copenhagen has, since 2009, expressed its ambition to become the world's first carbon neutral capital city. This vision expresses local leadership on climate change on a world stage. As one might expect, the social and material contexts in which this vision is situated differ from those above. With a more concentrated and densely populated urban environment, it is more difficult to think about ecological resurgence within Copenhagen and its surrounds than in the deep soils and sub-tropical hinterlands of Byron Shire. But this urban context offers its own affordances for transformative change to reduce greenhouse gas emissions. Exploring this form will help to situate the City of Copenhagen's sociotechnical imaginary for community-scale carbon neutrality and reveal the conditions of possibility in which it has taken hold.

4.3.1 Energy infrastructures

From certain vantage points Copenhagen's energy infrastructure is a visible part of the city. At the popular Amager Strand beachfront, the sweeping arc of wind turbines on the Middelgrunden reef stretch out across the Øresund. The views from the top of Copenhagen's five iconic towers, though these are not tall by the standards of many large cities, provide panoramic vistas and reveal the smokestacks of the Combined Heat and Power (CHP) plants at the margins of the city. Catching a ferry across the harbour, or cycling around the city, reveals glimpses of these ubiquitous

energy infrastructures, as much a part of the daily experience as the smooth, wide cycle paths that traverse and connect every neighbourhood.

The new Amager Bakke waste-to-energy plant is a large intervention on the industrial edge of the harbour, but its height and bulk are turned to advantage with the roof functioning as a ski-slope for winter recreation. However not all parts of the energy system are so obvious. The local utility company HOFOR is responsible for distribution of water, heat and power to Copenhagen. It is majority-owned by the City of Copenhagen, and has its crest stamped on countless manhole covers around the city. These signal the extensive network of hidden pipes that carry heat from the CHP plants to approximately 600,000 people, covering 99 per cent of heating supply within the Greater Copenhagen area (HOFOR, 2016). Frank Jensen, the Lord Mayor of Copenhagen since 2010, has described how the city has changed since he first arrived in the Østerbro district, 'back when you could still smell the carbonised coal and the petroleum as district heating had yet to replace the small, polluting heating systems' (Municipality of Copenhagen, 2018: 5). In winter months, the steady warmth from the radiators provides comfort and relief from long months of cold and dark. The Danish term *hygge* expresses a sense of cosy togetherness. Infrastructure, resource flows, and culture combine to give meaning to these sociotechnical systems.

The material and social forms that characterise the City of Copenhagen have been shaped by multiple interconnecting factors. The 1973 oil crisis saw many European countries face critical energy shortfalls. In Denmark, oil imported from the Middle East supplied 94 per cent of Danish energy consumption. Denmark introduced various measures to deal with the shortfall, including car-free Sundays, a tradition that continues in the Copenhagen district of Nørrebro (field notes, 21 March 2018). The oil crisis prompted national planning to ensure Danish energy independence by minimising reliance on imported oil through conversion to coal-based heat and power generation, and the development of national oil and gas reserves in the North Sea. The significance of transboundary environmental issues was emerging at the time, with deepening unease over new kinds of risks that accompanied modernity – comprising long-range and invisible threats such as acid rain and radioactive fallout (Beck, 1992). A strong anti-nuclear movement forced the Danish government to drop plans for nuclear energy (Læssøe, 2007: 235-236). Preferences for energy generation to be located where waste heat could be used efficiently by growing urban populations led to the development of district-scale energy generation in the form of CHP plants. The oil crisis and economic recession that followed pushed the City of Copenhagen to give up on several projects to "modernise" the city in favour of car-based transportation, and stimulated mass protests for better cycling conditions that prompted the city's first cycling strategy in 2002 (Gössling and Choi, 2015: 108).

Away from the cities, the wind industry grew rapidly through this period with much of it driven by small-scale cooperatively owned projects developed through informal planning processes (Karnøe, 1990; Garud and Karnøe, 2003). The iconic sweep of

the Middelgrunden turbines was built in the late 1990s from processes similar to the village meetings in West Jutland where the Danish wind industry began. Considerations over building enough generation capacity to cover the cost of the undersea transmission cable had to be balanced with neighbour's concerns over noise and visual impacts. Shared ownership models helped to relieve these concerns, establishing Middelgrunden as the largest cooperatively owned wind farm in the world with 8,552 share owners (Larsen et al., 2005). So too did replacing the initial proposal for 39 turbines arranged in three rows, with a plan for 20 turbines in a single arc. The design has a historic and political significance, according to Hans Christian Soerensen, an engineer and board member with the Danish Wind Turbine Owner's Association. 'The single line of turbines was envisaged as a symbolic defence against [Sweden's] nuclear power, as it follows the circumference of the defence line built around the city in 1890 to protect against artillery fire' (interview, 29 May 2018). The past shapes possibilities for the future.

In the City of Copenhagen, large-scale technological systems are managed by public authorities for the public good, such as centralised electricity and heat and seamlessly interconnected cycling paths. Publics are also involved, with cooperative organisation not only a feature of organising wind energy infrastructures but common in many parts of Danish society – from their origins in agricultural enterprise, to housing cooperatives and supermarkets. In Copenhagen, these sociotechnical configurations of energy infrastructure underpinned the conditions of possibility in which to imagine a carbon neutral city.

4.3.2 The Copenhagen Narrative

Sociotechnical systems of energy production form part of the everyday experience of life in Copenhagen. While some are cooperatively owned, many of these are publicly owned and managed by large utility companies for the public good. The City of Copenhagen promotes its wind turbines, amongst other cutting-edge technologies, as emblems of Copenhagen's leading edge on climate and energy policy. The Copenhagen Climate Plan is oriented towards large sociotechnical systems of district heat and power, wind energy, buildings, waste management, and urban transport. While there are policies and actions that seek to address emissions from all of these urban systems, the technical feasibility of Copenhagen's vision was framed in the first instance on substituting technologies used in energy production. In particular, converting the existing CHP network to run on biomass instead of coal, and investing in wind turbines to generate renewable electricity. These technical substitutions supported the feasibility of the vision for a carbon neutral Copenhagen. But the conditions of possibility for this vision to take shape as a sociotechnical imaginary emerged in relation to an already existing political imaginary of the city – its administration, its citizens, and its place in the world – known as the Copenhagen Narrative.

Simon Hansen was an adviser to Lord Mayor Ritt Bjerregaard in 2009, and later worked for C40 Cities at their London office before returning to his home country to establish the organisation's Copenhagen office. Simon explained that in the City of Copenhagen, the seven administrations are quite independent; each with their own elected mayor. Decisions are made through a committee structure, and the Lord Mayor (who also leads the Finance Administration) cannot direct the other mayors on what to do or fire them. (Municipality of Copenhagen, 2018). In this context, substantial efforts have gone into building cohesion between the seven administrations by creating a unified narrative, which Simon described in the following way:

> The "Copenhagen Narrative", as it became known, establishes the twin aims of green growth and quality of life. As high-level and abstract as this might appear, it has applications in every area of city administration. If there are decisions about which companies to support, about urban development, about any kind of strategy, they have to be made in a way that supports these aims (interview, 20 April 2018).

In one sense, the Copenhagen Narrative is focuses on the situated experiences of Copenhagener's – their quality of life – within their city. In another sense, the narrative cuts across domains of local administration and across layers of government through a strong alignment to national strategies for green growth – that is, economic growth within boundaries of environmental sustainability (Hoff, 2017). Both of these orientations are important, and both are linked by the expectation that the means to sustain and improve quality of life is through green economic growth.

The Copenhagen Narrative can be understood as a discourse of ecological modernisation with administrative and discursive implications. Christoff (1996) identifies the range of ways this concept has been deployed, from narrow technological reforms aimed at improving environmental and economic efficiencies, to more deeply embedded and ecologically self-conscious forms of cultural transformation. The form expressed in Copenhagen seems to align with Hajer's proposal of ecological modernisation as a discursive strategy to promote environmental protection as economically responsible. In this definition:

> Ecological modernisation is basically a modernist and technocratic approach to the environment that suggests that there is a techno-institutional fix for present problems. Indeed, ecological modernisation is based on many of the same institutional principles that were already discussed in the early 1970s: efficiency, technological innovation, techno-scientific management, procedural integration and co-ordinated management. It is also obvious that ecological modernisation as described above does not address the systemic features of capitalism that make the system inherently wasteful and unmanageable (Hajer 1995:32 in Christoff, 1996: 483).

With Denmark preparing to host the COP15 international climate conference, a strong policy coalition emerged around this discourse of green growth. There were a number of high-performing Danish companies already in this space (such as Vestas in wind energy), and others looking to expand their international profile. Simon

Hansen described how the Danish Prime Minister had highlighted action on climate change as a business opportunity, famously reversing his criticism of so-called "green experts" telling everyday Danes what to do (interview, 20 April 2018). In the context of the Copenhagen Narrative in which climate change would be framed primarily as an economic issue, the city's Technical and Environmental Administration was pushing for the most ambitious objective they could think of – that is, a carbon neutral Copenhagen. From his position in the Finance Department, Simon Hansen described how this vision for the carbon neutral city came to be seen as a politically and financially feasible proposition:

> Contrary to the customary fiscally restrictive position of the Finance Administration, the Lord Mayor saw a political opportunity and supported this highest ambition proposal. Then the decision became more of a technical question about what both administrations felt was achievable, rather than a rivalry between competing bureaucracies (interview, 20 April 2018).

A key factor in bringing these economic and climate agendas together across the City of Copenhagen's administrators and politicians was analysis of the investment needed to deliver the carbon neutral objective. Simon recalled that the analysis 'returned a very big number, in the order of 80-90 billion DKK. But it also showed the direct investment needed by the city was only small, in the order of 1 billion DKK, which would leverage the larger investment from other actors' (interview, 20 April 2018). According to Simon, this analysis helped to bring the Finance Administration on board because it demonstrated the financial feasibility of the carbon neutral goal.

The feasibility of the carbon neutral imaginary rested on a combination of measures but was largely underwritten by the transition from burning coal to biomass in the CHP plants, and developing a substantial number of new wind turbines. According to Simon, these interventions were mainly discussed in technical terms, such as the need to source biomass such as wood chips from sustainable sources, and possible locations for new wind turbines. In both of these areas of energy production, there was a lot of support from the municipal utility companies. The technical and financial feasibility of carbon neutral energy supplies for Copenhagen underwrote confidence that the carbon neutral city could be achievable. Emissions from other sources such as urban transportation and waste were not insignificant but were much smaller than emissions from energy production and were not thought to be insurmountable.

The key technological substitutions that underpinned the vision for carbon neutrality were determined, by city planners and politicians, to be technically, politically, and financially feasible. The viability and desirability of this vision, shaping it as a sociotechnical imaginary of community-scale carbon neutrality, were framed in relation to the existing political imaginary of the Copenhagen Narrative. The City of Copenhagen's inaugural Climate Plan (City of Copenhagen, 2009) signalled the kind of society and economy anticipated to underpin successful attainment of the goal. Alongside lowering greenhouse gas emissions, the Climate Plan was designed around accommodating a growing urban population and continued economic growth.

Policies and investments in energy production, energy consumption, urban transport and municipal operations would develop the city as clean and prosperous environments for local residents, attractive sites for business investment, and places where other urban elites could find solutions to their own social and environmental issues.

Like the Copenhagen Narrative, the Climate Plan also faces outwards and inwards – positing a fair contribution towards global problems and at the same time contributing to a quality of life by creating place to live well, coupled together through the concept of green growth. These sentiments espousing the public good, and the means for the City of Copenhagen to achieve that good for its citizens and as a city of the world, allowed the imaginary for community-scale carbon neutrality to gain broad support. Thus, the Copenhagen Climate Plan can be understood as an action plan through which to deliver economic growth and its promise of prosperity while at the same time addressing social and environmental ills.

4.3.3 Public good

The Copenhagen Climate Plan is largely overseen by the Technical and Environmental Administration. Their offices are located in a brown brick building in the district of Islands Brygge, a block away from the harbour and above the district library and a small supermarket. With an annual budget of 1.8 million kroner and around 2,200 employees, the Administration is in charge of implementing strategic plans including the Climate Plan (Municipality of Copenhagen, 2018: 35). Taking the lead on this implementation is the small Climate Secretariat of around ten staff. Within this team, Niels Kristensen is the lead planner on energy production for the Climate Plan. A young man with abundant energy suited to his role, Niels has been leading this work for over two years. 'It's by far the biggest sector when it comes to the emissions reductions, but the other parts are also really important and the objective won't be possible without them' (interview, 30 May 2018).

Niels described the main challenges in his area as converting Copenhagen's network of CHP plants from coal to biomass and setting up wind turbines, and he expressed the importance of good dialogue with the utilities in achieving these goals. Underlining the importance of the utility companies, Niels Kristensen described the relationships that the Technical and Environmental Administration is cultivating in order to deliver on the Climate Plan.

> We have full authority over the things we own, our buildings, car fleet, supply chain and procurement decision. We leverage all our authority in these areas and only have ourselves to blame if we fail to meet our goals. We have partial authority over the utilities. Copenhagen and other municipalities own the utilities, so our politicians are represented on the Board. We have direct and indirect influence in this way. But there are also other agendas in those companies, such as district heating has to be cost effective, and support reliable energy and heat supply, and manage costs to consumers. We have little control over private businesses and private citizens, and in areas such as the transport sector. We have few tools, and we just can't control the

> decision people make. We have to go into dialogue, make partnerships and so on (interview, 30 May 2018).

This description highlights the opportunities and constraints that are perceived to shape the City of Copenhagen's policies, and that of its partners, to change systems of energy production and curb greenhouse gas emissions. In particular, there is a strong delineation between infrastructures and entities that are in the public realm, and entities in the private realm. This delineation can essentially be understood as negotiation and contestation over regulatory approaches compared to policies and mechanisms that might nudge decisions and behaviours of individuals, households and businesses within the city. There are other approaches to shifting human activities and sociotechnical systems, such as the conscientious individual and collective actions we saw earlier in Byron Shire. Of course, all of these approaches are important, and while all are in play in each of the field sites they are emphasised differently. Observing these negotiations helps to reveal the social arrangements – existing and envisaged – that underpin sociotechnical imaginaries for community-scale carbon neutrality.

The City of Copenhagen has substantial control over its utility companies as a majority owner. HOFOR is a major player in charge of utilities including district heat and electricity, town gas, water, district cooling, and is central to establishing more wind energy around Denmark in order to deliver elements of the Climate Plan (HOFOR, 2016). Amagær Resource Centre carries out waste management and conversion of waste to energy, including developing the new Amager Bakke waste-to-energy plant on the edge of the harbour. Biofoss implements wastewater treatment and plays a part by setting up solar on their land in order to minimise energy use in their plant. As Niels described, they also produce biogas from the wastewater treatment process that goes into the town gas supply, and into some buses in the city's public transport network, so as to reduce emissions from natural gas (interview, 30 May 2018).

The transition of energy production systems has made good business sense to HOFOR, which purchased the Amagærverket heat and power plant in 2011 and also expanded its business into wind energy to support the City of Copenhagen's carbon neutral objectives. Continuing our discussion in the first floor Højbro Plads meeting room, Niels Kristensen described this important relationship.

> We as a municipality can't invest ourselves in energy production, because there are national laws that prevent that. We can't directly own the energy production; it has to be through a utility company. We made a goal together with HOFOR, and they had key areas to develop projects within the municipality and on land in other municipalities, and to go for two big national tenders in 2016 for coastal wind parks (interview, 30 May 2018).

Danish methods of carbon accounting, which I discuss in more detail in later chapters, allow surplus renewable energy to be counted as a "carbon offset" in municipal greenhouse gas inventories. Energy exported from wind turbines owned

by the City is used to counteract emissions from within the city, wherever the turbines are located. Thus, HOFOR's wind turbines could be located anywhere while the energy they produce is counted towards the total share of Copenhagen's total renewable energy production.

From his experience of overseeing those parts of the Climate Plan concerned with the energy production system, Niels Kristensen noted that the extensive district heating across the Greater Copenhagen area has made the transition from coal to biomass relatively straightforward, with all but one of the city's biomass facilities being conversions of existing plants. 'Biomass is the cheaper solution than coal. And the overall impact of the conversion of coal to biomass is perhaps around half of the total emissions reductions needed to get to carbon neutral' (interview, 30 May 2018). Niels also emphasises how important it is for the city and HOFOR that the biomass is sustainable, such as residues from cropping and forestry, or from forest areas that are managed so that they are expanding over time. The International Energy Agency (IEA) Bioenergy argues that bioenergy can be carbon neutral, 'because the carbon that is released during combustion has previously been sequestered from the atmosphere and will be sequestered again as the plants regrow, i.e. if sustainably produced' (IEA Bioenergy, 2018: 2). To this end, Dansk Energi and Dansk Fjernvarnme (the Danish District Heating Association) established an Industry Agreement on sustainable biomass, covering wood pellets and wood chips (HOFOR, 2017). Through the Industry Agreement, 'large scale biomass users in Denmark commit to meet and document a number of sustainability requirements on forest-derived biomass fuel' (HOFOR, 2017: 2).

Copenhagen's sociotechnical imaginary of community-scale carbon neutrality, at least a major portion of it, is inscribed in the audit trails for sustainably harvested biomass and the tallies of electricity production and consumption that divulge a surplus or deficit of renewable energy. In this sense, the carbon neutral imaginary has foregrounded expert technical knowledge, and assumed a cooperative public would accept the changes necessary to realise the vision. The conventional approach to energy infrastructure is to make it invisible, functioning unseen and as given. Greening energy infrastructure involves people entering into new relations with it. Sometimes this involves making it visible, as when new wind turbines are built in the neighbourhood or the harbour. Other times the changes might go unnoticed, as when wood chips replace coal in existing CHP plants. Flows of electricity and heat and end-user experiences remain relatively unchanged. The ambition of the carbon neutral goals makes them transformative, but these transformations tend to be thought of in relation to technologies more than in relation to the social contexts in which those technologies are situated. Even so, the technological changes involved in realising the vision of Copenhagen as the world's first carbon neutral capital city are not independent of people but, rather, bring new sociotechnical relations into existence.

Bringing these observations together, imaginaries for community-scale carbon neutrality in both Byron Shire and Copenhagen have been projected outwards to serve as exemplars of what local governments and communities can achieve in response to the threats of climate change. Yet as might be expected, there are differences in the conditions of possibility in which these visions have been able to emerge and take hold as a viable and desirable sociotechnical imaginary. Copenhagen's carbon neutral imaginary was largely framed in relation to the socio-historic development of publicly owned systems of energy production, in particular wind energy and district heat and power. The Climate Plan envisages public authorities and large companies acting on behalf of the city and its citizens to deliver economic prosperity alongside environmental quality and quality of life. This contrasts against the imaginary in Byron Shire with its strong threads of the community acting on its own behalf, and an unease about the involvement of large corporations. That is not to suggest a lack of involvement by Copenhageners themselves; the 2009 Climate Plan contained a strong set of actions that could only be delivered through public participation. These included growing the share of cyclists and public transport users and improving energy performance in buildings by encouraging building occupants and owners to upgrade their appliances and renovate with energy efficiency in mind. Yet underlying social orders contrast between these places – in Byron Shire the imaginary was premised on sociotechnical change by the community and for the community, while in Copenhagen it was premised on public authorities delivering changes on behalf of, and for, the public good.

4.4 The City of Melbourne as Zero Net Emissions by 2020[13]

The City of Melbourne's vision for carbon neutrality was, from the outset, oriented strongly outwards. It developed what was, perhaps, the earliest comprehensive strategy by any local government for community-scale carbon neutrality with its 2003 "roadmap" to a climate neutral city (City of Melbourne, 2003). This strategy put forward an agile and innovative approach to the threat of global climate change by framing the City's response as a significant opportunity. That is, to enhance Melbourne's global reputation as an emerging "world city" and to grow the local economy through new industries oriented towards environmental sustainability and reducing emissions. Yet the City of Melbourne's desire to demonstrate leadership on the world stage was constrained by its relatively limited jurisdiction – in terms of size and authority – making local entrepreneurship a key ingredient in its vision for community-scale carbon neutrality.

[13] An earlier version of this section was published as Pollard S. (2020) Imagining the Net Zero Emissions City: Urban Climate Governance in the City of Melbourne, Australia. In: Hoff J, Gausset Q and Lex S (eds) *Building a Sustainable Future: The Role of Non-State Actors in the Green Transition.* Routledge, p211-229. Available at: https://doi.org/10.4324/9780429280399.

4.4.1 Local entrepreneurship

The City of Melbourne covers an area of 37.7 square kilometres at the geographic centre of Greater Melbourne. It is one of 32 municipal governments within this larger metropolis of almost 10,000 square kilometres and 4.8 million people. At present, more than 158,000 people live within the municipal area, while the daily influx of workers, students, and visitors to the central city has been estimated at 928,000 (City of Melbourne, 2019). Just as in other places, these municipal boundaries are traversed by people, goods, and infrastructures. Many of the surrounding municipalities have their own targets and strategies to reduce emissions for corporate operations and across their communities, creating a patchwork of responses to climate change across the urban landscape that are permeated and cut across by sociotechnical systems and human activities.

The municipality is located on the lands of the Wurundjeri people of the Kulin nation and encompasses the densely developed city centre and 11 surrounding suburbs. The central business district comprises wide boulevards laid out on a grid, interspersed with small laneways celebrated for their lively music venues, street art, and international food. Skyscrapers tower overhead and present a formidable skyline, and tower cranes signal continued upwards expansion and densification. Corporate headquarters and government agencies, universities and medical precincts, galleries and museums, festivals and events, position the city at the heart of the state of Victoria's economic productivity and innovation. The central city is fringed by the Yarra River, which is called Birrarung Marr in the local indigenous language, and is surrounded by parklands and sporting arenas, including the iconic Melbourne Cricket Ground. These give way to an assortment of urban environments, including the Port of Melbourne's heavy industry, sites of urban renewal, gentrified inner suburbs and public housing estates, shopping strips and public parks, all interspersed with networks of road, rail, footpaths, and cycling paths.

As these assorted urban forms suggest, activities in the city are diverse. The City of Melbourne has authority over planning and building, rates, local roads, waste management, parks and gardens, amongst other things. However, former Director of Urban Strategy for the City of Melbourne, Kate Vinot, explained 'the ability of cities to influence [emissions] varies dramatically. Some cities run a lot of big buildings, schools, bus fleets. The City of Melbourne is unusually small in terms of its jurisdictional authority' (interview, November 2017). Much of the activity within the city that causes greenhouse gas emissions lies outside the domain of local government authority. Emissions from stationary energy are very high due to Victoria's reliance on brown coal for electricity. The state government also powerfully shapes the urban environment through land-use zoning, planning, and building controls for large developments, and major infrastructure and services, including toll roads and public transport. Coupled with this is ambivalence over the best way for policy to shape decisions and actions that are considered the domain of private property and individual freedom. As Councillor Cathy Oke described, 'it's easy enough to make

sustainability decisions about the public realm, but far more challenging to influence decisions about the private realm' (interview, December 2018). Thus, the city administration is one actor amongst many involved in shaping the future direction of the central city and the wider Melbourne metropolis.

The delineation between private and public realms emerges as a common theme in this examination of the contexts in which sociotechnical imaginaries for community-scale carbon neutrality emerge. Compared to the City of Copenhagen's control over urban utilities and infrastructures, the City of Melbourne established its objectives for carbon neutrality in a context of more limited authority. In the early 2000's, its power to develop climate change policies was based on reforms to local government legislation. The remit of Australian local governments had been largely confined to property services, or dealing with "roads, rates and rubbish" (Painter, 1993: 194-195), and while these reforms were directed towards the corporatisation of local administrations, they also gave "general competence powers" that allowed councils to act in the interests of their local constituents and environment (Bulkeley, 2000). So, while the City of Copenhagen holds regulatory power and director influence over its utilities, the City of Melbourne developed its approach to sociotechnical change based on influencing private companies and individuals to shift decisions and behaviours. Both of these approaches contrast to Byron Shire where grassroots activism and community solidarity formed the foundations upon which to reimagine local configurations and flows of energy, wealth, and power.

4.4.2 Economic opportunity

In 2002, the City of Melbourne announced its commitment to reduce greenhouse gas emissions and achieve net zero emissions by 2020, both for its own operations and "community wide" across the municipality. It published its first strategy towards this objective in 2003, Zero Net Emissions by 2020 (ZNE2020): A roadmap to a climate neutral city, establishing the municipality as an early mover in efforts by cities to respond to climate change. The strategy frames climate change as a matter of global environmental risk requiring cities, and their citizens, to contribute a fair share towards collective action. In this respect, the strategy sets out to 'end the city's contribution to climate change', encompassing the local government and the commercial, industrial, and residential inhabitants of the city (City of Melbourne, 2003: 3). The moral valence of this imperative resonates with the values of care and protection we saw earlier with Byron Shire. Yet here in Melbourne, the economics of acting to reduce emissions are more akin to the model of "green growth" we saw in Copenhagen.

The political commitment to alleviate the municipality's contribution to climate change was also designed to elicit support from local businesses and residents with its positive portrayal of the economic and social benefits that would flow from these actions. For a local government with only a slight grip on the levers that influence urban emissions, the actions and language of the strategy make it clear that

addressing climate change by reducing emissions was not intended to be heavy handed, but rather to establish local economic opportunities and an international reputation: 'A sustainable business advantage through "green productivity" in Melbourne will enable the City of Melbourne to persuade its businesses, workers and residents to embrace and live the principles of sustainability' (City of Melbourne, 2003: 4). This approach contrasts with the sense of place and belonging that underpinned Byron Shire's imaginary for community-scale carbon neutrality, and the City of Copenhagen's position of strength in reconfiguring technological systems of energy production. At the same time, it resonates with concept of ecological modernisation discussed earlier, but in this case with a stronger emphasis on the features of capitalist enterprise, rather than the techno-managerialism evident in the City of Copenhagen.

Alongside its objectives for action on climate change, the City of Melbourne was advancing multiple plans to position Melbourne on the world stage. Former councillor Martin Brennan explained, 'the trends of globalisation were taking hold, and there was a sense that Melbourne could occupy its own niche in this global context if it could develop the capacity to attract finance, investment, knowledge, and people from around the world' (field notes, 13 February 2018). These aspirations to strengthen standing in global networks illustrate what Harvey (1989) has called urban entrepreneurialism (compared to urban managerialism), where local government actors take on more than basic service provision and focus on promoting economic growth by enabling the private sector to flourish. Again, this contrasts with Copenhagen's valorised public administration (acting in partnership with private companies and cooperative organisations) and Byron Shire's valorisation of civil society. Besides assessing climate risks, the strategy framed rapid urban growth in Australian cities and overseas as threats to the urban environment and the quality of urban life, and globalisation as changing the nature of competition between cities for investments of financial capital. These risks were cast as opportunities to position Melbourne as an attractive centre for "green" productivity that coupled 'productive, knowledge-based industries with a quality lifestyle and environment' (City of Melbourne, 2003: 3).

The conceptual boundaries of the carbon neutral targets were defined in relation to the territorial boundaries of the municipality and the jurisdictional authority of local government. The City's first municipal carbon accounts delimited an area aligned to the administrative boundary of the municipality, identifying total emissions of 3.75 million tonnes of carbon dioxide equivalent (CO_2-e) across commercial buildings, industry, residents, and waste (City of Melbourne, 2003: 15). Demand for stationary energy was identified as the major source of emissions from activities within the municipality. The accounts excluded transport and embodied energy, noting their small contribution to total emission and the council's limited influence over these areas (City of Melbourne, 2003: 5), although transport emissions were brought into later strategies.

The City of Melbourne's climate strategy set out actions for the net zero emissions city in three core areas: "leading edge design" to reduce energy demand, "decarbonising electricity" by influencing the renewable energy generation, and "carbon sequestration" to counteract remaining emissions (City of Melbourne, 2003: 4). Leading edge design would exploit the normal cycle of rebuilding and refurbishing to improve design and was expected to halve the energy use of the City's residential and commercial building stock with minimal additional capital cost and good payback through lower operating costs (City of Melbourne, 2003: 4). The power supply would be decarbonised by stimulating demand for renewable energy and energy efficient power, including in decentralised forms within the urban area. Carbon sequestration would be used to counteract any remaining emissions in the municipal greenhouse inventory with carbon offsets (City of Melbourne, 2003: 4).

On this latter point, the strategy outlined a pilot municipal carbon trading scheme where the City of Melbourne could generate carbon offsets by investing in blue gum mallee eucalyptus plantations in a regional municipality (City of Melbourne, 2003: 53). The longer term would see the pilot developed into a carbon trading scheme for the city's businesses, residents and industries as a way to encourage these actors to 'shoulder their own responsibility' for greenhouse gas emissions (City of Melbourne, 2003: 53). And although corporate emissions from the City of Melbourne's own operations accounted for less than one per cent of total community-scale emissions, the City was keen to leverage its authority and leadership by reducing emissions across its own assets and activities (City of Melbourne, 2003: 9).

The City of Melbourne's imaginary was explicit about the need to trade carbon across local boundaries, in contrast to Byron Shire's expressed desire for self-sufficiency in carbon and Copenhagen's reliance on flows of renewable energy. In each place, social and material contexts framed the conditions of possibility to imagine community-scale carbon neutrality as viable and desirable. Each of these imaginaries was oriented towards a future that would be accepted as viable and embraced as desirable by the local actors. Yet each of these three sociotechnical imaginaries for community-scale carbon neutrality rested on, and reinforced, somewhat different conceptions of social and natural order.

4.4.3 Market conditions

From the outset, the City of Melbourne's strategy for carbon neutrality anticipated measures to reduce emissions outside the municipal boundaries and beyond the council's direct control, acknowledging limits to local government power and agency in matters affecting greenhouse gas emissions. The net zero emissions target rested in large part on a perception of the inevitability of global carbon markets and the emergence of policy and legal frameworks to participate in these markets. Discourses around carbon trading had been emerging through the international climate regime as a viable, low cost, and "optimal" response to climate change (City of Melbourne, 2003: 3). Conditions for such markets to emerge were being established both locally

and internationally with the creation of carbon offsets (Bumpus and Liverman, 2008; Callon, 2009; MacKenzie, 2009; Lohmann, 2010).

The proposal for a municipal carbon trading pilot was developed in the context of Australia's response to the Kyoto Protocol, which prioritised land-based sequestration and pioneered methods of carbon accounting from afforestation, revegetation, reduced land clearing and the like (Commonwealth of Australia, 1998). Nationally, carbon trading was emerging as the preferred response to climate change with the Bush for Greenhouse program developing tools to account for the carbon content of certain types of land use and forestry, and work on legal instruments, standards, and guidance that would later provide the structure for carbon trading in Australia (Kuch, 2015). At the state level, the Victorian Government had amended the *Forestry Rights Act 1996* to encourage investment in forest plantations as carbon sinks by disaggregating legal rights to land, trees, and carbon and allowing carbon held in certain trees to be traded (City of Melbourne, 2003: 44). These kinds of technical details were not all straightforward. Sometime prior to becoming a Director at the City of Melbourne, Kate Vinot had worked as a technical adviser to the Bush for Greenhouse program. She recounted negotiations over how trees should be defined in the models and tools that were being developed, including 'whether trees that a kangaroo could jump over could still be counted as trees in calculations for carbon sequestration' (interview, November 2017).

Rather than waiting for carbon markets to emerge internationally, the City of Melbourne envisaged a local carbon trading market to provide a 'least cost, flexible and effective collective response' while preparing the city administration and local residents and businesses for 'eventual international trading in carbon credits' (City of Melbourne, 2003: 3). The strategy asserted that action must be quick because: 'a City of Melbourne profile that integrates economic benefit with environmental and social gains will be hotly contested in future years by other cities' (City of Melbourne, 2003: 5). Innovation, in this setting, was focused towards establishing and capitalising on an emerging market for carbon offsets. In Byron Shire and Copenhagen, by contrast, innovation was more geared towards social enterprise and technological improvements respectively. Of course, each of these elements of innovative potential can be seen in all three places, but with a different emphasis in each.

To lay the groundwork and instil confidence in this approach, the City of Melbourne's 2003 climate strategy proposed a pilot scheme to offset a portion of council's own emissions by purchasing the carbon rights for blue gum mallee eucalypts. These types of trees had been identified, at the time, as a good carbon sink and a profitable investment (City of Melbourne, 2003: 54). The pilot would see 10 per cent of corporate emissions sequestered in a plantation located in a specified municipality in the north of the state, increasing to 50 per cent by 2010. The eucalypts would store carbon in their roots, while the growth above ground would be used as feedstock for power generation (that is, bioenergy) and with eucalyptus oil as a valuable by-product (City of Melbourne, 2003: 41). 'Combined with the 50 per cent

target in the City of Melbourne's use of renewable energy, sequestration will deliver net zero corporate emissions' (City of Melbourne, 2003: 41).

Managing the pilot sequestration project as a commercial proposition would mean harvesting trees, which would incur a carbon debt. The strategy describes that 'replanting is necessary to not only fill the gap created by harvesting and other losses such as tree death and thinning, but continuous planting must be at a rate that will meet the City's sequestration target by 2020. Beyond 2020, plantings would need to keep pace with maintaining the rate of sequestration required to keep the City's net emissions neutral' (City of Melbourne, 2003: 47). These phases of growth, harvesting and renewal would have to be carefully and continually evaluated and reconciled against the carbon debts generated within the municipality: 'A system of control measures is needed to measure, independently verify and report on the sink's performance at regular intervals, currently set at five-year periods' (City of Melbourne, 2003). Complex nature would be rationalised and disaggregated in order to conform with this sociotechnical imaginary of community-scale carbon neutrality.

With limited jurisdictional authority, this vision for a low carbon urban future would also require an urban citizenry to take responsibility for their own emissions, voluntarily at first and with the possibility of regulations to come. The City of Melbourne's strategy for investing and trading in carbon offsets would position the municipal administration as a key broker in establishing and maintaining arrangements and transactions between these parties. The disordering potential of global climate change was deflected and turned to advantage by framing ambitious climate action as a way to manage transition risks (such as economic risks arising from the regulation of greenhouse gas emissions in the future) into an economic opportunity. But it was also framed to elicit support by promising numerous "goods", including a low-cost way to counteract emissions associated with everyday urban activities, generate investment returns to the city, attract international interest and investment, produce renewable electricity, and strengthen relationships between urban and regional communities by trading in carbon. Thus, the local community's responsibility for carbon emerges as a common theme in all three places, but the envisaged mechanism to bring about that community response differs in each place. The conscientiousness of locals and visitors to Byron Shire to act for the collective good has underpinned the carbon neutral imaginary. For Copenhageners, all would stand to benefit from a well designed and implemented Climate Plan, positing trust in the public administration. In Melbourne, individuals and businesses were to be persuaded or incentivised to act in ways that would benefit the municipality and, ultimately, reap those benefits through an adept repositioning as a world city with a green and sustainable reputation within global networks.

To summarise, the City of Melbourne's imaginary of community-scale carbon neutrality was influenced by a desire to demonstrate leadership and take advantage of economic opportunities expected to arise from a new world order of global carbon trading. The carbon neutral imaginary was as much a business case to redirect flows

of finance into and out of the municipality, as it was a plan to address greenhouse gas emissions within the city. Securing flows of international finance into the urban centre, reducing emissions through efficiency, innovation and design, and displacing flows of greenhouse emissions to elsewhere would establish the local government as an enterprising authority over carbon. The emphasis on energy efficiency, new technologies and carbon trading delineated the boundaries of carbon neutrality as win-win scenarios for rational economic decision-making. In that sociotechnical imaginary, private responsibility and private property were the dominant frames through which "community" came to be understood as the subjects of carbon neutrality.

4.5 Conclusion

This chapter has examined the conditions of possibility in which particular sociotechnical imaginaries of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom). Visions for community-scale carbon neutrality emerge and take hold as sociotechnical imaginaries within the here and now of shifting social and material histories. These visions must be made meaningful within these situated contexts in order to gain adherents and become communally adopted.

The vision for Zero Emissions Byron is for the community to become self-sufficient in carbon within the territorial boundaries of the municipality. Viewed as a sociotechnical imaginary, this commitment was predicated on powerful histories of collective organisation to protect and enhance local social and ecological qualities and values. The City of Copenhagen's vision to be the world's first carbon neutral capital city by 2025 is underpinned by technologies, replacing coal with biomass in CHP plants alongside large investments in wind energy. As an imaginary, this policy goal was grounded in a strong public administration that would reconfigure energy infrastructures for the public good. The City of Melbourne's vision to become a carbon neutral city predicted carbon markets would take hold as an inevitable and preferred response to climate change, and saw carbon offsets as an opportunity for local leadership and economic development within the city and its hinterlands. This imaginary emphasised competitive and entrepreneurial judgement as a crucial quality to reposition the city within a global paradigm of carbon trading and gain economic advantages that would flow through to businesses, households, and individuals.

These characterisations are not definitive but, rather, are drawn out as reference points from the complex histories, actions and interactions explored in this chapter. They point to the social and material relationships that shape human interactions and sociotechnical systems, including those that may emit or remove greenhouse gases. The analysis highlights varied preferences for which parts and aspects of those activities and systems are sought to be reconfigured through efforts to reimagine these three specific places and communities as carbon neutral. In each of the three field sites, starting points from which these sociotechnical imaginaries are framed as viable and desirable become most specific as they bring together influences from

many places. These conditions of possibility might be thought of as contingent lineages (Tsing, 2005: 127) – a form of assemblage that draws attention to the ways social and material elements are brought together in continually unfolding processes of sociotechnical change.

Alignments between existing cultural and political ideals and values is significant as the means through which visions gain adherents, through persistent efforts to build coalitions and through exertions of power. Relationships of power begin to emerge through this analysis, not least being the paradigm of economic growth that underpins dominant trends of globalisation and urbanisation. This pattern is not directly confronted in any of these imaginaries, although each expresses possibilities to reshape the pattern. Creating local circulations of renewable energy and money, and moving towards self-sufficiency in relation to other resource flows, would strengthen local autonomy in Byron Shire. Yet the influx of visitors and tourists to the region – and with them significant opportunities for economic growth – presents an obvious challenge to possibilities for self-sufficiency. The emphasis in Copenhagen to develop technological solutions for the city, on behalf of the citizens and for adoption by the world, was focused on inflecting trajectories of economic growth onto a more climate friendly and ecologically sustainable path. For the City of Melbourne, the imaginary was more attuned to take advantage of a perceived inflection in global carbon markets that was seen to be taking place. By doing so, the imaginary would strengthen the city's position as a leader within the local community and also within wider networks of world cities.

Comparison highlights differences between who is doing the imagining in each of these places, and how local publics – the "community" situated within the community-scale – is envisaged and performed through these imaginaries. In each place, there are different emphases on the social mechanisms for sociotechnical change – collective actions by and for the community in Byron Shire, public authorities acting on behalf of citizens in the Copenhagen, and individual responsibility in Melbourne. In each place, imaginaries for technological and ecological change are deeply enmeshed with existing and envisaged social arrangements. It is these underlying social relationships – between individuals, communities, and institutions – that are negotiated and contested and that must be seen as viable and desirable by a constellation of actors and institutions that is powerful enough to sustain the imaginary and pull other actors along with it. These constellations are not only situated within the local community. Alliances formed between local policy actors and networked organisations add weight to local visions, and outward-facing projections about the prospects of sociotechnical change can grab hold of actors in other places.

The viability and desirability of these sociotechnical imaginaries is also fashioned by delineating boundaries around the community-scale and around carbon neutrality. Harnessing sun, wind and water to generate electricity can reduce the amount of fossil fuels that would have been burnt. Altering farming practices, protecting forests

and planting trees can sequester carbon into soil and organic matter. To render renewable energy exports as carbon offsets, however, or biomass as carbon neutral, or plantation eucalyptuses as carbon credits, entails abstracting from nature. These renderings all require greenhouse gas emissions and removals to be made legible in order that they can be managed within, and exchanged across, the conceptual and spatial boundaries delineated around sociotechnical imaginaries of community-scale carbon neutrality.

In sum, sociotechnical imaginaries for community-scale carbon neutrality emerge from specific local circumstances and take hold in relation to existing cultural and political ideals and values. They emerge from the here and now of social and material forms and relationships – unique starting points from which to conceive future possibilities. In this sense, possibilities for sociotechnical change are shaped by the perceived affordances of emplaced social and material forms and possibilities for human action. As policy actors translate the concept of global net zero emissions into local goals for community-scale carbon neutrality, boundaries must be delineated to hold these imaginaries in place. These boundaries shape, from the outside, conditions of possibility for sociotechnical imaginaries of community-scale carbon neutrality by delineating *here* in relation to other places. In the next chapter I turn to examine these practices of boundary making.

Chapter 5. Counting to net zero: local boundaries and global networks

5.1 Introduction

> **Net-zero** (adj) | net-ze·ro | \ˈnet-ˈzē-(ˌ)rō , -ˈzir-(ˌ)ō \ : resulting in neither a surplus nor a deficit of something specified when gains and losses are added together
> – Merriam Webster Online Dictionary

This chapter focuses on how practices to define boundaries around community-scale carbon neutrality co-produce objects and scales of local climate governance. It is the next step towards addressing the central research question of this thesis concerning how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

With reference to opening definition, the concept of net zero emissions rests on calculative practices – a result that equals zero when gains (emissions sources) and losses (emissions sinks) of specified greenhouse gases are added together. As with all processes of generalisation, the category of greenhouse gases must be specified, and this requires a space of compatibility between different types of gases and modes of emission and absorption. Defining and evaluating objectives for net zero emissions involves specifying boundaries around what counts, and does not count, in measuring greenhouse gases. Delineating spatial and conceptual boundaries around greenhouse gases enables possibilities for those gases to be measured and managed in relation to those boundaries. Yet these boundaries are not definitive or absolute; they must always, to some extent, attend to local specificities.

In this chapter, I examine how practices of municipal carbon accounting have been shaped in each of the three field sites at the core of this study, and, in turn, how these practices have stabilised respective sociotechnical imaginaries for community-scale carbon neutrality. I take a wide-angled view to situate the three field sites within timelines and structures of multilevel climate governance. This helps to develop understandings of the institutions and dialogues that shape local approaches to defining boundaries around community-scale carbon neutrality, alongside the focus on actors and material realities within the previous chapter. Each field site offers a distinctive vantage point from which to trace the development of municipal carbon accounting practices as they relate to local goals for community-scale carbon neutrality, and in relation to national and international climate governance.

As discussed earlier, the production of knowledge about the climate as a *global* system helped to constitute and reinforce the need for *global* institutions to govern that system (Miller, 2004; Miller and Edwards, 2001). While discourses to "think global, act local" impart awareness of the connections between actions that are local and their wide-ranging effects, practices of carbon accounting generate knowledge about greenhouse gases to render them legible, which in turn shapes possibilities for

governing those gases. These practices rest on collaborations between actors, institutions, and material realities, but also on erasures across difference to create convincingly agreed upon generalisations in the form of carbon accounts. As Tsing (2005: 89) describes with such generalisations, 'the contingency of the collaboration, and its exclusions, no longer seem relevant because the facts come to "speak for themselves"'. The discursive instability of the concept of community-scale carbon neutrality (highlighted in Chapter Three) suggests a productive field of inquiry to examine the collaborations and erasures through which these general categories are brought into being, stabilised and destabilised.

The analysis presented in this chapter highlights that, within the three field sites, boundaries defined around community-scale carbon neutrality align to institutional systems of climate governance in other places and across other levels and, equally conform, to some extent, to local specificities. Comparison across different localities draws out the dialogues through which general categories of carbon dioxide equivalent (CO2-e) and the "community-scale" are produced – objects and scales of climate governance. At the same time, the comparison draws attention to the situated contingencies that these boundaries must conform to in each place.

The structure of this chapter follows the chronology of commitments for community-scale carbon neutrality in the three field sites, starting with the City of Melbourne in 2003, moving to the City of Copenhagen in 2009, and then to Byron Shire in 2015. Each section begins with the international context of climate negotiations at a key point in time and draws attention to important interactions with transnational municipal networks. Arranging the chapter in this manner highlights how each of the three imaginaries for community-scale carbon neutrality are situated within wider networks of climate governance and shaped through interactions between local and global. This comparison across these three vantage points and over time draws attention to key interconnections between institutions involved in measuring and managing greenhouse gases.

5.2 The City of Melbourne and the Kyoto Protocol

The City of Melbourne's first municipal carbon accounts, produced in 2002 to support its inaugural strategy for Zero Net Emissions by 2020 (ZNE2020), were aligned to the boundaries of its municipal territory (City of Melbourne 2003). The previous chapter highlighted that, without material affordances to sequester greenhouse gas emissions within these boundaries, the strategy included a proposal to establish a pilot "municipal carbon trading scheme". This would be used to counteract any residual emissions after efforts to reduce emissions within the city had been exhausted. This section situates the City of Melbourne's approach to municipal carbon accounting within broader institutions and dialogues, specifically the international Kyoto Protocol, key climate change policies of the Australian government, and alliances with transnational municipal networks. Through these dialogues, greenhouse gases generated by activities within the City of Melbourne's

municipal boundaries were rendered as objects that could be governed as a tradeable commodity in relation to the "community-scale".

5.2.1 Cities for Climate Protection

In the late 1990s and early 2000s, the initial dynamics of globalisation were taking hold, and the threats posed by global climate change were also taking shape. As discussed in the previous chapter, the City of Melbourne's 2003 climate strategy was premised on confidence that the international Kyoto agreement heralded a shift in the global order of climate governance. This set the scene for the Council to reframe the threat of global climate change into a local opportunity by establishing the city as a world leader on environmental sustainability, thus securing economic prosperity into the future.

Climate change was not a new item on the city's policy agenda. In 1997, then national Minister for the Environment the Hon. Robert Hill approved funding for 29 municipal governments to get involved in an early pilot of a program developed by the International Council on Local Environmental Initiatives (ICLEI) called Cities for Climate Protection (CCP). Through this support, the Australian government established local climate policy as a key part of its domestic response to Kyoto (Bulkeley, 2000: 303). The City of Melbourne was a founding participant in the program, and in 1998 agreed to host ICLEI Oceania's regional office. Martin Brennan was a councillor at the City of Melbourne during this period. He was also the manager of recruitment and political support for ICLEI Oceania. In our correspondence, Martin summarised that 'the CCP campaign launched in 1998 achieved in a decade an 80% coverage of Australia's population through the participation of 233 local councils across urban, regional and rural communities' (personal communication, 21 February 2019). In its ten years of operations, the program saved 18 million tonnes of CO_2-e, with participation from every Australian capital city, all of the metropolitan councils, and several regional cities (field notes, 1 November 2017). The program also captured scholarly interest as the subject of early research on multilevel climate governance (Betsill and Bulkeley, 2004; Bulkeley, 2000; Hoff, 2010).

Participation in the CCP program followed a well-defined format. Martin recounted that councils must make a political declaration and then an undertaking to complete five milestones: setting emission reduction goals, a climate action plan, implementing priority projects, evaluating the quantitative reduction in greenhouse gas emissions, and reporting on the level of investment and savings (personal communication, 21 February 2019). In an earlier conversation, Martin commented that, in order for the emissions and savings reported by local governments to be seen as a legitimate contribution to national and international efforts, the approach to carbon accounting needed to reflect international standards (interview, 13 February 2018). To this end, the CCP used software developed in Canada to support a consistent approach to developing and tracking emissions inventories for corporate operations, and to test

ways of measuring community-scale emissions. These early approaches towards municipal carbon accounting were designed to align with the guidelines developed by the Intergovernmental Panel on Climate Change (IPCC) for nation states to monitor their greenhouse gas inventories under the Kyoto Protocol.

5.2.2 Guiding Greenhouse Gas Inventories

In earlier discussion of global climate models and inputs (Chapter Two) I touched on the construction of CO_2-e as an object that enables greenhouse gases to be rendered legible and, thus, governable. The premise of the IPCC guidelines on greenhouse gas inventories is that it is not possible to accurately measure all of the greenhouse gases that are emitted or removed within national (or, for that matter, municipal) territories. Therefore, consensus is needed on the best way to estimate these emissions by using reliable, generally acceptable and comparable methods and guidelines (Eggleston et al., 2006).

These estimates follow a basic equation: $E = AD \times EF$; where E (emissions or removals) is equal to AD (activity data – that is, the extent of an activity such as fuel consumption) multiplied by EF (emissions factor – that is, emissions or removals per unit of activity, such as mass of a specified greenhouse gas emitted per unit of fuel consumed). The emissions factor is a simple equation by which effects of emitting each of the six greenhouse gases identified in the Kyoto Protocol are translated into a "carbon dioxide equivalent" (the amount of carbon dioxide that would have the same effect), expressed by the scientific notation CO_2-e. The IPCC publishes guidance on how to calculate emissions factors, and national governments are required to apply these frameworks to calculate emissions factors relevant to their national greenhouse inventories.

The IPCC guidelines for greenhouse gas inventories provide a framework for policy makers to estimate greenhouse gas emissions or removals within defined geographic territories and in relation to certain "sectors" of human activity. The first guidelines were published in 2001 and have been updated and refined to clarify and simplify inventories, in particular to reduce the chance of "double counting" emissions across sectors. The most recent update consolidates its guidance for national greenhouse inventories based on these sectors of activity: Energy (including stationary electricity, transport, and direct fuel combustion); Industrial Processes and Product Use; Agriculture, Forestry and Other Land Use; and Waste (Eggleston et al., 2006).

These guidelines have served as the basis for non-state actors to develop their own frameworks for greenhouse inventories, primarily through the Greenhouse Gas Protocol Initiative. The World Resources Institute (a U.S. based environmental non-government organisation), and the World Business Council for Sustainable Development (a coalition of 170 international companies) established this protocol approach in 1998 in partnership with other businesses and non-government organisations. This initiative led to the publication of the *Corporate Accounting and*

Reporting Standard (World Resources Institute, 2001), which provides a guide for companies to quantify and report their greenhouse emissions.

In this context of corporate greenhouse gas inventories, the concept of emissions "scopes" was developed to delineate emissions with respect to demarcated boundaries of companies' operational responsibility. The distinction between Scope 1, 2, and 3 emissions can be summarised in the following way. Scope 1 emissions are those generated within a specified boundary (which could be a single office building, a campus or a collection of corporate headquarters, a warehouse, a house, or a municipal territory). These would include sources such as direct fuel combustion used for cooking and heating, aerosols from refrigeration and air-conditioning, or emissions from industrial processes. Scope 2 emissions are classified as those arising from energy generated outside of those boundaries to meet operational demands within them, such as from coal or gas-fired electricity to power lights and appliances. Scope 3 emissions are distinguished as those embodied in supply chains, associated with procuring goods and services, and with transporting and dealing with waste (World Resources Institute, 2001).

These methods of carbon accounting stabilise greenhouse gas emissions in relation to well-established categories such as sovereign territory, and economic and political actors (Lövbrand and Stripple, 2011). Framing carbon in relation to economically and politically stable categories, such as the state, the market and the individual, render it a coherent object that can be governed. Organising emissions into "sectors" delineates boundaries around different types of human activities and sociotechnical systems. Designating scopes is a way for actors to trace accountability and responsibility beyond the boundaries of these discrete sites and activities. Calculating CO_2-e allows heterogeneous greenhouse gas emissions and removals to be aggregated and exchanged.

Carbon accounting has received substantial critical attention. MacKenzie (2009) has argued that accounting methods are the basis for turning carbon into a fungible commodity. Bumpus and Liverman (2008) have highlighted that, at international levels, carbon offsetting produces highly unequal geographies by relying on the development of cheap carbon reductions in the global south and allowing actors in the global north to claim these as reductions in their own emissions, while at the same time claiming sustainable development benefits. International carbon markets have been criticized for loose definitions of emissions reductions and development benefits, neo-colonial practices of unequal exchange, and a lack of transparency and participatory governance (Bumpus and Liverman, 2008: 148). The assumed interchangeability of greenhouse gases that underpins the functioning of carbon markets may also impede efforts to steer away from fossil fuel dependence. As Lohmann (2010: 28) has argued,

> While carbon trading encourages ingenuity in inventing measurable 'equivalences' between emissions of different types in different places, it does not select for

innovations that can initiate or sustain a historical trajectory away from fossil fuels (the effectiveness of which is less easy to measure).

I now turn back to the City of Melbourne and its involvement in ICLEI's CCP program to see how its municipal carbon accounts were developed and examine implications with respect to this warning about unequal geographies and entrenched fossil fuel dependence.

5.2.3 Carbon trading[14]

The CCP affirmed and strengthened the role of municipal governments as "international partners" in global issues of climate change and environmental sustainability. It became an important vehicle through which local efforts to reduce emissions could cohere. The methods used to develop municipal carbon accounts were integral to framing local governments as legitimate actors in global climate governance. But rather than bypassing national contexts of climate policy, approaches to municipal carbon accounting were shaped in relation to national policies and preferences for how to measure and manage greenhouse gas emissions and removals.

The CCP was generously funded by the conservative Australian government, led by Prime Minister Howard, as a key part of its strategy to address climate change. That government was careful to contain Australia's commitments under Kyoto by negotiating special concessions in the sector of Agriculture, Forestry and Other Land Use, and allowances to increase greenhouse emissions under Phase 1 and 2 of Kyoto (Kuch, 2015).[15] Together, Howard and his Environment Minister, Robert Hill, signed the Kyoto Protocol in 1998 and established the Australian Greenhouse Office (AGO), which was responsible for developing the carbon accounting methods and inventories as required under the agreement, along with the Bush for Greenhouse program for land-based carbon sequestration mentioned previously. The framing of carbon neutrality presented within the City of Melbourne 2003 strategy for zero net emissions with its proposal to pilot a municipal carbon trading scheme reflected and reinforced the role for land-based carbon offsets in addressing climate change.

Although the city's original ZNE2020 strategy framed a market-based solution as logical and natural, it also placed limits on how far that solution ought to extend. The strategy asserted that the location for carbon trading 'must be in Victoria – it would be inappropriate for the City of Melbourne to partner with an organisation from

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[14] An earlier version of this section has been published in Pollard S. (2020) Imagining the Net Zero Emissions City: Urban Climate Governance in the City of Melbourne, Australia. In: Hoff J, Gausset Q and Lex S (eds) *Building a Sustainable Future: The Role of Non-State Actors in the Green Transition.* Routledge. Available at: https://doi.org/10.4324/9780429280399.

[15] Lately the Australian Government has proposed to use its overachievement in meeting Kyoto targets as "carry-over credits" to meet emissions reduction commitments pledged under the Paris Agreement (Morton, 2019).

another State' (City of Melbourne, 2003: 43). The strategy suggested that pre-existing partnerships within the municipality that was proposed to host the eucalyptus plantation would help to develop trust with participants in the nascent market. It also suggested that, through the partnership, rural and urban communities would be encouraged to 'learn of the wider impact of their simple day-to-day actions on their household, the environment and the wider community' (City of Melbourne, 2003: 46). Although based in market exchange, the intention of the policy was that exchanging carbon would also encourage the exchange of other knowledge and values, including the repercussions of everyday activities and dependencies between the city and its hinterlands.

The City of Melbourne updated its ZNE2020 strategy in 2008 and again in 2014. These updates continued to assert the "zero net emissions city" objective, even as emissions within the municipality climbed. By 2006, estimates of community-scale emissions had grown to 6.4 million tonnes and were anticipated to increase to almost 8 million tonnes by 2020. The 2008 update set a goal to reduce these by around 1.5 million tonnes by 2020, with the remainder to be offset (City of Melbourne, 2008: 22). In response to anticipated shifts in national climate policy, however, the City abandoned its proposal for a municipal carbon trading scheme. Instead, national commitments to establish emissions trading and renewable energy targets were expected to significantly reduce urban emissions. The update considered it 'highly likely' that new market conditions created by these policies would result in 'investment to support the most economically viable, locally sourced, renewable and low-carbon technologies within the boundaries of the City of Melbourne' (City of Melbourne, 2008: 2). Expectation of action by other levels of government, and by corporate actors responding to anticipated government policies, reshaped the prospects that the City of Melbourne perceived for lowering emissions within municipal boundaries.

In terms of carbon accounting and offsetting, national standards and methods were further developed to generate trust in carbon markets. These standards were aligned to the guidance developed for greenhouse gas inventories under the Kyoto Protocol, which also supported the emergence of voluntary carbon trading alongside the regulated carbon markets established under Kyoto (Bumpus and Liverman, 2008). The National Carbon Offset Standard (NCOS) established a benchmark approach to carbon accounting for organisations, including local governments, and criteria for purchasing offsets generated in Australia and overseas that met basic criteria for accountability (Department of Environment and Energy, 2010). This standard, alongside other developments in carbon accounting and reporting such as the *National Greenhouse and Energy Reporting Act 2011*, came to define the technical benchmarks against which the City of Melbourne, alongside many other organisations, sought to establish its carbon neutral status (City of Melbourne, 2016).

Given these developments, the City of Melbourne never went ahead with its proposed pilot program to sequester carbon in regional Victoria, choosing instead to

purchase carbon offsets through voluntary markets that were being established elsewhere. In the 2011–12 financial year (and every year thereafter), it was certified as a carbon neutral organisation under NCOS (Department of Environment and Energy, 2018). While these offsets related to corporate rather than community-scale emissions, they show that the City of Melbourne's preferences to trade carbon to a known and specific hinterland and organised with trusted partners were supplanted by a more commoditised approach. That is, transactions between the entity that generates the offsets and the entity that purchases those offsets do not presume or produce any ongoing relationships between the transactors.

The City's ability to carry out these exchanges relied on a global system of standards, verification, regulation, and oversight to generate trust between market participants who are largely unknown to each other. The City's participation in these global markets displaced carbon farther away and mediated these trades through impersonal relationships, making the environmental, social, and economic impacts and implications of these trades much harder to discern. The development of technical standards and global markets in carbon trading reconfigured the way the City of Melbourne achieved carbon neutrality for its corporate emissions. However, the accounting standards that established carbon as a tradable commodity also make it difficult to justify more relational displacements of carbon – such as those initially proposed by the City to displace urban emissions to a known set of partners in a specified hinterland. Abstracted carbon markets serve to disembed climate solutions from their ecological and sociotechnical contexts and re-embed them in theories and practices of economic exchange, property law, and risk management (Lohmann, 2010: 28). The particular relations underpinning municipal carbon trading envisaged in the 2003 strategy – with rural municipalities and eucalyptus trees – became altered as carbon itself was detached from these tight relational bonds.

Municipal carbon accounts situate greenhouse gas emissions within municipal territories and render them governable by local councils. By adopting international and national conventions for greenhouse inventories circulated through the ICLEI CCP program, the City of Melbourne asserted itself as a legitimate actor in climate governance with accountability and responsibility for a discrete set of greenhouse emissions within its operational sphere and municipal territory. Just as equivalence and exchange were a strong feature of Australia's national approach to carbon accounting and climate governance, so too were carbon offsets central to early iterations of the City of Melbourne's carbon neutral imaginary. These approaches specify carbon as a private good – that is, excludable and rival in consumption, compared to public goods that are neither rival in consumption nor excludable, and common goods that are rival in consumption but not excludable (Ostrom, 2008; Selle et al., 1999). This framing of greenhouse gas emissions reflected and reinforced the emphasis within the City of Melbourne's carbon neutral imaginary on individual responsibility for carbon, rationalising climate governance as being largely a problem for economic actors.

The City of Melbourne's legitimacy as a climate actor rested on the adoption of international accounting orthodoxies while, at the same time, being shaped by national preferences for the interchangeability of land-based carbon dioxide emissions and removals in balancing the carbon accounts. Viewed through the lens of co-production, practices of carbon accounting helped to stabilise greenhouse gases as an object that could be governed in the same way as other abstracted commodities, opening up possibilities to govern carbon through regulated and voluntary carbon markets. The City of Melbourne's proposal to develop carbon markets reinforced framings of carbon as a private good, which in turn underpinned the emphasis within their sociotechnical imaginary on entrepreneurialism, competitiveness, and individual responsibilities to reduce emissions. This analysis highlights important institutional dialogues and circulations within local climate governance, in which the City of Melbourne's policies are shaped by and nested within national climate policies while at the same time extending beyond these limits. The prominent role of carbon offsets within the City of Melbourne's sociotechnical imaginary for community-scale carbon neutrality was ultimately abandoned through shifts that I examine in later chapters. I turn now to consider practices of municipal carbon accounting in a different context, picking up the story from Copenhagen at the time when the city hosted the international climate negotiations in 2009.

5.3 The City of Copenhagen and COP15

Moving along the sequence of international climate negotiations, and taking up another vantage point, this section focuses on the way municipal carbon accounting was applied in the context of the 2009 Copenhagen Climate Plan to align with Denmark's climate and energy policies and to support the emphasis on the public good within the city's commitments to carbon neutrality. Just as with the City of Melbourne, the City of Copenhagen's policy goals for community-scale carbon neutrality were also shaped and stabilised in relation to wider dialogues and institutions of climate governance. While Copenhagen's municipal carbon accounts conformed to the territorial boundaries of the municipality, we saw in the previous chapter that this boundary enclosed a different set of social and material affordances, including with respect to energy infrastructures. The greenhouse gas emissions generated from activities within these boundaries, although measured using similar practices of municipal carbon accounting, could be managed differently as a result of different sets of interactions between actors, institutions, and material realities.

5.3.1 COP15

In December 2009, Copenhagen hosted the 15th round of international climate negotiations (COP15) at the Bella Centre, Denmark's second largest conference centre located adjacent to the Amager Fælls (Amager Commons) between the city centre and the airport (Bernstein et al., 2010). Several hundred years ago, this area was farmland where food was grown for the city. Now, it is a high-end commercial and residential district developed by the City of Copenhagen's development agency,

By og Havn.[16] This round of negotiations was significant because it was meant to deliver a legally binding agreement with robust targets and measures for nation states to reduce emissions that would take effect after 2012 when the first commitment period of the Kyoto Protocol ended. Instead, the negotiations failed to deliver anything apart from a political text and a formal decision to extend interim negotiations to the next round of meetings (Christoff, 2010: 637).

In 2009, Simon Hansen was a senior adviser in the City of Copenhagen's Finance Administration. When I met him in 2018, he was Director of Regions for C40 Cities and head of its Copenhagen office. We were talking together in a meeting room in the brand new BloxHub building on the edge of Copenhagen Øresund, where Simon and his small team are co-located with dozens of other companies, research institutions and organisations engaged in various dimensions of sustainable urbanisation (BloxHub, 2020). From the large windows overlooking the harbour, we could clearly see the outline of the Bella Centre's towers pressing dramatically against the bright spring sky, where the COP15 meetings took place almost a decade earlier.

Simon explained that, in the lead up to the 2009 negotiations, politicians and senior officials at the Copenhagen City Hall wanted to send a message to those international diplomats and negotiators at the conference:

> The idea was that cities had a major role to play in creating a sense of pressure on the decision makers who would be negotiating. The natural question was what level of ambition should we aim for? The carbon neutral target for Copenhagen was framed to show leadership and push national and international ambition at the negotiations (interview, 20 April 2018).

This attempt at influence drew on, and added momentum to, a sense that cities and local governments could contribute to climate politics and governance in new ways. Copenhagen was a small but already powerful member of the C40 cities network, an organisation first established in 2005 when the Mayor of London, Ken Livingstone, oversaw development of London's first Low Carbon Action Plan.

In practice, Simon noted, Copenhagen's ambitious commitments did not create the desired pressure on the international negotiators:

> The mood in the City Hall was positive, and it galvanised a belief, especially in C40, that something special was happening in cities. C40 was well resourced at the time, with [Michael] Bloomberg as the incoming Chair.[17] The organisation supported the meetings at Copenhagen City Hall. The mood from the Bella Centre was exactly the opposite. It was off-putting, and it left people feeling hopeless and without energy (interview, 4 April 2018).

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[16] Locating this event within the social and material fabric of the city highlights the ways in which urban histories are continually unfolding and helps to situate the politics and diplomacy of international climate governance in a specific place.

[17] Michael Bloomberg is an American businessman, philanthropist, and former Mayor of New York City. He has served as Chair of C40 Cities and as the UN Secretary-General's Special Envoy for Climate Action.

Even so, the emergence of influential city-networks can be seen to redraw boundaries around who are the legitimate actors, and what are the legitimate actions, in global climate governance. While COP15 marked a low point in international climate negotiations, it heralded a rise in the organisation and influence of city networks in general, and of C40 in particular.

The City of Copenhagen's commitment to carbon neutrality was directed towards urban publics, especially in relation to systems of energy production. It was also meant to strategically influence national and international policy and politics around global issues (Bulkeley and Schroeder, 2012). This commitment highlights the ways in which constellations and coalitions of actors work with and against each other in multilevel climate governance. It also emphasises an interpretation of these engagements as motivated by political and economic interests – such as with competition between "world cities" mentioned previously. Yet these are not the only interests at play in shaping local approaches to climate policy.

During our first meeting, Simon Hansen posed the question, 'Why should cities bother to act at all, if action by others is not guaranteed?' (field notes, 9 March 2018). He went on to give a lucid account of why, even if Copenhagen, Melbourne, or any other city reaches its targets, the impacts of climate change will still be felt. Unless, that is, every other city and nation in the world also pulls its weight. This issue highlights, to Simon at least, that the appeal to address transboundary risk will not be enough to motivate local action on emissions reduction. Rather, the perceived local benefits of reducing emissions must make it worthwhile to do so, even if there is no guarantee that others will follow suit. From this argument, we can trace the origins of appeal to locally situated co-benefits – actions that can be justified on their own merits that have the additional benefit of reducing emissions – as a key driver behind local climate mitigation. The concept of co-benefits shifts the boundaries of climate mitigation from the "global" level, where all stand to benefit only if everyone acts collectively, to the "local", where the additional benefits of changes made to reduce emissions outweigh the rationale for delaying action until others have done so. It may not even be the reduction of emissions, per se, that generates the local benefits.

Financial savings for local governments, such as through energy efficiency measures, are often framed as an important co-benefit for local climate action and underpinned much of the early advancement of the CCP program considered earlier (Bulkeley, 2000). Broader economic advantages often underpin commitments for community-scale climate action, whether through opportunities for green growth via global circulations of capital, or locally circulating capital through development of community owned renewable energy, as we saw respectively with the City of Melbourne and Byron Shire. Situated co-benefits related to improved health and amenity outcomes have also gained increased attention. Yet even with the flip in emphasis, locally situated climate mitigation and its co-benefits may also be abstracted through practices of municipal carbon accounting. Applying these methods of carbon accounting allows discrete and disparate local actions to be

aggregated and made meaningful at global scales. I take a closer look at the City of Copenhagen's municipal carbon accounts to further unpack these processes.

5.3.2 Surplus wind energy

Morton Højer is an environmental economist, and one of the few economists working in the City of Copenhagen's Technical and Environmental Administration. He mainly works on the economics and accounting for the Climate Plan, but also spreads his expertise across other areas such as waste management. He is curious about my research, asks me a lot of questions, and gives an impression that he likes collaborating with others to solve difficult problems.

Morten recounted that the Danish national government had established its own standard for municipal carbon accounting in 2008, to make it easier for Denmark's local governments to develop municipal carbon accounts. As with the standards developed under the CCP that we saw earlier, Denmark's system adapted IPCC guidelines in order to define the boundaries around these accounts in relation to Danish municipal territories. While this approach offers a tidy and nested set of accounts by which to measure greenhouse gases across scales of government, these boundaries also intersect with flows of people and resources in interesting ways.

One illustration of these intersections relates to emissions from transport. The City of Copenhagen's municipal territory is shaped like a donut, with the municipality of Frederiskberg occupying the hole in the middle. Flows of people, bicycles, cars and buses cross these administrative boundaries regularly. (I did so most days during my fieldwork, in my short bicycle commute from an apartment on Grundtvigsvej in Frederiksberg to the Faculty of Social Sciences on Øster Farimagsgade in Copenhagen.) On the ground, there are few indications that one is crossing an administrative boundary, except that the manhole covers are not stamped with HOFOR and bike lanes narrow slightly when one enters Frederiksberg. This, as my colleagues at the university wryly explained, reflects resistance by the wealthier inhabitants of Frederiksberg to these incursions into road space where they drive and park their prestige cars (field notes, 5 March 2018). The picture becomes more complicated when one considers that the area of Greater Copenhagen spreads out far from the city centre and is generally thought to extend across the Øresund Bridge into Malmö in Sweden. Many people who live in this larger metropolitan area regularly commute to work or study in central Copenhagen. Yet the municipal carbon accounts are supposed to capture only those emissions resulting from travel within the municipal territory. Accountability and responsibility for moveable transport emissions, within the abstracted landscape of municipal carbon accounts, is bisected at the borders of municipal territories.

Another illustration of particularities in municipal carbon accounting is the way methods in Denmark have been designed to deal with emissions (or, rather, the lack of emissions) from wind energy. Using energy that is produced from renewable

sources avoids the need to burn fossil fuels for energy. The Danish rules for municipal carbon accounting were designed to encourage local municipalities to make investments in renewable energy projects in order to reduce their reliance on fossil fuels to meet energy needs. Morton described to me how it works:

> If a city invests in renewable energy outside of its geographic boundary, it is allowed to include that in its [carbon] accounts. This forms the basis for the Copenhagen accounts. They are not purchasing carbon credits through the European ETS [Emissions Trading Scheme], but rather they are counting ownership shares from investments by HOFOR in wind energy projects. For instance, if HOFOR invests in 100MW of wind, the energy generated by those turbines enters the accounts as a reduction against fossil fuel-based consumption within the municipality (interview, 18 June 2018).

Morten went on to explain how these values are calculated by measuring the total annual consumption of stationary energy within the municipality, comprising electricity and heat, and multiplying this by the emissions factors for electricity and heat production to give the total emissions for stationary energy (following the equation $E = AD \, x \, EF$ we saw earlier). They also assess how much energy HOFOR's wind turbines have produced over the course of the year and the surplus relative to electricity consumed within the municipality. Multiplying this amount by the emissions factor of the Nordic electricity grid calculates the value of surplus wind energy as carbon offsets (interview, 18 June 2018).

In summary, the City of Copenhagen's policy is to be a 'net exporter of wind, which allows for an offset, with the value determined by the difference between what we produce and consume and the CO_2-e [emissions] factor' (interview, 18 June 2018). I had heard from other planners at the Technical and Environmental Administration how important surplus wind energy was to the viability of the Copenhagen Climate Plan. Morton reflected that these details about renewable energy exports and their equivalent value as carbon offsets are contained within the municipal carbon accounts, but acknowledged they are not well described in the public facing documents (interview, 18 June 2018). Niels Kristensen, the Technical and Environmental Administration's lead planner on energy production in the Climate Plan, reinforced this point. He noted that HOFOR counts electricity produced from all the turbines it has been responsible for developing. 'It doesn't divide electricity production or subtract the stake from that 20% or 33% [of shared] ownership or whatever. That would become too complicated' (interview, 30 May 2018). Further balancing out occurs by calculating net electricity consumption and wind energy production over the course of the year, smoothing out fluctuations in the life of the city and variations in the weather and the seasons. Periods of high wind produce much more electricity than is needed, with excess electricity exported to other countries and balancing out periods with little or no wind. Periods of low energy consumption within the city, such as over the summer holiday period when many businesses close down and residents go on holidays, are also smoothed out.

The City of Copenhagen's policies to shift energy production away from fossil fuels are supported by their accounting treatment of surplus wind energy and the carbon neutral status of biomass. Biomass enables rapid transition away from coal-fired power in district heat and power, but it also relies on tightly controlled supply chains to ensure that harvest and regrowth cycles are managed sustainably. Investing in more wind energy than is needed for the City of Copenhagen's own inhabitants displaces fossil fuels that would have been burnt to generate electricity for others elsewhere. It also enters into the competitive market of corporate wind energy. In both these examples, primary responsibility for managing supply chains and developing wind energy projects falls to the city's utility companies, reflecting a hybrid model of climate governance involving public and private entities.

Recalling the alignments that we saw previously between the City of Melbourne's approach to carbon trading and national preferences for land-based carbon offsets, boundaries around community-scale carbon neutrality must be negotiated in relation to national and international policy contexts. Equally, those boundaries are always shaped, to some extent, by local specificities. The City of Copenhagen's approach to calculating values for surplus wind energy is consistent with international methods of carbon accounting and seen as legitimate in the eyes of the nation state. It needs to be so, in order to assert the authority and legitimacy of the city administration as an actor in climate governance. Alignment between municipal and national methods co-produce stable objects of climate governance – that is, surplus wind energy as an object that can be exported and exchanged with calculated reductions in CO_2-e. Alignment between industry actors on the carbon neutral status of sustainably certified biomass serves to stabilise this object of energy production in relation to the City of Copenhagen's carbon accounts. Local governments, and the utility companies acting under their direction, are stabilised as legitimate actors to make investments in large energy infrastructures within and beyond the city in order to deliver the emissions reductions and emissions offsets that underpin the carbon neutral strategy.

Viewed through the lens of co-production, the City of Copenhagen's approach to carbon accounting helped to reinforce the Climate Plan as a means to deliver on local and national preferences for green economic growth, driven by the development of large-scale renewable energy infrastructures. These framings, in turn, underpinned the emphasis within the Copenhagen Climate Plan on the role of public authorities and large companies to deliver public goods in the form of economic prosperity, environmental quality, and quality of life.

The alignments and alliances formed through Copenhagen's municipal carbon accounts may, however, also serve to destabilise other actors and sociotechnical arrangements. Corporate investments in wind energy are a significant shift from small-scale cooperatively owned projects in which the Danish wind industry emerged (as we saw earlier) and may shift the autonomy and power of local communities to be involved in, and directly benefit from, these investments. The classification of biomass as a carbon neutral feedstock relies on well-managed supply chains and audit

trails, but these transactions may be difficult to trace for those outside of the industry circle. There are similarities here with the City of Melbourne's move towards a more commoditised approach to carbon trading in which trust is generated through standards, verifications, and oversights, rather than ongoing relationships.

Looking more broadly, the City of Copenhagen's impact at the 2009 international climate negotiations marked a rise in the strategic influence of local governments and city-networks and C40 Cities in particular. Through these networks, local governments were able to sidestep their national territories and participate in global affairs by speaking and acting on behalf of actors and activities within their local territories. As we see in the next section, participation of local actors in international climate governance grew substantially in the lead up to the 2015 climate conference in Paris, where hope was pinned on not repeating the failures experienced in Copenhagen.

5.4 Byron Shire and COP21

Shifting now to the international climate negotiations of 2015 and taking up a perspective from Byron Shire, this section examines the increasing standardisation of municipal carbon accounting methods. Shared protocols for municipal carbon accounting further stabilise carbon as an object of local climate governance and strengthen the ability of local governments, however small on their own, to unite and present consolidated accounts of the effects of local actions on global greenhouse gas emissions. At the same time, knowledge expressed through these general categories – of CO_2-e and the community-scale – must also attend to specific contexts and circumstances, as is revealed in the way volunteers in Byron Shire developed their own set of municipal carbon accounts. Just as we have seen in the other field sites, these specific collaborations are crucial in shaping the way greenhouse gases are rendered legible and governable at local levels.

5.4.1 Global carbon budgets

The Mayor of Byron Shire, Councillor Simon Richardson, was one of 1,500 local leaders from around the world who came to Paris in December 2015. He had been invited to attend the Climate Summit for Local Leaders, accompanied by the CEO of Beyond Zero Emissions Stephen Bygraves, to share their vision for Zero Emissions Byron, and to seek inspiration and gather support in their attempts to progress local actions on climate change. Simon noted that it was the sub-national governments who were 'raising the bar on climate action […] actually delivering on the targets needed to respond to the science' (Parkinson, 2015b). Lacking explicit council support for their ambitious goal for the Shire to become carbon neutral, Mayor Richardson and Bygraves used crowd sourcing to raise the funds for their trip (field notes, 12 January 2018). The lack of official support and funding that necessitated this approach reflects a degree of contention within the Shire council and local community about the Zero Emissions Byron commitment. Joining into global climate

negotiations was seen by some to overstep the bounds of local office. Others, however, saw it as an important way to share what was happening in Byron Shire and to learn from other local governments and communities with similar aspirations.

COP21 was seen by many as the last chance for nation states to reach a global agreement on climate change after the disappointing outcomes in Copenhagen six years earlier. The fortnight-long meeting was held at Le Bourget airfield on the outskirts of Paris, the only site large enough to hold the estimated 45,000 people who attended the conference. Elsewhere in the city, a range of events drew attention to the climate crisis and hopes for the future. Throughout the conference, the second installation of artist Olafur Eliasson's *Ice Watch* slowly melted away at the Place du Panthéon:

> Twelve large blocks of ice cast off from the Greenland ice sheet are harvested from a fjord outside Nuuk and presented in a clock formation in a prominent public place. The work raises awareness of climate change by providing a direct and tangible experience of the reality of melting arctic ice (Eliasson, 2019).

While attention may have been drawn to Le Bourget, the installation gave a palpable reminder that the words in those rooms would have a real effect.

At the close of negotiations, the accord was widely celebrated as a success, with elated leaders clasping hands to a standing ovation when the final agreement was passed. The text incorporates the concept of net zero emissions. It also defines key thresholds of climate risk in the form of temperature targets of 1.5°–2°C. These numbers delineate a boundary for a "safe" level of global warming, while at the same time leaving open interpretations of whom that level would be "safe" for. At the Paris meeting, advocacy to include the lower temperature target of 1.5°C was loudest from countries most severely affected by the impacts of climate change though having contributed least to greenhouse gas emissions (The Guardian, 2015). A special IPCC report on the 1.5°C target published in 2018 stresses that global average temperatures have already increased by around 1°C and that climate impacts are being experienced more intensely and more frequently than anticipated (IPCC, 2018).

Achieving the 1.5°C or 2°C temperature thresholds will depend on rapidly reducing emissions to "net zero" and then maintaining this equilibrium over time. As touched on in Chapter Two, these global temperature thresholds and state of climate equilibrium are held in relation to each other through the concept of the cumulative global carbon budget. This mediating concept is based on probabilistic analysis of the total amount of greenhouse gases that could be emitted between the year 2000 to 2050, while still maintaining global average temperature below certain thresholds for the remainder of the Century (Meinshausen et al., 2009). The authors of this seminal paper on the carbon budget note that:

> Determining probabilistic climate change for future emission scenarios is challenging, as it requires a synthesis of uncertainties along the cause–effect chain

> from emissions to temperatures; for example, uncertainties in the carbon cycle, radiative forcing and climate responses (Meinshausen et al., 2009: 1158).

The carbon budget is based on simplified relationships between cumulative greenhouse emissions, the effect of these gases in the atmosphere, and global average temperatures. A certain threshold for global average temperatures equates to a level of cumulative emissions, within a range of uncertainty. The concept effectively reframes climate mitigation from a problem of annual "flows" of greenhouse gas emissions into one of cumulative "stocks" (Millar et al., 2016), and establishes a method to estimate how much greenhouse pollution the climate system can bear before particular temperature thresholds are breached. Carbon budgets have been estimated by several different methods, with different approaches and interpretations returning a range of results that have prompted debate about just how much of the budget remains to keep global warming below 1.5°C (Hausfather, 2018; Millar et al., 2017; Millar et al., 2018; Rogelj et al., 2017; Schurer et al., 2018).

Despite these uncertainties, the concept of carbon budgets establishes a clear message. The sooner global emissions peak and begin to decline, the greater the share of the carbon budget will remain and the more time we will have in which to establish an equilibrium between sources and sinks. Expressed graphically, an earlier peak means a more gradual descent to zero will be possible, with more time to transform infrastructures, economies and societies. Global temperature targets and the climate budget establish the framework within which greenhouse gas emissions must be reduced and removed from the atmosphere. Yet despite the Paris Agreement, the voluntary commitments of nation states to reduce emissions from within their countries (called nationally determined contributions) are not currently sufficient to achieve the goals outlined in the Paris Agreement. The UN Environment Program estimated that, even if these commitments were implemented in full, global average temperatures would still increase by 3–4°C (UNEP, 2015: 4).

It was in this context, with the emerging focus on boundaries and budgets for emissions and growing recognition of the inadequacy of national responses, that the imaginary for community-scale carbon neutrality in Byron Shire could be stabilised in relation to wider structures and networks of climate governance. Efforts to reduce emissions in Byron Shire would have tangible local co-benefits, just as in the cities of Melbourne and Copenhagen, although different kinds of benefits were emphasised in each place. The commitment to a zero emissions Byron Shire within ten years also established a leadership position within regional Australian communities, just as the City of Melbourne and the City of Copenhagen had been seeking to grow their own reputations as leaders on climate change. The emerging discourse of global carbon budgets and reframing climate change as a problem of "stocks" rather than "flows" reinforced that every effort to reduce emissions, no matter how small, is important to meet the Paris Agreement targets.

5.4.2 Aggregating local leadership

Against the shortfall in nationally determined contributions to reduce emissions, the local leaders who gathered at Paris City Hall suggested that their actions could help to close this gap. The Climate Summit for Local Leaders attended by the Byron Shire Mayor was held at Paris City Hall on 4 December. Out of the meeting, local leaders released a joint statement called the Paris City Hall Declaration, which read:

> Given that cities around the world are home to half the global population and their activities generate 2/3rds of global greenhouse gas emissions, local and regional leaders have an increasingly important role to play in charting the course to a low carbon future (Cities for Climate, 2015).

The statement framed climate change as a common challenge and shared responsibility, and asserted that local leaders are legitimate actors in international climate governance. The Declaration went on to outline several collective commitments, including to:

> Deliver up to 3.7 Gigatons of urban greenhouse gas emissions reductions annually by 2030—the equivalent of up to 30% of the difference between current national commitments and the 2-degree emissions reduction pathway identified by the scientific community (Cities for Climate, 2015).

The combined pledge was made possible by methods of accounting for greenhouse gas emissions within these locally situated "nodes", estimating opportunities for how to reduce these emissions, and creating an overall tally for these potential greenhouse gas removals. Estimating greenhouse gas emissions and potential reductions *across* city networks was enabled by the development of increasingly standardised methods of municipal carbon accounting and their rapid and widespread adoption.

Calculations of local contributions to global climate change can be understood to rest on a claim of moral legitimacy to represent and speak "on behalf of the people" (Buchanan, 2002). The assertion is held in place by twin framings. The first is that local commitments to reduce emissions are made with reference to delineated administrative boundaries and the people those boundaries encircle. The second is that these discrete localities are situated within networks through which the populations and emissions within each local "node" can be aggregated. Through these framings, aggregated localities come to represent a majority of the global population and be held responsible for a two-thirds majority of global emissions. Practices of municipal carbon accounting define accountabilities and allocate responsibilities to local actors in relation to climate change (Rice, 2010). Joining up municipal carbon accounts also establishes a way for the actors that speak (claim to speak) on behalf of these localities to assert their accountability and responsibility within a climate regime that has tended to frame nation states as the primary actors. Summing greenhouse gas emissions across local areas, however, requires that approaches to municipal carbon accounting be standardised.

The Global Protocol for Community-scale Greenhouse Gas Emissions Inventories, or GPC, has emerged as a standard method that enables comparable calculations of local greenhouse gas emissions. The need for such a standard is framed in the following way:

> Inventory methods that cities have used to date vary significantly. This inconsistency makes comparisons between cities difficult, raises questions around data quality, and limits the ability to aggregate local, subnational, and national government greenhouse gas emissions data. To allow for more credible and meaningful reporting, greater consistency in greenhouse gas accounting is required. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) responds to this challenge and offers a robust and clear framework that builds on existing methodologies for calculating and reporting city-wide greenhouse gas emissions (Greenhouse Gas Protocol, 2014: 9) .

Municipal carbon accounting delineates greenhouse gas emissions in relation to specific local territories and supports assertions of legitimacy from local actors engaging in climate governance. The GPC establishes a common method for municipal carbon accounting so that these discrete assignations and claims can be aggregated – like for like – through municipal and sub-national networks. By establishing a consistent methodology to define inventory boundaries and calculate community-scale emissions, the GPC establishes a framework for aggregating greenhouse gas emissions and removals across discrete territories, nested within larger scales.

Similar to the *Corporate Accounting and Reporting Standard* discussed earlier, the GPC was developed by the World Resources Institute in collaboration with several transnational municipal networks including ICLEI and C40 Cities. The GPC was promoted through the Compact of Mayors (later re-named the Global Covenant of Mayors on Climate and Energy). To join the Compact, local governments are required to follow five steps (bearing a close resemblance to the requirements of the CCP outlined previously): pledge to reduce corporate and community-scale greenhouse gas emissions by a stated amount; establish an inventory of current, or baseline, emissions using the GPC method; develop a climate action plan to meet the pledge; monitor emissions based on annual updates to the GPC inventory; report annually on progress through an online portal – either the Carbon*n* Climate Registry or the Carbon Disclosure Project (CDP), with these platforms integrated in April 2019 (UNEP, 2019a). The GPC website reports that 'the first step for cities to realise their potential is to identify and measure where their emissions come from – you can't cut what you don't count' (Greenhouse Gas Protocol, 2014), a discourse that reinforces a technocratic and managerial approach to local climate governance.

It is worth looking in detail at how these accounts are put together. Examining at these processes in Byron Shire offers insight because it was a group of volunteers rather than professionals who undertook the calculations (notwithstanding the expert qualifications held by many of the volunteers). The calculations, and the assumptions that underpinned them, were somewhat unfamiliar and the process of piecing

together patchy information more explicit. The quantum of greenhouse gas emissions from Byron Shire, by any reckoning, is small. But the sociotechnical imaginary for net zero emissions within the Shire conveys a vision for a desirable local future and seeks to set an example for other local communities that wish to shape their own prospects. Together with other local commitments, these small contributions have the potential to equate to something more substantial.

5.4.3 Collaboration and erasure

The Mayor of Byron Shire pledged community-scale carbon neutrality through the Compact of Mayors and the GPC, and by doing so established this goal as a legitimate local contribution to global climate governance. Yet the premise that pledges and emissions reductions can be seamlessly integrated and aggregated via shared methods of carbon accounting belies a complicated practice.

In Byron Shire, volunteers from the local community worked together to compile a baseline greenhouse gas inventory for the Shire. Vicki Brooke was one of those initial volunteers, and she later took on key leadership roles within the project. We first met at the beachside cafe behind Clarks Beach. Vicki was generous with her time and knowledge on that first, and subsequent occasions. Our conversations revealed formidable business acumen forged through experience in the corporate world and now, in retirement, channelled towards climate activism.

Vicki described how the working groups tried to follow the GPC as closely as possible but encountered several challenges. Some of these were to do with the form of available information. Much of the data from the Australian Bureau of Statistics does not drill down to the local government level, so groups had to make estimates based on data organised at regional or state levels. For transport, the working group accessed the statistical data for vehicle registrations in the Shire and used that to calculate car ownership. They also estimated emissions from off-road vehicles such as used in farm work and construction work around the Shire. They then made some assumptions about average vehicle fuel consumptions and distances travelled. There was a fair degree of uncertainty about the transport related emissions from visitors to the region. As Vicki described, 'there are also 2 million visitors to the Shire each year, with impacts that you just can't ignore. There is a lot of uncertainty about the travel done by these visitors and the duration of their stays' (interview, 17 January 2018). These are not unique challenges to Byron Shire, recalling how the City of Melbourne's first municipal carbon accounts excluded emissions from transportation because of the difficulties associated with making accurate estimates. And we will see in the next chapter that emissions from transport have also proved challenging to address in Copenhagen.

Another challenge involved gaining access to data in the first place. Vicki was involved in the group charged with working out emissions from energy generation in the Shire. Gaining information about gas consumption was especially tricky. 'It took

a lot of work talking with gas suppliers to try and estimate how much gas was supplied and consumed across the Shire. The gas suppliers considered much of this information to be commercial-in-confidence, and thus it couldn't be accessed for the emissions inventories' (interview 17 January 2018). She also mentioned the fugitive emissions from sewerage that were left out of the baseline inventories entirely, which turned out in later assessments to contribute a substantial amount to direct emissions within the local area. Commercial operators were not the only organisations holding back access to information. Dr Amanda Cahill was part of the initial steering group with Mayor Richardson and CEO of Beyond Zero Emissions Stephen Bygraves. She recounted that council staff had been told not to share information with the volunteer groups, and this created gaps in the data they needed for their baseline emissions reports (interview, 12 January 2018).

These observations about practices of municipal carbon accounting illustrate situated collaborations and contingencies. The type and quality of activity data that forms the basis of emissions estimates is variable. Processes to estimate greenhouse gas emissions in Byron Shire involved collaborations between gas and electricity retails to generate bottom-up estimates of activity data within the local area. It involved using top-down statistical data to generate representative estimates of activities within the local area. It involved elisions of activities that were thought unimportant but later proved to be significant. Local contingencies are a part of producing carbon accounts in the other field sites, such as the City of Melbourne excluding and then integrating transport emissions into its inventory, and the City of Copenhagen recalculating, over time, the value of its surplus wind energy exports. What is also common to these processes in each field site are the erasures required to produce greenhouse gas emissions inventories that stand alone, abstracted from the collaborative processes through which they were produced. These processes of collaboration and erasure are how emissions estimates and pledged reductions are able to be aggregated – disembedded from place into abstracted municipal carbon accounts, and re-embedded within an abstract "global carbon budget".

Viewed through the lens of co-production, Byron Shire's approach to municipal carbon accounting helped to reinforce the emphasis within the imaginary for Zero Emissions Byron on local autonomy as a driving force behind sociotechnical change and reducing emissions. Gaps and uncertainties within the accounts also highlighted that efforts to internalise carbon within municipal boundaries in a push for carbon self-sufficiency would be challenged by flows of people across those boundaries. By comparison, the City of Melbourne's municipal carbon accounts were to be balanced with imports of carbon credits. The City of Copenhagen's municipal carbon accounts incorporated flows of surplus renewable energy to counteract some of the emissions within the municipal boundaries and counted as "zero" emissions from biomass used to generate heat and power within the city. In all three field sites, boundaries delineated around community-scale carbon neutrality can be seen to conform, to some extent, to local specificities.

5.5 Conclusion

This chapter has examined how practices to define boundaries around community-scale carbon neutrality co-produce objects and scales of local climate governance. Practices of municipal carbon accounting define greenhouse gases in relation to discrete administrative territories. Through these practices, boundaries are defined around CO_2-e and the community-scale for each of the three field sites. These boundaries are produced through dialogues and interactions with institutions, actors, and material realities at international, national, and local levels. These collaborations shape the way greenhouse gases are measured and managed in particular places, collaborations that are subsequently erased as carbon and the community-scale are rendered as general categories – that is, brought into being and stabilised as objects and scales of climate governance.

Boundaries defined around carbon and the "local" hold imaginaries for community-scale carbon neutrality in a specific place and stabilise the imaginary in relation to wider matrices. Tracing boundary making processes through the idiom of co-production helps to reveal dialogues between knowledge and action across levels of climate governance. Practices to render greenhouse gases legible (known) are developed in dialogue with preferences for how to govern (act upon), as seen with dialogue between land-based carbon offsets in Australia, the development of large-scale renewable energy infrastructures in Denmark, and desires for local autonomy in Byron Shire.

Comparison across the three field sites and over time helps us to apprehend the twin shifts that have occurred over time: between tighter definitions of the "local" as a discrete site in global climate governance, and the formation of local governments and their networked alliances as distinct actors in multilevel governance. Orthodox methods of carbon accounting, developed at the international level, rest on sovereignty and territoriality. By adopting the hegemonic assumptions of international carbon accounting, local actors have asserted themselves as discrete entities in global climate governance. Applying common methods gives the appearance that discrete greenhouse gas emissions and actions add up to a seamless whole. Municipalities transcend their discrete geographic territories to form aggregations of populations and infrastructures, economic engines, mayoral powers, and citizen engagements. This approach to carbon accounting assumes dovetail joints – interlocking without overlap, nested within scales. Adopting a coherent and shared set of boundaries around greenhouse gas emissions rests on underlying conceptions of the globe as a universal whole, constituted in turn by nested scales and discrete territories that reinforce the global scale as the locus of understanding and prediction.

Simultaneously, local governments are constructed as legitimate agents to do the governing. These claims to legitimacy are politically stabilised by way of municipal carbon accounts that define greenhouse gas emissions in relation to local government territories. They are also stabilised in relation to moral legitimacy by way of speaking

and acting on behalf of the "local" (or "community-scale") and its citizens. Greenhouse gases assigned to local territories remain hierarchically nested with the nation state, but at the same time provide a way to sidestep these hierarchies by enabling emissions to be calculated and aggregated in relation to networks.

While objects and scales of climate governance are co-produced and stabilised through practices of municipal carbon accounting, the boundaries delineated around the community-scale must conform, to some extent, to local specificities. In each place, boundaries are contingent – negotiated and shaped through ongoing interactions. The City of Melbourne had initially explored a municipal carbon trading scheme and purchasing carbon offsets to help achieve carbon neutrality, effectively importing credits from projects that sequester carbon or avoid emissions elsewhere. The City of Copenhagen's conceptual boundaries allow exports of surplus wind energy to be counted as a carbon offset, from turbines owned by the city's utility company wherever those turbines are located. Byron Shire's conceptual boundaries are aimed at internalising carbon towards realising self-sufficiency, but these edges are permeated by the high number of visitors to the region each year.

Looking more broadly, practices of carbon accounting contribute to the production and stabilisation of knowledge about greenhouse gases that is, to some extent, disembedded and abstracted from the social and material contexts of their emission and absorption. Methods of carbon accounting interposes boundaries across the complex ecologies, sociotechnical systems, and flows of people and resources that animate localities. Organising emissions into "sectors" delineates boundaries around different types of technical and economic systems. Designating "scopes" allows accountability and responsibility to be assigned to actors within and beyond specified boundaries. These methods produce orderly accounts aligned with administrative logics and dominant geopolitical and economic structures, even while the social and material realities from which these figures are drawn do not necessarily or easily conform to neat categories and nested scales. Rather, these methods produce new administrative scales populated by objects and agents that may be governed in relation to the global climate.

In sum, boundaries delineated around greenhouse gases connect sociotechnical imaginaries of community-scale carbon neutrality to a specific place, and at the same time render an abstracted version of that place populated with objects and agents of climate governance. Practices of municipal carbon accounting help to define accountability and responsibility for global climate change in relation to greenhouse gas emissions at the community-scale. They shape, from the outside, conditions of possibility in which particular sociotechnical imaginaries of community-scale carbon neutrality could be achieved. These conceptual and spatial boundaries are also interposed across complex ecological and sociotechnical systems. In the next chapter, I approach these systems as "carbon assemblages" in order to examine constellations of communities, technologies and natures that are sought to be reconfigured through efforts to enact community-scale carbon neutrality.

Chapter 6. Assembling community-scale carbon neutrality[18]

6.1 Introduction

This chapter focuses on the ways in which efforts to enact carbon neutrality are negotiated and contested as policy actors attempt to assemble new connections between, people, technologies, and nature. While imaginaries of community-scale carbon neutrality are held in place by boundaries, efforts to realise these collectively imagined futures involves communication and transformation within and across these conceptual edges. The analysis in this chapter is a further step towards addressing the central research question of this thesis about how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

In each of the three field sites, efforts to redirect human activities and sociotechnical systems in ways that reduce and remove greenhouse gases are situated amongst a range of pressing social and environmental changes and challenges. Such issues include population growth, urban development, traffic congestion, social exclusion, costs of living, and housing affordability. As established in Chapter Four, the conditions of possibility in which sociotechnical imaginaries for community-scale carbon neutrality are seen as viable and desirable might be thought of as contingent lineages – a form of assemblage that draws attention to the ways social and material elements are brought together in continually unfolding processes of sociotechnical change. Contingent lineages are at play in shaping cities, the politics of urban design, and pathways of imagined and actual low carbon transition, as they emerge through negotiation, struggle and compromise. These are arenas of "urban cosmopolitics", as expressed by Blok and Farias (2016: 2), highlighting that urban worlds are 'always in the process of being subtly transformed, destabilised, decentred, questioned, criticised, or even destroyed'. The deep and lasting transformations in ecological and sociotechnical systems that are signalled by commitments to community-scale carbon neutrality bring these world-making processes into view. Building on the analysis of boundary making examined in the previous chapter, thinking through assemblages encourages an open-ended appraisal of the multitude of relationships that sit within, permeate and cut across the boundaries delineated around policy goals for community-scale carbon neutrality.

I enter into discussion of these engagements by exploring, in each of the three field sites, an exemplar project that brings together elements of sustainable and low carbon

[18] An earlier version of parts of this chapter (6.2 and 6.4) has been published in Pollard S. (2019) Cities as Forerunners: Local Climate Governance and the Carbon Neutral City. In: Maginn P and MacCallum D (eds) *9th State of Australian Cities National Conference 30 November - 5 December 2019.* Perth, WA. Available at: https://apo.org.au/node/305270.

urban development. The purpose of this more narrowly focused frame of analysis is to examine locally situated efforts to enact processes of sociotechnical change. Council House 2 (CH2) is a single office building in the central city located next door to the Melbourne Town Hall. As the City of Melbourne's main administration building, it strongly reflects municipal policies and strategies for environmental sustainability and climate change. Habitat is a small, newly developed village located to the north of Byron Bay at the eastern edge of the Arts and Industrial Estate. It has been developed independently from wider municipal targets and strategies, with limited involvement from the Shire Council (aside from the usual planning and building approvals). Nonetheless, the project embodies strong principles for environmental and social sustainability. Nordhavn is a large residential and commercial precinct to the north of the Copenhagen city centre, the vision for which was established through an international design competition held alongside the city's hosting of the 2009 international climate change negotiations. The design brief specified carbon neutrality as a key criterion for the precinct (Blok, 2013: 8-9).

Although far from equivalent, each project purports to represents a microcosm of the city at large, and to address wider issues afflicting the town or city that it is nested within. These issues include (to varying degrees) climate change and policy goals for net zero emissions. The projects also differ in degree of municipal government involvement and reflect the range of actors involved in local climate governance. Focusing the analysis on these three projects provides a way to examine actions and interactions around issues of urban development and low carbon futures, and generate insights into how efforts to enact sociotechnical changes are being negotiated and contested in particular places.

The analysis presented in this chapter applies the concept of "carbon assemblages" (Pollard, 2019) to trace how carbon, citizens, technologies and natures are dissembled and assembled through CH2, Habitat and Nordhavn. Assemblages come together around a focal point but extend open-endedly, always contingent but never bounded. Carbon assemblages come together around a focal point of carbon dioxide equivalent (CO_2-e) as an object of climate governance. These three projects reconfigure complex sets of heterogeneous social and material elements in relation to broader ideals of urban sustainability and, especially in the case of CH2 and Nordhavn, carbon neutrality. Framing these projects as heterogeneous assemblages of social and material elements is one way to trace the uneven relationships of knowledge and power through which processes of sociotechnical change are enacted. This approach helps draw attention to the ways in which carbon assemblages – such as the City of Melbourne's imported carbon credits, Byron Shire's internalised carbon removals, and the City of Copenhagen's exported surplus renewable energy considered previously – are stabilised and destabilised, negotiated and contested.

Informing the empirical substance of this chapter, I participated in guided tours of all three sites, and made informal visits on several occasions, which I convey in the form of brief ethnographic accounts. I supplemented these primary sources with publicly

available documentation about the projects and other local climate strategies. I also benefited from in-depth examinations of the CH2 and Nordhavn design processes by Hes (2007; Hes and Bayudi, 2005) and Blok (2012; 2013; Blok and Meilvang, 2014) respectively. Primary and secondary materials on Habitat are not readily available, reflecting the smaller size of the development and the more informal work culture of the area. As the lead architect on the project, Dominic Findlay-Jones, explained when I asked about accessing some of the design materials: 'There was never a formal brief issued from the client – it evolved over many years of late-night conversations' (Personal communication, 28 May 2019).

The structure of this chapter brings projects of different sizes, formats, and situations successively into view – an administrative office building in the central city, a village development on the urban edge, and a waterfront precinct carved out of an industrial zone. I then trace outwards from these projects to examine wider efforts to assemble urban sustainability and carbon neutrality in relation to the three field sites. Comparison within and between the field sites highlights the importance of both assembly and disassembly in efforts to reconfigure relations between people, technologies and nature and enact community-scale carbon neutrality.

6.2 Assembling carbon neutrality through Melbourne's CH2

> The building needed to be greenhouse neutral; a lighthouse project; improve employee wellbeing; and analogous to industry transfer
> –Mick Pearce, Lead Designer for CH2 (quoted in Hes and Bayudi, 2005: 236).

In its inaugural strategy for Zero Net Emissions by 2020, the City of Melbourne (2003: 4) identified "leading edge green design" as a core strategy to meet its emissions reduction targets. As with many cities, the City of Melbourne identified energy consumed in buildings as the major contributor to the municipality's emissions (City of Melbourne, 2003: 15). In order to reduce this component of its emissions from its corporate operations, and to provide a new benchmark for commercial offices in the city, the Council undertook to redevelop its administrative offices on the corner of Swanston Street and Little Bourke Street to the highest environmental standards (City of Melbourne, 2003: 13). The opening quote conveys that net zero emission was one of several objectives that the council and its partners on the project set out to achieve. The principle of carbon neutral operations was pursued through energy and resource efficiency and by maximising the use of on-site renewable energy. Turning first to these through an ethnographic encounter with the building, I then go on to examine how carbon neutrality has been inscribed into CH2 based on measures that extend beyond the city.

6.2.1 Assembling CH2

Liam Henderson, a sustainability officer with the City of Melbourne, greeted me in the ground floor foyer of CH2 on Tuesday afternoon, 11 June 2019. Liam conducts public tours each year for events like Melbourne Open House, and regularly guides

new council employees through the building. He describes these partly as orientation sessions to help people get the most from the building, such as with the cycling facilities and energy efficient features. He also uses these tours to demonstrate the whole suite of council's sustainability and climate policies.

We begin the tour outside in Rainbow Alley, the hum of the city punctuated by the sound of trams rumbling along Swanston Street. Above us, wooden louvers on the western aspect distinguish the building from its surrounds and shade the glass-walled elevators and stairwells that rise 9-floors above the foyer. It is dark in the laneway, but a vertical garden of vines, creepers and flowers fractures the gloom on the northern elevation. Liam describes the green façade, and the rooftop garden above, as capturing the essence of Council's 2017 strategy for Nature in the City (City of Melbourne, 2017b). While these growing elements of the building are not exactly thriving, he tells me that issues with the design and maintenance of the green walls and roof have directly informed Council policies and engagement on green infrastructure. This includes through Council's partnerships with the state government and other inner metropolitan councils on the Growing Green Guide (Department of Environment and Primary Industries, 2014), and on the Council's own Green Our City Strategic Action Plan 2017-2021 (City of Melbourne, 2017a).

Alongside the balconies, understated chimneys vent warm air from the interior through four micro-turbines on the roof, which were designed to recapture some of this energy. Liam points out how the windows taper with elevation to optimise the natural light inside. Staff can open the windows for fresh air, and in hot weather they open automatically during the night to purge the warm interior. On the southern elevation above bustling Little Collins Street, air is drawn into the building and cooled through four "shower towers" using rainwater caught on the roof. While these elements contribute to CH2's energy and resource efficiency, Liam noted that they also reflect Council's desire to integrate environmental sustainability, resource efficiency, and water sensitivity into urban development.

Moving inside, the open plan office is a comfortable temperature, and the overhead lighting is subdued. It was designed to be half as bright as other office environments to reduce energy use, supplemented with natural light and desk-lamps. The most distinctive feature is the waffle-shaped ceiling. Its thermal mass helps maintain interior temperatures, and the undulating curves channel the warm air that rises from human bodies and desktop computers to the chimneys we saw from the alley. Simultaneously, cool air enters through floor vents at each workstation to create a cylinder of fresh air around each employee that is intended to improve health and well-being and, ultimately, boost productivity.

As with all of Liam's tours, ours ended on the rooftop. 'How lucky are we', reflects Liam, 'to have this outside space in the middle of the city'. From this rooftop oasis, he directed my gaze out across the city where there is hardly a hint of green amidst the towers of glass, steel and concrete. For the new employees who also end their tour

here, this is a moment that, in Liam's experience, often evokes reflection: 'There is so much work to do, but it's also a call to action'.

What is being assembled in CH2 are new material relationships between sun, wind, water, light, timber, and plants. New social relationships are also entangled in these reconfigurations with respect to how employees might choose to travel to and from their place of employment, move around within the building, and interact with others and with those material elements listed above. The building itself is an intervention within the city, somewhat overshadowed by the built environment in which it is located while also demonstrating an alternative approach to urban development within that setting. On a small scale, the building reflects and embodies the City of Melbourne's efforts to design and enact sociotechnical change starting with a key part of its own operations.

6.2.2 Assembling local government leadership

A key goal for CH2 was to demonstrate environmentally sustainable design and technological innovations, paving the way for adoption of these by Melbourne's development industry. Councillor Cathy Oke reported how important it is for the City of Melbourne, as a capital city, to promote good urban design and sustainability outcomes (interview, 8 December 2017). In this respect, the "analogy" to industry transfer specified in the opening quote was an important drive behind CH2's experiments with design and technology. Liam reflected during the guided tour, and in our other conversations, that CH2 'intentionally pursued innovations such as black water treatment, wind turbines, shower towers, and phase-change materials that weren't proven technologies at the time, in order to show the development community new possibilities and to reduce the innovation costs for those that followed' (Personal communication, 28 February 2019).

As I learned on the tour, many of these experiments have failed. Maintenance of the micro wind turbines proved more costly than the energy they generated; the black water treatment did not have enough water flowing through to operate properly; and the phase-change materials were not replaced at the end of their lifespan, causing them to rust. Even the interior lighting has been retrofitted several times, with employees working on the design floor, for instance, installing brighter lights to support their vision-intensive duties. Liam related the negative commentary that surrounded these failures, with some in the urban development industry writing off the project as a "white elephant". But as with the green infrastructure mentioned earlier, these lessons have helped to improve policy development, industry engagement and community outreach by council officers (field notes, 11 June 2019).

Liam commented that public tours of the building continue to attract people, reflecting that CH2 remains a landmark in Melbourne's urban landscape. Commercial buildings in Melbourne have slowly shifted towards more energy efficient and environmentally sustainable design, with council promoting the

adoption of energy ratings for commercial tenancies (using the National Australian Built Environment Rating System, abbreviated to NABERS) and providing low-cost loans for environmental upgrades of older buildings through its 1200 Buildings strategy (City of Melbourne, 2014: 19).

The "green" qualities of CH2 have also been quantified in various ways. Upon its completion in 2006, the Green Building Council of Australia rated CH2 Australia's first "as built 6-star Green Star" office building, pushing the industry standard considerably (City of Melbourne, 2008; Hes, 2007). The "Green Star" rating tool encourages designers to set specific sustainability targets and manage these alongside costs and other constraints. It also acts a marketing tool to help compare and communicate a project's "greenness" with other developments (Hes, 2007: 255). However, the focus on achieving a high rating could have unintended consequences, as Hes documented during a discussion of water issues; new options were suggested that would save additional water but these were not, in the end, pursued because the maximum number of points had already been achieved in the water efficiency category (Hes, 2007: 255). In this instance, the ratings tool constrained adoption of further possibilities for resource efficiency. Nonetheless, evaluation of the building's passive ventilation system supports claims of improved employee health and well-being. This in turn informed the business case for higher capital expenditure on the basis that it would improve productivity and reduce employee sick days (Hes, 2007; Paevere and Brown, 2008). Adding experience to this claim, for Liam the fresh air is the single best thing about the building: 'I feel better being inside all day because I'm breathing fresh air' (field notes, 11 June 2019).

Commercial office developments in Melbourne have shifted towards more energy-efficient and environmentally sustainable design, and the City of Melbourne is justifiably proud of CH2 as a pioneering development. Weighing on this success, building regulations have not tightened to the extent anticipated in Council's 2003 climate strategy, and a gap remains between this kind of "best practice" and the business-as-usual approach to urban development (City of Melbourne, 2008; City of Melbourne, 2014).

In particular, the high-rise apartments that are growing in number within the central city appear to be a more emissions-intensive form of habitation than other dwelling types (City of Melbourne, 2008: 26). David Craven, a director with the C40 Cities network based in Melbourne, described how the Global Financial Crisis that emerged in 2008 constrained many of the opportunities that had been opening up for environmentally sustainable urban development (interview, 10 October 2017). When investments are flowing into urban development, the local council is only one amongst many actors seeking to shape the form that development takes. In Melbourne, planning applications for large developments in the central city (over 25,000m) are automatically channelled to the Minister for Planning under the state's planning framework, reflecting the wider political and economic significance of urban development in the central city (Melbourne Planning Scheme, 2018). Building codes

and regulatory functions are unevenly spread across local, state and national jurisdictions.

Amending the local planning scheme is a significant undertaking. Councillor Oke recounted the enormous amount of work that went into a 2005 amendment to the City of Melbourne's planning scheme that tightened up energy performance standards for commercial buildings (interview, 8 December 2017). Much of this work was led by council officers who developed the scope and options for regulatory changes, consulted with stakeholders in the property industry and more broadly, drafted and revised amendments and accompanying documents. Alongside this, Councillor Oke described the work behind-the-scenes with private developers, property industry representatives and other councillors to build support for the proposed amendments. Cr Oke reflected that 'while the Planning Scheme Amendment for Melbourne was leading edge, other municipalities are now way ahead because their schemes reference best practice benchmarks while the City of Melbourne is more prescriptive' (interview, 8 December 2017). This tenuous process of altering legal and regulatory frameworks reflects key challenges involved in reshaping how urban development in the central city takes shape. In this respect, CH2 signals the Council's broader approach to urban sustainability and low carbon development, of leading by example, developing partnerships with the private sector, and encouraging others to take voluntary actions.

As a demonstration project, the intention behind CH2 was to pioneer new technologies and innovations that could be more widely adopted by the private sector in urban development. While this has occurred to some extent, the project has done little to disassemble existing materialities of urban development. Nonetheless, the project reflects and reinforces the role of City of Melbourne as one of leading by example and encouraging others to follow suit in the context of limits to authority and somewhat restricted powers of compulsion. In this respect, the project can be seen to have gently shifted relationships with other actors in urban development, in particular through the "Green Star" certification, without dramatically reshaping these relationships.

6.2.3 Assembling carbon neutrality beyond the city

Greenhouse gas emissions are often intangible compared to other material elements of the urban environment, even while they are embodied in the most mundane and everyday things and activities. Bringing CH2 into being as carbon neutral has required that carbon to be traced and inscribed beyond the building and the city. There have been two key steps along this path: the City of Melbourne's certification as a carbon neutral organisation under the National Carbon Offset Standard (NCOS), and, later, procurement of renewable energy through the Melbourne Renewable Energy Project (MREP).

Some five years after CH2 was completed in 2006, the City of Melbourne was certified as a carbon neutral organisation. The carbon neutral status of CH2 (and other corporate activities) is inscribed in the files of the government department that regulates the scheme (Department of Environment and Energy, 2018). As with the "Green star" rating, NCOS allows council to communicate its "greenness" to others. While the relatively low cost of carbon offsets made this market-based approach to carbon neutrality feasible from an organisational perspective, the proposition to expanding the approach to meet the community-scale target (as anticipated in the 2003 Zero Net Emissions strategy) was becoming more questionable.

Carbon offsets remained part of the 2008 and 2014 update, though with some reservations. The 2014 update estimated that offsetting community-scale emissions in 2020 would cost around AUD$30 million (City of Melbourne, 2014: 3). This would be a recurring cost and would vary depending on the success of other measures such as renewable energy uptake, cutting emissions from transport and waste, and the cost of carbon offsets into the future. It was also realised that offsetting carbon at such a scale would likely defer more fundamental changes to sociotechnical systems, lifestyles, and behaviours in favour of crediting actions taken elsewhere. This awareness served to dilute the economic imperatives for action defined in earlier iterations of the net zero emissions strategy. Despite their continued place in the City of Melbourne's climate strategy, carbon offsets appeared to be in growing tension with the net zero emissions city imaginary. In 2018, the City of Melbourne revised its timeline for community-scale carbon neutrality to 2050, acknowledging that reliance on carbon offsets would entail high ongoing costs, and would not encourage more fundamental changes to urban sociotechnical systems (City of Melbourne, 2018; Pollard, 2020).

Alongside the diminishing role for carbon offsets, the City of Melbourne developed alternative strategies to meet its corporate objectives for carbon neutrality. MREP is a council-led consortium with other large energy consumers in the central city organisations (City of Melbourne, 2017c). By pooling their demand, they collectively contracted renewable energy from a new wind farm in regional Victoria. When the wind farm came online in January 2019, the City of Melbourne achieved 100 per cent renewable energy for its corporate operations (Vorrath, 2019). The lead sustainability officer on the project, Adam Zaborsczyck, described how MREP positioned the City of Melbourne in a brokerage role within a highly contested and uncertain landscape of national energy and climate policies, with council negotiating complex arrangements between large organisations that had widely varying needs (interview, 18 December 2018).

CH2 and MREP both demonstrate the City of Melbourne's efforts to reduce the risks for the private sector to invest in new technologies and enterprises. Taken together, the socio-material assemblage of the building, the NCOS derived inscriptions of carbon neutrality, and the flows of green electricity secured through MREP reveal CH2's carbon neutrality as a moveable project that continues to

unfold. Carbon is a focal point of these assemblages, with a key purpose of renewable energy procurement to reduce council emissions by disassembling reliance on fossil fuel based electricity generation.

This discussion has taken us some way towards appreciating how carbon neutrality is negotiated and contested through sustainable city-making projects as policy actors work to forge new connections between people, technologies and nature. Since the goal to establish CH2 as carbon neutral largely concerns the City of Melbourne's own operations and employees, however, it offers little purchase on the question of how citizens may be enrolled in local climate governance. To examine this question further, I turn next to Byron Bay and the Habitat development, and then Copenhagen's Nordhavn precinct, and the various ways that these projects also have forged new connections between technologies, people and nature in relation to carbon neutrality and urban sustainability.

6.3 Assembling the commons through Byron Bay's Habitat

> Embodying the Byron Bay lifestyle and everything it represents, Habitat is a fluid, all-encompassing destination 5-minutes from the beach and a 10-minute cycle to town. It was designed for a creative and passionate community, who value the good life as much as getting things done (Habitat, 2019b).

Byron Shire has been experiencing a period of unprecedented growth and development, much of which is concentrated in the town of Byron Bay as a cosmopolitan hot spot for eco-tourism and lifestyle change. This growth is a concern for many locals, evincing unease with the economic promises of development, and the environmental and social ills they are perceived to create and exacerbate. Amidst this change, the Habitat village is a commercially driven project aimed at creating a new kind of place for communal living and working. Unlike the City of Melbourne's CH2 or Copenhagen's Nordhavn precinct, Habitat has not been shaped by, and nor does it contribute directly to, Byron Shire's emissions reduction strategies. Nonetheless, I situate Habitat alongside these other projects in order to look more closely at efforts within the Shire to assemble new connections between, people, technologies, and nature, and the negotiations and contestations that these efforts entail.

6.3.1 Assembling Habitat

Habitat is a 12-acre site, with two acres developed as a commercial precinct and the remainder being established as a village with 100 dwellings. It is built in a low-lying area of wetlands 4km west of Byron Bay, on the north eastern side of the Byron Arts and Industrial Estate. It is also the site of my first interview in Byron Shire with Dominic Findlay-Jones, known to his friends as Dom, lead architect on the Habitat project. We meet at the Barrio cafe, downstairs from Dom's first floor office.

Over lunch, Dom fills me in on the history of Byron's urban development. He moved here eight years ago from Western Australia, and now lives in the nearby town of

Bangalow, a 15-minute drive away. He mentions the "deep green" council that said no to virtually all development throughout the 1990s.

> It's easy to say no to new development, but it can lead to worse outcomes. On the one hand, it has protected the "real" Byron, but on the other hand it tightened up supply and pushed up the costs of housing (interview, 8 January 2018).

More recently, the council's stance on development has shifted, much of which he attributes to the influence of the Shire Mayor, Simon Richardson. 'He has taken a more progressive view that change will happen, and that we have to manage it to make the best of it and get the best outcomes for the community' (interview, 8 January 2018).

What makes Byron attractive for visitors and locals alike, according to Dom, is that 'you've got a lot of like-minded people. Everyone is on an equal footing. It doesn't matter who you are, you can get around in board shorts and no one cares. That's why lots of people come here' (interview, 8 January 2018). While this is a boon for economic development in some respects, the expectation that tourist-led economic development would be the "tide that floats all boats" hasn't eventuated. The huge growth in tourism pushes the prices high and puts a lot of pressure on scarce housing: 'It's the opposite of community', reflects Dom, 'because where people do have a house available for rent, they prefer to rent it over summer for huge amounts, and its hard [for locals] to get in again afterwards' (interview, 8 January 2018).

Asking about these pressures between locals and visitors, Dom replies that the whole dilemma can be summed up as "potholes".

> Road assets are paid for by rates. There are a lot of roads, and there is a lot of rainfall that erodes the roads, as well as something like six billion tourists [laughs], or more like two and a half million, that visit the area each year. How do we get visitors to pay for their impacts? Visitors paying money at the Woolies [supermarket] and the cafés don't actually trickle down to pay for the basics. The council has considered things like bed taxes for years, but only the state government could introduce these. The paid parking [in Byron Bay] is the first attempt to extract taxes from visitors, but the model doesn't see much revenue actually flowing to council (interview, 8 January 2018).

While I heard about these issues first from Dom, almost everybody that I spoke with during the course of my fieldwork mentioned something about potholes and parking to me. It is in this context of pressure for urban development and erosion of local assets and qualities, that the Habitat project has been assembled. Recognising existing socio-material configurations of people, cars, and roads within the Shire, the project was conceived to address issues of a growing population, housing unaffordability, and car dependencies by reassembling these relationships.

6.3.2 Assembling the village

Habitat is framed to address local problems of housing costs and traffic congestion, while at the same time complementing and enhancing the local environment. The "village" imaginary is a central component of the Habitat development. The (informal) design brief was for a village where people could live and work in the one place, and thereby reduce reliance on a car for the daily commute.

The potential for ambitious, village-style, live-work developments is high in Byron Bay because, in Dom's view, 'there is something unique about Byron…(but) it could work wherever there are enough people who want to live and are prepared to look at their work and life differently in order to achieve it' (field notes, 8 January 2018). He noted that a lack of jobs in the area used to be a real problem. 'Habitat shows that the solution is here. Brandon [the developer] had the vision 20 years ago, when he bought the site, that "creatives" would be able to work from anywhere. […] Habitat provides the place to realise this' (field notes, 8 January 2018). The project taps into the laid-back Byron Bay ethos to entice people away from the city. This is a key message in the promotional material and blog found on the Habitat website. For example, one post reads:

> I think Byron is one of the few regional locations in this country from which you could easily base an international business. You really can be a "global player" from what is essentially a small regional town. This is increasingly the trend. Cheap air travel and good Internet is enabling people to make the change - to "live the dream". Who doesn't want that?(Habitat, 2019b).

As I learned later from the Habitat website, the site was zoned "village" some thirty years ago. 'What we've designed is in many ways just an extension of that original intent – somewhere people can live and work in a socially and environmentally progressive, village environment' (Habitat, 2019a; see also Byron Shire Council, 1988). This kind of village imaginary resonates powerfully in the Northern Rivers region, an area where alternative "hippie" societies and intentional communities flourished through the late 1960s and 1970s (Duke, 2010; McCarthy, 2008).

Some of these communities were established along more formal lines, such as Jindibah, the home of Chris Sanderson and Christobel Munson who encouraged the Shire Council to adopt new planning frameworks that would better support rural land-sharing arrangements (interview, 16 January 2018). Welcoming me into their home, I learned how they tirelessly advocated to legitimise intentional communities with the local council via new land titles. At Jindibah, I saw how shared resources are managed collectively across the 113-acre property, with returns held in common by its 12 households (interview, 16 January 2018). Measures to reduce greenhouse gas emissions and integrate with the surrounds are built into the property from first principles, such as with passive-solar designed houses, rainwater harvesting compulsory for all houses, and bushfire preparedness. Like many of their neighbours, Christobel and Chris set up a 10kW solar farm to power their lot in 2011, and in 2019

added to this with batteries and an electric car (personal communication, 23 July 2020). The Jindibah community has planted almost 12,000 trees on their collectively managed property, including 900 trees for each house built in a rural zone as required under local planning laws (Byron Shire Council, 2014). They have space to do so within the Shire, with its history of timber cutting and dairy farming. These kinds of rural land-sharing arrangements have since been taken up by more commercially driven developers to establish "eco-villages" in the region, with several of these now located along the small country road out to Jindibah. Resonant with these approaches to more communal ways of living, Habitat is formulated on the village concept of private tenures and common property and, at the same time, combines the global connectedness of creative cosmopolitan industries with the laid-back values of a beachside lifestyle.

Following our lunch, Dom took me on a tour of the site, pointing out various environmental and social design features. The site is located on ecologically sensitive wetlands, raised to 1.5 metres above sea level using locally sourced infill (carted away from other construction sites) as a precaution against projected sea-level rise from climate change. The architecture responds to this setting in various ways, with covered outdoor spaces between buildings for shade and ventilation, and subtropical gardens that blur the boundaries between inside and outside. The southern edge of the site features an ephemeral creek that is watered from rain cascading off the edge of roofs that have deliberately not been fitted with gutters. This creates a habitat for the tiny and endangered Wollen frog. As Dom describes: 'the rain recharges the creek and the frogs love it. Then the water subsides, and the frogs go back underground' (field notes, 8 January 2018). Thus, the foundations of the Habitat development are formed from the discarded earth taken from other local construction projects to assemble a platform that rises above anticipated climate impacts. Traditional built forms – walls and gutters – are removed to blur the divisions between interior and exterior and to assemble multi-species habitats.

The commercial part of the development wraps around a large central courtyard, with the cafe and shops on the ground floor and office spaces above. There are shared facilities such as a board room, smaller meeting rooms, kitchenettes and private cubicles for phone calls or focused work. As Dom explains, 'The idea is to have the very best facilities, but to share them amongst all of the tenants to keep the costs down' (field notes, 8 January 2018). Across the large open courtyard behind the café where we had eaten lunch, the larger part of the site designated for housing is partially complete but still under construction. Dom tells me that the dwellings are small by modern Australian standards, mainly one- and two-bedroom formats, but that there are some larger dwellings for families. Each dwelling includes space for a studio, workshop or shopfront, creating flexibility and potential for a mixed-use precinct. These smaller private spaces are enhanced with communal facilities including a lap pool, edible gardens, meeting rooms, electric vehicle charging points, strata solar, and Tesla batteries. As with the shared office facilities, this sharing of

services is meant to keep costs down for tenants and lower electricity bills, while also encouraging opportunities for people to bump into each other and create more of a community feel.

The Habitat development was created in a way that would reconfigure people's relationships with their homes and workplaces and with the people around them. The project reassembles homes as workplaces, and workplaces as homes, co-located around common areas and shared facilities. The design features disassemble strict divisions between private and public spaces and properties and, by doing so, create common spaces for more indeterminate and open-ended encounters between people and natures. These design principles and elements resonate with community-minded approaches to living in other parts of the Shire – such as Jindibah and the design concepts of architect John Sparks that we saw in earlier chapters – bringing these village-type assemblage of community and commons from the rural hinterlands to the urban edge.

6.3.3 Assembling sustainability

At the end of my tour, Dom introduced me to the developer, Brandon Saul. When I described my research on local approaches to carbon neutrality, he drily related his idea to get to zero carbon is to 'stop everything — stop eating meat, stop driving, stop building, stop having kids, and stop breathing' (field notes, 8 January 2019). Greenhouse gases emissions and carbon neutrality are not explicitly inscribed into Habitat's design, construction, and operations, such as we saw earlier with technical and calculative practices of CH2. Nonetheless, carbon is assembled into and reconfigured as part of the project through principled approaches towards reducing cars and consumption within its boundaries and for its inhabitants, increasing renewable energy and energy efficiency, and investing in high-quality and long-lasting materials. This distinction between technical practices to define and inscribe carbon, compared to principled approaches, reflect an ambivalence towards the calculative imperative to account for carbon we saw in the previous chapter. Observing this alternative to carefully inscribed carbon accounts and offset projects (such as we saw with CH2) demonstrates that emissions reductions may result even where carbon is not at the focus of these assemblages.

Habitat brushes up against other ways of assembling people, energy and carbon within Byron Shire through projects that, like Habitat, are not necessarily underpinned by calculations of greenhouse gas emissions. A vision for the Shire to be powered by 100 per cent renewable energy sits alongside the zero emissions imaginary. That vision is promoted by organisations such as Community Owned Renewable Energy Mullumbimby (COREM), Enova Energy and Zero Emissions Byron, championed by Mayor Richardson and endorsed by the Shire Council. Local resident, energy consultant, and COREM member Rob Passey (2017) developed the feasibility study for the "100 per cent renewable" goal. He considered potential types and volumes of renewable energy technologies that could meet the target, alongside

their potential contribution to a cohesive and self-sufficient community. Building renewable energy systems within the Shire would contribute to the region's energy independence and resilience and would demonstrate possibilities for regional communities to integrate high penetrations of renewable energy. Ownership of renewable energy systems by local individuals and organisations would keep the money paid for electricity within the Shire. Ownership by those in the lower income strata would help to reduce the flow of money to the already wealthy (interview, 10 January 2018). Rob described:

> This has the potential to decentralise electricity, and also to decentralise power and decision making. With money to pay for the [renewable energy] systems, it empowers the community and gives a community organisation a leg up. It is a democratisation as much as a decentralisation (interview, 10 January 2018).

The vision for renewable energy in the Shire involves a disassembly of existing structures of power, as well as systems of energy production. Renewable energy is at the focus of an assemblage that would reconfigure social, economic, and political relations as well as material relations.

Adjacent to Habitat, a trial micro-grid is being developed within the Byron Arts and Industrial Estate. This trial is specifically about new ways of sharing renewable electricity by assembling networks between individual premises rather than relying on centralised distribution networks. Enova's Managing Director, Tony Pfeiffer, reflected the potential for these kinds of commons to extend beyond electricity:

> The real innovation is to consider how micro-grids can develop as integrated systems that optimise inputs, flows and outputs across multiple utilities and sectors. For example, when there is a surplus of electricity, water and sewerage can be pumped to store energy for later. Excess energy can go into hydrolysis to generate hydrogen, and then to generate ammonia for fertiliser in agricultural systems. Digital technology can help all of this function and co-optimise the system across all of the parts (interview, 11 January 2018).

Such an assemblage seems highly technical, but is not only technological. It is also driven by imaginaries for energy decentralisation, local economic development, community empowerment and resource self-sufficiency. In the same way that the Habitat development creates common facilities and spaces for its tenants, the micro-grid points towards an energy commons that blurs boundaries between producers and consumers of electricity, and also between those sectors of carbon accounting such as energy, transport, industrial processes, and agriculture.

This discussion has highlighted some clear contrasts in the ways that carbon neutrality is negotiated and contested through sustainable city-making projects. Consider how having carbon at the focal point of an assemblage, such as with the CH2 certification as carbon neutral under NCOS, serves to manage carbon through a calculative and transactional approach to clearing a debt of carbon emissions. At the same time, that assemblage shaped sociotechnical relationships in open-ended and indeterminate ways – such as with the innovative technologies deployed within that

building reshaping relationships between City of Melbourne employees with their workplace and with other actors in the urban development sector. Now consider the social and material elements at the focus of the assemblages in Byron Shire – the village and the energy commons. These assemblages will also shape greenhouse gas emissions, though in more open-ended and indeterminate ways than when carbon is held at the focal point. Not calculating emissions in these projects foregrounds different relationships between people, technologies, and nature that may only appear marginally, or not be revealed at all, through practices of carbon accounting.

As we saw in the previous chapter, producing a community-scale greenhouse gas inventory was a part of the process of shaping the Shire's sociotechnical imaginary for carbon neutrality. Indeed, developing a set of "baseline emissions" is put forward in the Beyond Zero Emissions (2017) "Zero Carbon Community Guide" (co-authored with Zero Emissions Byron) as a fundamental early step to chart a course towards a low carbon future. Through the assemblages considered above, we can see that carbon is being negotiated differently within the Shire compared to its foregrounding in more outward-facing relations with other actors in climate governance. Within the Shire there is ambivalence (perhaps a form of contestation) to calculative practices compared to principled actions. These responses to inscribing carbon are also forms of engaging with, and negotiating, efforts to enact low carbon futures.

The investigation of CH2 highlighted the City of Melbourne's efforts to pursue innovation and demonstrate leadership amongst the urban development industry by assembling an environmentally sustainable and carbon neutral office building. Examining the Habitat development generates insights into a patchwork of assemblages within Byron Shire that, while not strictly holding CO_2-e as a focal point, nonetheless constitute important parts of the collective efforts to enact low carbon futures. These assemblages hold social and energy commons as focal and reconfigure relations with carbon through more indeterminate and open-ended encounters. Disassembly is also important to blur divisions between public and private spaces and properties. These analyses draw attention to different ways of enacting carbon neutrality within the field sites, from tightly focused to more loosely arranged social forms, and from authoritative calculation to more ambivalent appraisal. Copenhagen's Nordhavn precinct also exhibits these forms of social and material assemblage. This precinct was envisaged as a large residential and commercial neighbourhood involving city authorities and enrolling citizens to realise carbon neutrality as a central design goal.

6.4 Assembling carbon citizens through Copenhagen's Nordhavn

> Our city planning already integrates climate challenges. In the development areas of Nordhavn, Carlsberg and Amager Fælled, we are committed to creating carbon neutral neighbourhoods of the future (City of Copenhagen, 2009: 22).

A former industrial and port area to the north of the city centre, Nordhavn is the largest urban development project in Scandinavia and is envisioned, within the Copenhagen Climate Plan, as a model of urban sustainability. Nordhavn is one of several "lighthouse projects" intended to encapsulate, in a single precinct, the vision of Copenhagen as the world's first carbon neutral capital city (City of Copenhagen, 2009: 22). And while Copenhagen has a reputation as one of the best places in the world to live, the designers of Nordhavn propose to address a suite of pressing urban issues, including population growth, housing affordability and traffic congestion alongside wider crises of climate change and resource depletion . In this respect, the precinct is explicitly framed as a site for urban experimentation, including in environmentally sustainable design and smart city technologies.

In Copenhagen, city planners and politicians have always expressed a strong desire for the city's carbon neutrality to manifest locally in symbolic and material ways. Blok (2017) describes the launch of Copenhagen's Climate Plan in 2009 alongside the international climate negotiations of that year, and the staged spectacle of children laying their handprints on the blade of a wind turbine in the Copenhagen Town Square. Nordhavn has been designed around expectations that citizens will accommodate and adapt to low carbon technologies within the precinct. These include an assemblage of everyday technologies such as bicycles, large-scale energy infrastructures such as wind turbines, and more obscure technologies such as sensory equipment and smart building control systems to moderate energy consumption (City of Copenhagen, 2015b: 30-31). Each of these technological interventions reconfigures sociotechnical relations. Their strategic deployment through the Nordhavn project reflects the efforts of policy actors in Copenhagen to negotiate and enact carbon neutrality within a specified precinct.

6.4.1 Assembling the car-free city

Copenhagen is known as one of the best cities in the world for cyclists (City of Copenhagen, 2017a). Amongst other things, the city is relatively small and concentrated, the terrain is reasonably flat, the network of bike paths is fine-grained and seamless, and cyclists feel safe with physical barriers of kerbs and parked cars between themselves and moving traffic. Nordhavn promises to be a predominately car-free precinct, simultaneously reducing emissions from urban transportation while tackling congestion and acute shortages of inner-city housing (City of Copenhagen, 2009: 22). The cover of the 2016 Copenhagen Climate Projects report (City of Copenhagen, 2016) features a photo of Nordhavn that conveys this compact ideal, depicting a rooftop playground and outdoor gym built in the centre of the new precinct, people crowded under the swirling pull-up bars, and the shining harbour visible between the neighbouring buildings. Intrigued with this image, I visited the precinct with my family on Friday 6 April 2018. Because first impressions can be revealing (Tsing, 2005: 101), I offer an ethnographic encounter with Nordhavn.

It is a sunny day, but it is also very windy. Rugged up against the cold, we cycle across town along wide bike lanes with the wind blowing in the children's hair as they huddle in the front of our boxy three-wheeled "cargo" bike. We ride past the procession of the guards at the Queen's palace and then along to catch a glimpse of the famous statue of the Little Mermaid, peering through the crowds of people spilling from the tourists coaches. Forced away from the harbour onto an arterial road, the last part of the ride has cars and trucks whooshing past, and the tracks for the S-train running alongside, giving a sense of being cut off from the rest of the city. We turn into Nordhavn past a mosaic of temporary fences and piles of dirt that signal the next stages of construction. Towards the centre of the precinct, funky cafés and galleries line the street while apartments and offices tower above. Finding the rooftop playground, we discover that it sits atop a five-storey car park.

By all appearances, this building is a landmark of sustainable design. The rusted metal facade evokes the area's industrial history, while the vertical garden signals "greenness". It has parking for bicycles and charging points for electric vehicles. A small co-generation plant and batteries send clean energy to surrounding buildings. There is even a pop-up community centre where people can swap unwanted goods. On the rooftop we find in-ground trampolines, climbing frames, swings and seating, but no people on this particularly cold day. There are sweeping views across the harbour, from the majestic Øresund Bridge to Malmö, the iconic arc of 20 wind turbines on the Middelgrunden Reef, the Amagærverket heat and power plant, the Amager Bakke waste-to-energy plant with its "ski-slope" roof, and the neighbouring Maersk terminal where automated cranes load containers on and off ships in elegant choreography. Bouncing on the trampolines, my children are shouting "we are in the future!". But within the vision of the carbon neutral city, a five-story car park feels out of place. The car park signals the obduracy of car-based transport in the city, but strong markers of sustainability and liveability mute the signal. Nordhavn feels suspended between past and future, and the vision of a car-free district remains a work in progress.

Within the Nordhavn precinct, the material design of the iconic car park assembles numerous "green" elements to enhance the experience of urban living – the quality of life for Copenhageners – while contributing to the green economic growth of the city as a whole. The topography of the precinct carves out a niche within the wider city, reclaiming industrial space, expanding into the harbour, and extending upwards through high-rise developments that would be considered far too tall for established parts of the city. Yet despite imagination and effort, disassembling cars from the urban assemblage is not a simple thing to achieve.

6.4.2 Assembling renewable energy

The desire to integrate wind turbines into the material fabric of the city, and into the social identity of its citizens, was epitomised in Nordhavn's design and planning. The new district was envisaged to be energy self-sufficient, supplied with power by four

wind turbines in the adjacent harbour. However, these intentions were derailed by resistance from residents in surrounding neighbourhoods, in concert with powerful allies in Denmark's national parliament. Contestation over Nordhavn's proposed wind turbines entailed deep, place-based concerns about heritage, ecology, and amenity that were dismissed by proponents for the wind turbines as a not-in-my-backyard, or NIMBY, response. Yet these concerns also reflected local knowledge and appreciation of existing values, and the turbine plans did not feature any role for locals in the maintenance and protection of these values (Blok, 2013; Blok and Meilvang, 2014). As such, local resistance emerged over claims as to which knowledge is considered important in shaping visions for the future. Localised concerns spilled into mobilised forms of resistance to the planned turbines and, in an awkward alliance, merged with the national government's resistance to the wind turbines in favour of developing the container port in the area (Blok, 2013: 16). Thus, local and national actors mobilised to subvert the wind turbines, only for local concerns to be overridden in favour of a container terminal that, arguably, reflects even less concern for local values.

Looking more broadly, Hans Christian Soerensen from the Danish Wind Turbine Owner's Association reported that virtually no corporate-led wind projects are getting off the ground near existing communities. Wind farms are being pushed further away from people, to remote areas and offshore (interview, 29 May 2018). He attributed this to the fact that, by the time a local community sees the plans for a corporate-led wind farm, all the major decisions have been made in order to secure finance at the lowest possible cost. Where existing turbine projects have been established in the city, such as at Middelgrunden, they were developed with much more participatory planning. With models of participatory planning, it is possible to take a more flexible approach to design and negotiate conflicts and trade-offs with those affected. Hans shared his view that 'politicians and planners have not understood that power plants have a big impact, and locals need to be involved in how that impact is felt and managed. But it seems easier [to them] to develop wind away from people, such as offshore' (interview, 29 May 2018). This is the situation that the City of Copenhagen finds itself in, both for Nordhavn and for its wider strategy to achieve carbon neutrality that relies, to some extent, on surplus wind energy (City of Copenhagen, 2017b: 19).

To be clear, it is not the City of Copenhagen and its utility company HOFOR that have flipped this model around. Renewable energy is big business in Denmark and around the world. At the opening reception of Nordic Clean Energy Week, the Chairman of Vestas Board of Directors, Bert Nordbergwith, recounted the humble beginnings and global expansion of the company. 'The vision of wind energy in Denmark began with a group of blacksmiths and farmers who saw that wind is an unlimited resource. Forty years ago, they pioneered the Danish wind industry in Jutland. Now Vestas has 92GW of wind globally' (field notes, 21 May 2018). He humorously remarked that 'if every country in the world became like Denmark, we

in Vestas would be very rich' (field notes, 21 May 2018). Yet the participatory planning that characterised this early vision is heavily curtailed in the industrial expansion of wind energy infrastructures.

It is not only technologies being assembled through efforts to develop wind energy projects. Different forms of knowledge and constellations of actors are also pulled into assemblages through efforts to enact these sociotechnical projects. While wind turbines are at the focus of both participatory and industrial assemblages of wind energy, knowledge and power relations are shaped in different ways through these different forms of engagement. Participatory processes to developing wind infrastructures are not as easily scalable and transferable because they are assembled in relation to situated people, natures, and knowledges. This makes contingencies and negotiations more explicit. More industrial approaches to developing wind infrastructures distance and disassemble people and their situated knowledge, making sociotechnical infrastructures more scalable and transferable through abstraction, but never entirely overcoming situated contingencies.

6.4.3 Assembling energy consumers

Attempts to increase the supply of renewable energy to Copenhagen have been synchronous with efforts to recalibrate energy demands. The Nordhavn Energy Lab is central to this task, reassembling various elements of the Nordhavn precinct towards a vision of the smart city of the future (City of Copenhagen, 2017b: 17-18). The Lab's work includes collection consumer data from residents and businesses in the Nordhavn precinct. This data is used to plan and deliver up to 100 projects on urban energy consumption (EnergyLab Nordhavn, 2015). As I learnt on a public tour of the precinct conducted as part of Nordic Clean Energy Week, many residential and commercial tenancies in Nordhavn require tenants to participate in Energy Lab trials to develop cost effective smart energy systems, which ultimately will provide the energy flexibility needed to maximise the use of renewable energy (field notes, 21 May 2018). The trials being run through the Energy Lab are testing how to shift consumer behaviour in order to better calibrate energy demand for when renewable energy is abundant, and so integrate more wind and solar power into the energy system. To this end, a mix of technologies and financial incentives are being used to 'persuade residents and businesses to surrender control of parts of their energy consumption. Instead, the consumer will specify certain comfort levels' (City of Copenhagen, 2015b: 31).

The underlying premise of these trials is that what is needed to shift energy consumption patterns to take better advantage of renewable energy is a combination of financial incentives for consumers to change energy consumption patterns, innovative building automation systems, and increased climate awareness. Within the 2012-2016 Climate Roadmap, a "lack of knowledge" is identified as a barrier to realising gains from reduced consumption through new technologies (City of

Copenhagen, 2012: 29), signalling the premise that a knowledge deficit is to blame for poor public relations to new technologies (Jasanoff et al., 1997; Felt et al., 2007).

The transition from centralised electricity generation based on burning fossil fuels to more dispersed renewable energy generated from the sun and wind involves reassembling sociotechnical infrastructures and human activities. Understanding processes of assembly and disassembly are thus keys to success. The Nordhavn EnergyLab is part of this reconfiguration as it tests new ways to mediate flows and stores of energy within buildings and by residents and workers within the precinct. The Energy Lab and its trials of smart city infrastructure is intended to address the intermittency problem of renewable energy and allow wind energy to be deployed at greater penetration within the electricity grid. Nordhavn provides a setting in which to explore how heat pumps, battery storage, electric vehicles and other technologies might be integrated to create more flexible energy consumption that would balance out more flexible supply (City of Copenhagen, 2016: 26). These are assemblages of technology, but people must be included in the process of assembly.

The experiments in Nordhavn directly inform technical questions of technology substitution and optimisation, but they can also be seen to limit people's agency when it comes to their engagement with these sociotechnical systems. Smart cities and homes become places where people are redundant – where it doesn't matter when you decide to put on your washing machine, because the system will optimise how and when appliances operate. In practice, however, attempts to disassemble people from sociotechnical systems are often challenging. These risks appear to be recognised in Nordhavn, to some extent, with explanatory material describing that trials will be curtailed if they affect the comfort levels of inhabitants, and that participants can opt out of trials if they are disaffected (field notes, 6 April 2018; see also City of Copenhagen, 2016: 26-27).

In sum, Nordhavn's rooftop playground is both an attempt to construct a place of attachment for local residents and visitors to the district, and an exercise to present Copenhagen to the world as a place where low carbon solutions can be found. Showing the vision as fully formed, however, elides Nordhavn as a moveable project facing ongoing social and material attachments to the car. Disassembling the car from these attachments is proving difficult. Equally, the lack of attention given to local resident's attachments to place in the plans for Nordhavn's wind turbines contributed to their undoing. Technical efforts to reconfigure energy consumption appear somewhat ambivalent, at least at this stage of the experiment, about what knowledge and values energy consumers themselves might attach to their consumptive practices. I do not mean to suggest that Nordhavn is underperforming as a low carbon urban development but, rather, to emphasise that citizen engagements are as important as technological fixes, and that these unfold over uncertain timeframes and in unpredictable ways.

6.5 Conclusion

This chapter has focused on how efforts to enact carbon neutrality are negotiated and contested as policy actors attempt to assemble new connections between, people, technologies, and nature. Exploring CH2, Habitat, and Nordhavn as carbon assemblages draws attention to these situated negotiations and contestations. Enacting carbon neutrality involves efforts to disassemble and reassemble social and material elements within and across conceptual boundaries. Encounters between social and material elements, though focused around carbon, are open-ended, such that processes of sociotechnical change are always, to some extent, indeterminate. The focal point of carbon assemblages also shifts, with equivalences between sources and sinks calculated and appraised in different ways. In this regard, CO_2-e is an assemblage of social and material elements around which other assemblages are refocused, within continually unfolding contingent lineages of urban development.

The City of Melbourne's CH2 building reflects and embodies wider municipal goals for community-scale carbon neutrality. The project is a landmark of central Melbourne and an exemplar of Australian green design. Yet the council's efforts to realise the building as one with net zero emissions have relied on purchasing carbon offsets and renewable energy, which themselves rest on equivalences asserted through industrial, legislative, and regulatory ensembles that extend well beyond the city itself. These assemblages of carbon credits and green electricity appear viable as the basis for asserting carbon neutrality of council's own corporate operations. The viability and desirability of relying on carbon offsets to realise community-scale carbon neutrality, however, has been heavily questioned as the conditions of possibility in which that pathway of sociotechnical change was framed have shifted.

In Byron Shire, the imaginaries and discourse around climate change and net zero emissions can, at times, seem peripheral to the mainstream push for development, which is driven much more by social and economic concerns over population growth and housing affordability. Where climate and net zero emissions are configured into urban development, it is from the principled direction of cooperative approaches such as at Jindibah. The Habitat development evokes the self-sufficient community of the village while framing this rural idyll within a globally connected cosmopolitan network. Marketing for Byron Shire's Habitat, particularly to cosmopolitan creatives located in cities elsewhere, invokes the village as a solution to the concerns those creatives may face in large cities elsewhere such as environmental quality, sustainability, housing affordability, and traffic congestion. While environmental sustainability is designed and built into the project as a marker of quality and an appeal to the sensibilities of the target market, carbon is not explicitly inscribed into the project and there is some ambivalence about "carbon calculations". Even so, Habitat can be seen as part of a patchwork of projects addressing sustainability and climate related concerns that are being assembled within the Shire by a range of actors, driven by a variety of interests.

Copenhagen's Nordhavn project has been designed around powerful ideals for energy self-sufficiency, car independence and carbon neutrality, while largely assuming that these ideals inhere in its citizens. The precinct is framed as a climate solution not only for Copenhagen but also for Scandinavia and the world. Yet the movement from design to development, such as with Nordhavn's car park and wind turbines, have involved contestation and renegotiation. The design of Nordhavn as a car free and energy self-sufficient district with optimised consumption is dominated by technologies, while eliding, to a certain extent, the social relations in which these new technologies are embedded.

Technologies are always socially situated, and processes of technological change cannot be understood apart from their social contexts and the reconfigurations of social relations and structures of power they entail. Touching up against the assemblages of CH2, Habitat, and Nordhavn, the analysis in this chapter has also examined wider reconfigurations of social and material relations, with renewable energy a common thread across the three field sites. The City of Melbourne's MREP project assembling large organisations with headquarters in CBD to underwrite the development, through their demand for electricity, of new energy infrastructures in the region. In Byron Shire, local businesses and households are being encouraged to come together around community owned renewable energy, such as through the Enova Energy microgrid, to develop an energy commons. The City of Copenhagen's push to increase capacity of wind energy is part of a larger reconfiguration of relations between local communities and large corporations in the development of renewable energy infrastructures. The new energy futures being negotiated and contested through these assemblages entail changes to physical infrastructures and to social relationships.

Rather than there being pre-designed and optimal configurations, exploring how carbon neutrality is assembled reveals ongoing processes of bricolage, fitting together various social and material elements in dynamic interplay – that is, disassembling and reassembling relationships and attachments between people and places. Crafting carbon neutral cities and climate-conscious citizens appears to involve much more than downscaling global climate concerns and carbon budgets to local municipalities, precincts and buildings, or developing low-carbon technologies that can be replicated and relocated. These are not only processes of technological innovation but exhibit the potential for responses to climate change to foster local attachments and social innovations. Equally, ambivalence, detachment, and contestation also feature in processes to disassemble and reassemble social and material elements.

Expanding from a narrow focus on carbon accounting and material technologies generates insights into the social disruptions and innovations that emerge around envisaged and actual processes of local experimentation in low carbon transitions. Even so, the assemblages being constructed around visions of carbon neutrality are unstable. To understand how they are held together, destabilised, decentred, and

transformed, we need to consider the frictions that emerge as policy actors struggle to enact sociotechnical imaginaries of community-scale carbon neutrality.

Chapter 7. Frictions in local climate governance

7.1 Introduction

Conditions of possibility in which to imagine community-scale carbon neutrality as viable and desirable are contingent and shifting. Boundaries that hold these imaginaries in place are produced through dialogues and interactions with actors, institutions, and material realities across multiple levels of climate governance. Connections forged between technologies, people and nature to reduce and remove greenhouse gas emissions and assemble carbon neutrality are open-ended and indeterminate. This chapter focuses on friction – 'the awkward, unequal, unstable, and creative qualities of interconnection across difference' (Tsing, 2005: 4) – that pervade social and material interactions as policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

Friction is involved in the definition of social structure, cultural form, and agency – a connection that can be seen in the context of earlier chapters. Recalling Chapter Four, the conditions of possibility in which policy actors could imagine community-scale carbon neutrality as viable and desirable were shaped by existing institutional arrangements, material infrastructures, ecological affordances, and cultural discourses. Friction is at play here, with particular starting points from which to imagine a pathway towards an imagined future also constraining imaginative possibilities. So too in Chapter Five, where analysis was focused on institutions and dialogues through which knowledge of greenhouse gases has come to be defined at a global scale and in relation to each of the field sites. That analysis revealed dialogues and interactions between multiple levels involved in stabilising objects and scales of local climate governance, alongside those agents and structures involved in doing the governing. The analysis of carbon assemblages in Chapter Six highlighted awkward, unequal, and unstable qualities of interconnection between people, technologies, and natures in efforts to disassemble and reassemble social and material elements in relation to urban sustainability and carbon neutrality.

Description and analysis in earlier chapters has foreshadowed key circumstances and interactions in each of the three field sites that have shaped, and continue to shape, the efforts of policy actors to imagine and enact low carbon futures. In this chapter, I concentrate on shifting contexts and relationships in each of the three field sites, and the efforts of local actors to stabilise their carbon neutral imaginaries in response to these shifts. The analysis traces the creative and inventive ways that policy actors in each of the three field sites reimagine low carbon futures and re-define boundaries around their policy goals. In doing so, new possibilities to reconfigure sociotechnical systems emerge.

Attention to friction helps to trace these movements and counter-movements as "sticky engagements" by highlighting the different positions of actors within dynamic and continually unfolding assemblages. Friction gives form and direction to situated efforts to imagine and enact community-scale carbon neutrality, and pulls at these trajectories through changing contexts and circumstances. When these forces are pulling in contrary directions, tension results and motion grinds to a halt. Friction holds assemblages of social and material elements together, allowing movement but also redirecting that motion and form as things are pulled along together.

In each of the three field sites, frictions emerge in efforts to enact carbon neutrality in relation to sociotechnical devices, institutions of climate governance, and people. In Copenhagen, technologies give the strongest direction towards the carbon neutral imaginary. As we have seen in earlier chapters, Copenhagen has a strong grip on institutions and infrastructures and is using this hold to pull the city towards carbon neutrality. For the City of Melbourne, institutions and networks give the strongest direction towards their net zero imaginary. That local administration has a weaker authority over technologies and systems than in Copenhagen and has been dragged away from its envisaged trajectory to net zero emissions. With limited authority over large-scale systems of energy, transportation, and the built environment, the council was unable effect all the changes needed to realise its goal for Zero Net Emissions by 2020. In Byron Shire, people within the local community give the primary direction to the zero carbon imaginary. The Shire is a place that is driven by the grip that people have on each other. Frictions developed between different views of who ought to be involved in shaping sociotechnical and ecological change towards net zero emissions, and how accountability and responsibility ought to be defined.

Comparison across the three field sites highlights that, while similar points of friction appear in each locality, processes of sociotechnical change follow different trajectories as a result of these interactions. I examine these interactions in turn, introducing each field site with a short vignette based on my own encounters to highlight significant contexts, events, and relationships that have shaped local processes of sociotechnical change. Because of differences between these places, and different sources of empirical material, the emphasis shifts between technical, institutional and interpersonal dynamics. Of course, all of these dynamics are present in each of the field sites. These interactions can also be understood as frictions between general and specific – global and local – as policy actors seek to translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality, signalling a point that I will develop further in Chapter Eight.

7.2 Re-imagining Copenhagen as fossil fuel free

The House of Green in downtown Copenhagen is prominently located within Industry House, directly opposite the Copenhagen Town Square and City Hall. At six storeys it is one of the taller buildings in the city centre, with a glass façade that is lit up at night with the emblems of prominent Danish "green-tech" businesses. The House of Green is the showroom for the State of Green, a not-for profit public-private partnership founded in 2008 through an agreement between the Danish government and leading business associations (State of Green, no date-b). Its purpose is to showcase Denmark's green solutions internationally and attract investment to Denmark, including by facilitating tours and meetings for international delegates. Around 2,000 delegates visit each year, and they mostly start their tours here. There were no international delegations on the afternoon of my visit on 21 March 2018. But there were a dozen other attendees who had registered to attend one of the regular presentations, most of whom appeared to be students, like me, interested in various dimensions of climate change, energy and technology related fields.

The showroom is a sterile space with white walls, boxy benches covered in green cushions, and interactive touchscreen displays. The presentation begins with a short promotional video about Denmark's State of Green, which identifies the oil crisis of 1973-74 as the trigger for developing the country's policies on energy efficiency and renewable energy (State of Green, no date-a). This change in trajectory is also mapped out in the large timeline painted on the wall of a meeting room attached to the showroom, which identifies the evolving political framework for Denmark's green transition from 1974 to 2014. Both the video and the timeline stress that Denmark's economy has grown by 70 per cent over that period while overall energy consumption has remained steady and greenhouse gas emissions have fallen. The video ends with the slogan "Join the future. Think Denmark". Yet there are no people in the video, only a robotic sounding female voice narrating a flat and emotionless story. The account evokes a technological determinism, with people the passive recipients of scientific, technical and policy innovations. The timeline, too, gives an impression that political and economic decisions determine processes of sociotechnical change, and that Denmark's green transition has unfolded in a linear and predictable way.

Tracing processes of change in relation to the Copenhagen Climate Plan reveals that the efforts of local actors to imagine and enact the city as carbon neutral are complex and outcomes are uncertain. Achieving the goal of carbon neutrality is not assured. Attending to friction generates insights into why things have moved and shifted the way they have. The City of Copenhagen's strong grip on infrastructures and technological systems has been used to pull the city towards carbon neutrality. These are the conditions of possibility examined earlier, anchored through and assembled across boundaries. Yet public acceptance of these sociotechnical interventions has not

unfolded smoothly or predictably. My focus here is on these interventions into urban mobility, wind energy, and district heat and power.

7.2.1 Urban mobility

> The city loves to cycle, the region likes to drive
> — Henderson, J. and Gulsrud, N.M. (2019) *Street Fights in Copenhagen: Bicycle and Car Politics in a Green Mobility City*: Routledge, p189.

Copenhagen is well known as a city designed for cyclists, yet cars are still a dominant mode of transportation within the region, and transport emissions remain a significant obstacle to meeting the goal of being carbon neutral by 2025. When planners at the Technical and Environmental Administration were developing the first Climate Plan Roadmap for the period 2012–2017 (City of Copenhagen 2012), they expected that transport emissions would fall within the municipality as a by-product of the national government's promise to introduce a congestion charge on drivers entering the city during peak periods. The charge was not intended as an environmental measure. Danish policy experts and politicians framed that proposal, primarily, as a solution to address an economic problem of externalities that arise from freedom of vehicle-based movement through the city, particularly congestion and lost labour productivity. Revenue raised by the charge was to contribute to a wider program of economic reforms (Birkbak, 2017).

The proposed congestion charge resulted in public resistance and media controversy and was ultimately dropped, despite the successful adoption of similar policies by several other European cities. Klaus Bundergaard, a senior planner within the Technical and Environmental Administration's Climate Secretariat, put this opposition down to a failure of communication.

> Firstly, they called it a "betalingsring", which translates as a "pay-ring", prompting people to ask, "what exactly are we paying for?". Then it attracted negative attention in the national media because of its effects on regular individuals who, for instance, lived on one side of the ring but whose children went to school on the other (interview, 25 April 2018).

Nuancing this interpretation, Birkbak (2017: 492) suggest that the reason this controversy was not resolved was that the pay ring was narrowly defined by policy experts and politicians as an economic issue, which prevented it from unfolding as a sociotechnical issue. New sociotechnical devices (such as a congestion charge and the regulatory, technological, and social interventions that such charges entail) must always be expected to spark controversy (Birkbak, 2017: 493). This is because the introduction of a new sociotechnical object into collective life always requires that existing worlds be reconfigured (involving disassembly and reassembly, as we saw in the previous chapter), which is certain to evoke new alliances, shifts in power, and contestation (Latour and Porter, 1996: 72; Latour, 2005) Birkbak's analysis reminds us that "the public" does not exist *a priori,* waiting to be addressed, and nor does it

remain fixed through processes of social or technological reform. Rather, publics emerge in relation to specific sets of issues, consultations and controversies.

Tsing's concept of friction helps to trace these movements. The proposed congestion charge generated frictions in relation to registers of urban mobility. These pulled actors together into unexpected alliances and new constellations – such as those united by concern over disproportionate impacts depending on where and how one lived in relation to the pay-ring, or by concern about overcrowded trains. While the extra spending was designed to overcome added friction in labour market productivity (in the form of increased costs of getting to work by car), it was not designed to address additional frictions within the public transport system or alternative travel modes. Thus, the proposal for a new source of friction within Copenhagen's system of urban mobility was felt differently by those positioned differently within that system – positionings that were overlooked in the dominant policy framing of the pay-ring as an economic issue.

Nor was the new charge framed in registers that related to the Climate Plan and greenhouse gas emissions, despite city planners' expectations that it would pull transport emissions down by changing people's travel behaviours within the city. Without the congestion charge, the policy hold on urban transport emissions slipped. Klaus Bundergaard recounted that transport emissions in 2025 are now expected to be around 440,000 tonnes of CO_2-e (interview, 25 April 2018). All these emissions will be from privately owned vehicles and freight movements within the municipality, since by that time public transport and council owned fleet will be producing zero emissions. Even getting transport emissions down to that level will require substantial work, including investments in cycling infrastructure, new public transport and municipal fleet, and charging stations for electric and hydrogen vehicles. Closing the option of a congestion charge opened another set of issues for the City of Copenhagen. To counteract the higher-than-planned emissions from transport in 2025, the City pivoted to its strongest grip within the Climate Plan and developed a strategy to expand its investments in wind energy.

7.2.2 Wind energy

Niels Kristensen, project leader for energy production at the Technical and Environmental Administration, described the process of renegotiating the targets for wind energy in the Climate Plan with HOFOR (one of Copenhagen's largest utility companies) and the city's Finance Administration. 'We figured out in the 2017-2020 Roadmap that the 360 MW proposed was not enough, and so we included an extra 100 MW of wind energy' (interview, 30 May 2018; see also City of Copenhagen, 2017b: 45). Achieving the carbon neutral target in 2025 will rely on generating

enough surplus wind energy to counteract those higher-than-expected emissions from private vehicles.[19]

It can be difficult to position wind turbines in Copenhagen and Denmark, as mentioned in earlier analysis of the Nordhavn precinct. Alongside some local resistance to wind energy projects, there is also steep competition amongst energy companies and a degree of uncertainty over Denmark's national energy policies. HOFOR had been part of an international consortium with a bid to develop a 600 MW offshore wind farm at Kriegers Flak in the Baltic Sea. That consortium withdrew from the bidding process after the Danish government announced it would renegotiate its major energy policy over concerns about the high financial cost of Denmark's energy transition (Offshore Wind Biz, 2016). Niels noted this as a major setback in the planned delivery of wind energy to meet Copenhagen's targets, and went on to describe the other challenges being encountered.

> This [withdrawal by HOFOR] is in a tough political climate as well. In February 2018, the FIT [Feed In Tariff] for wind energy fell away. So, the FIT goes towards zero, and there is a lot of opposition to wind farms in Denmark, a sort of NIMBY attitude emerging. There are people saying things like "Now Copenhagen comes and puts turbines in our backyard, I don't like that", and "How can they count the electricity that comes from here in their accounts over there?'" (interview, 30 May 2018).

Amidst these challenges, planners at the Technical and Environmental Administration are trying to place as many wind turbines as they can within and close to Copenhagen. Niels colleague, Klaus Bundergaard, had argued in an earlier conversation that 'building turbines offshore is preferable because it is more understandable that these will still be Copenhagen's. If turbines are built on another municipal territory, such as West Jutland, there might be problems with accounting and double counting' (interview, 25 April 2018). Expanding on this, Niels described their hierarchy of preferences for achieving the wind energy targets.

> We have 10 to 12 already within the city borders. There may be room for two or three more, but not more than that. The second preference is for near-shore turbines in Øresund near the Airport. […] They will be eight kilometres away, and 200 metres high, but in spaces where aeroplanes don't fly anyway. And like [the turbines at] Middelgrunden, it would be very good branding for the city. The third option is for turbines somewhere else in Denmark, and the fourth option is in other countries (interview, 30 May 2018).

Potential shifts in national energy policy introduced new frictions into the process of bidding to develop this offshore wind farm – reflecting a market that is not only shaped through competition, but also through interactions between political and cultural circumstances (Tsing, 2005: 21). Meanwhile, the methods of municipal carbon accounting that see surplus wind energy counted as a carbon offset in the

[19] As examined in Chapter Five, exports of surplus wind energy are counted as a carbon offset in Copenhagen's municipal carbon accounts because it displaces the need to generate electricity from burning fossil-fuels elsewhere.

city's carbon ledgers draw planners and publics together in relation to local issues and controversies. Within energy and carbon accounts, flows of electricity and greenhouse gases can be neatly summed and separated without friction. In reality, the introduction of wind energy infrastructures produces encounters between people, technologies, and places that are always, to some extent, unpredictable.

Frictions emerge because of the different ways that actors are positioned in relation to these sociotechnical infrastructures. Planners hope to place wind turbines within and close to the city in order to give material and symbolic expression to the carbon neutral city, while limiting the effects of these turbines on actors outside of the city. In some circumstances, these technological interventions pull people in directions that they do not wish to go. Developing wind energy offshore and away from people is a strategy to limit controversy over energy infrastructure. It also allows large corporations and consortiums to more firmly control the political economy of energy systems. However, this approach also limits public participation and, thus, loosens the grip that local actors and communities might have to shape and inflect processes of sociotechnical change.

Serving as something of a counterpoint to the above technical rendering of carbon neutrality is Samsø Renewable Energy Island. Papazu's (2016b) storytelling conveys how the inhabitants of this small island in the geographic centre of Denmark undertook a ten-year transition to generate more than 100 per cent of their energy needs with local renewable energy. The transition was based on using technologies that are recognisable as those being deployed through the City of Copenhagen's Climate Plan – including wind turbines, district heat and power plants, and energy efficiency upgrades. Differences between processes of sociotechnical change in each place warrant attention.

According to Soren Hermansen, the director of the Samsø Energy Academy, the island is not really part of the official Denmark story on the renewable energy transition, which he described as being more focused on the corporate side of things.

> The official Denmark story, communicated through the State of Green branding, doesn't really recognise Samsø. You have to dig down through many layers before you find us. But we are seen by others to have a balanced and genuine view. We are building things and getting things done, getting our hands dirty. People will seek us out to ask for our opinion, advice and help. State of Green is only interested in selling the finished product and getting the icing on the cake. But we have legitimacy from doing this stuff ourselves (interview, 8 June 2018).

In contrast to the technological determinism and linear timelines displayed in the House of Green, Samsø highlights how communities can be brought together around processes of sociotechnical change to take advantage of friction through what Papazu terms "participatory innovation" (2016b). As Soren remarked, this requires a certain relinquishing of control and a tolerance for uncertainty about how long things will take and what the outcomes will be. The island's wind turbines and district heating plants are the products of successful social processes – the material results of

participation (Papazu, 2016a: 23) rather than optimised responses to tightly-framed policy problem. Papazu's analysis illustrates how the islander's practical and material interactions with each other and with technologies has shaped the direction, form and meaning of the Renewable Energy Island project.

Those at the Samsø Energy Academy have been asked by visiting delegations if they can "upscale" their approach to the energy transition to a place like New York, or Cairo. Soren's response is 'Well, we could talk about it for one neighbourhood block. This is about networks of community. You need to break it down into reasonable entities, communities and networks of communities, and build it from there' (interview, 8 June 2018). This insight opens up a complex, multi-layered and messier view of sociotechnical change than that portrayed in the House of Green or expressed through the Copenhagen Climate Plan. Industrialised and "up-scaled" approaches to sociotechnical transitions tend to obscure more participatory forms of engagement through which actors in different positions may more easily and equally listen, negotiate, and adjust their positions and trajectories.

By increasing targets for wind energy, the City of Copenhagen was able to stabilise its trajectory towards carbon neutrality in response to the failed introduction of the congestion charge. Yet efforts to build wind turbines have encountered ambivalence over carbon accounting methods and contestation over turbine placements. A key strategy to overcome these tensions is to build offshore turbines, away from people. This approach closes down discussion of the energy transition by presenting it as a technical issue, rather than opening it up for discussion as a sociotechnical issue. By regarding the issues and controversies that emerge through these processes of sociotechnical change as concerned only with technical issues, opportunities to build trust and address social impacts and interests are eroded. The story does not stop there, however, because of the way wind energy intersects with other forms of energy production.

7.2.3 Heat and Power

The value of surplus wind energy as a carbon offset is decreasing over time. Denmark's 2012 Energy Agreement set out the intention for all energy and heating to be fossil fuel free by 2035 and use of all fossil fuel sources to be eradicated by 2050 (Government of Denmark, 2012). At this point, and as other countries in the Nordic electricity grid also increase renewable energy production, Copenhagen's surplus wind energy will have less value as a carbon offset. As Morten Højer, environmental economist at the Technical and Environmental Administration, noted,

> The energy system of the Danish national electricity grid is making the transition to low carbon much faster than originally anticipated. The CO_2-e reductions in 2025 in Copenhagen have therefore been cut in half twice over the past four years, as we have re-estimated the roadmap for the Climate Plan (personal communication, 4 August 2020).

The diminishing value of surplus wind energy as a carbon offset prospects have pushed planners at the Technical and Environmental Administration to find new ways to reduce emissions within the municipality. Key strategies include to reduce energy consumption and to reconfigure energy systems to use (rather than export) wind energy when it is in abundance, such as with battery storage or to generate heat. This is where wind turbines intersect with the other major form of energy production in the city, Copenhagen's Combined Heat and Power (CHP) plants.

Most energy use in Copenhagen is for electricity and heating, and this is where city planners are looking to make the largest emissions reductions (City of Copenhagen, 2016: 14). The district heating network, supplied by several CHP plants within the urban area, covers all but 2 per cent of Copenhagen's heating requirements. Niels Kristensen, at the Technical and Environmental Administration, described that replacing coal with biomass in these power plants has contributed almost half of the emissions reductions achieved through the Climate Plan (interview, 30 May 2018). In that calculation, biomass is considered a carbon neutral fuel, and while this status is not without controversy the 2025 target for carbon rests on maintaining this assumption.

Copenhagen's CHP plants were originally built to produce electricity, while making efficient use of the waste heat that resulted. Niels described how this situation has been turned on its head.

> Now, the main reason we need the plants is for the heat, and the electricity is more the by-product. We have switched to being well connected in a wider grid to Sweden, Norway, and Germany, so we can meet our electricity needs more flexibly. So, going into the future, where do we get that heat? We need other technology ready to take over, like heat pumps, geothermal, solar power, to take over from the district plants when they need to shut down (interview, 30 May 2018).

Beyond 2025, Niels explained, city planners are thinking about how to replace biomass in the CHP grid with increasing levels of wind, solar and geothermal energy, store energy using batteries and electric vehicles, deliver heat with heat pumps, and even store heat in buildings (City of Copenhagen, 2017b: 16). As seen in Chapter Six, many such interventions are being tested by in the Nordhavn precinct. The plan to eventually shift away from district heat and power appears to be driven by the desire to make more use of wind energy in the city. However, it is also related to potential controversies over city's the heavy reliance on biomass in the Climate Plan. Dependence on biomass to achieve carbon neutrality pulls against the image of Copenhagen promoted through the House of Green; that the world can turn to Copenhagen for solutions to climate change. As Niels described:

> The story we are thinking about is if the whole world adopted this solution [of biomass] it would start to be a problem because of the areas of forest that would need to be turned over to energy production, and the impossibility of that being done in a sustainable way. For us, we only buy the certified biomass, and we only think about using the biomass as energy within a transition period (interview, 30 May 2018).

This story reflects concern over the potential for widespread environmental and social impacts that may occur from "scaling up" the use of biomass in energy production by other cities. The reflexive concerns of city planners underline frictions at play between the image of Copenhagen as developing template solutions to climate change, and the situated contexts in which such solutions are always enacted. Copenhagen's solution for carbon neutral district heat and power is entangled within wider matrices of forestry practices, certifications, and transport logistics – collaborations across difference that are subsequently erased to create general categories. The reproducibility and scalability of such approaches will always be shaped by specific emplacements.

Looking within the city, there has been relatively little public engagement in Copenhagen around the conversion of CHP plants from coal to biomass. These energy infrastructures have largely remained invisible rather than being reanimated as "green" infrastructures as happened with the wind turbines, at least until they were moved away from people. Current acceptance or ambivalence for biomass as a carbon neutral substitution for coal could yet materialise as controversy if the reliance on this fuel is felt to pull Copenhagener's in a direction they may not wish to go – that is, away from a sense of themselves as environmentally sensitive citizens.

7.2.4 Fossil free Copenhagen

The contours of Copenhagen's carbon neutrality in 2025, should efforts around transport emissions, wind energy, and elsewhere succeed, will remain somewhat unstable as heat from biomass is replaced with electricity from wind. Changes in energy consumption and urban mobility will continue to unfold alongside wider changes to the urban population and the social and material fabric of the city. Planners at the Technical and Environmental Administration recognise the contingencies and dynamic instabilities of the carbon neutral imaginary and have begun looking beyond this date to plant the seed of a new vision for Copenhagen that will see it entirely free of fossil fuels, expressed thus: 'In 2050, Copenhagen is fossil-free, with clean air, no waste and no traffic noise. We have shown the world how to cope with climate change for the benefit of everybody' (City of Copenhagen, 2015a: 15). Although only a small piece of text, all the people I interviewed at the Technical and Environmental Administration referred to this vision of a "fossil free Copenhagen" in our discussion of the issues that had emerged in relation to the design and implementation of the Climate Plan.

The Technical and Environmental Administration's Klaus Bundergaard reflected that the vision of Copenhagen being fossil free, should it include consumption-based emissions, would encompass action in relation to everything from the ubiquitous plastic-wrapped food in supermarkets, to synthetic clothing fabrics, and those emissions embodied in the manufacture and transport of goods and materials into the city. 'This long-term plan will be even more of an umbrella than the Climate Plan. It will need to work across climate, energy, waste and mobility and will need to be a

shared plan across these various administrations' (interview, 25 April 2018). To illustrate this broad reach, Klaus pointed to the frictions developing in the city between energy and waste. 'When coal is fully phased out of Copenhagen's CHP plants in 2020 the incineration of plastics will be the biggest source of greenhouse pollution involved in heat production' (interview, 25 April 2018). The Amager Bakke waste-to-energy plant is the newest component of Copenhagen's energy production system. Opened in 2017, it is contracted to run at full capacity by taking in waste from Copenhagen and surrounds. As efforts to reduce the amount of waste generated locally take effect, the plant may increasingly rely on waste imported from elsewhere, entangling the energy transition in the complex terrain of manufacturing, packaging, consumption and waste collection.

The vision for a fossil free Copenhagen is not a formal policy. Yet even in its inchoate form it recasts the boundaries of the carbon neutral city in new directions. Reframing carbon neutrality as a phase within a process of ongoing sociotechnical change towards a fossil free Copenhagen serves to stabilise that sociotechnical imaginary – not as a fixed end-state but, rather, as a dynamic equilibrium contingent on a wide set of sociotechnical relations. Repositioning boundaries around a fossil free imaginary would also reposition actors in relation to wider systems of production and consumption beyond the territorial scopes and economic sectors of municipal carbon accounting.

The City of Copenhagen's strong influence over its energy system illustrates the importance of power and authority in shaping processes of sociotechnical change. At the same time, these processes cannot be understood without careful attention to interactions with other actors, within the city and beyond. In contrast to the contestations over technology that have pulled and inflected Copenhagen's envisaged pathway towards carbon neutrality, in Melbourne it is frictions emerging between institutions involved in climate governance that have shaped and redirected policies and actions. Of course, technologies and people are evident as well, but my focus in the next section is on how the City of Melbourne has renegotiated and stabilised its identity as an actor in climate governance in relation to international networks and other levels of government.

7.3Shifting boundaries in the City of Melbourne

The City of Melbourne's efforts to enact community-scale carbon neutrality by 2020 were pulled off course, with frictions most prominent in institutional interactions across multiple levels of climate governance. A limited grip on the speed, scale, and form of urban development, volatile national climate and energy policy, and ambivalence over the role of carbon offsets in achieving community-scale carbon neutrality, pulled against the pathways of change envisaged in the City of Melbourne's early climate strategies. The international Paris Agreement and close partnership with C40 Cities created opportunities to re-anchor the City of Melbourne's carbon neutral imaginary through a wholesale revision in 2018. I enter

into consideration of these shifts through a description of the Council meeting at which the new strategy was adopted.

7.3.1 Future Melbourne Committee

Late in the evening of Tuesday 7 December 2018, the City of Melbourne replaced its strategy for Zero Net Emissions by 2020 with the new Climate Mitigation Strategy to 2050: Melbourne Together for 1.5°C (City of Melbourne, 2018). The Future Melbourne Committee unanimously adopted the new strategy at the end of a marathon three-hour meeting. This committee is made up of 11 councillors and oversees the implementation of key council strategies and activities across 13 portfolio areas (City of Melbourne, 2012). Anyone can attend these meetings, subject to certain protocols. The room in which these meetings take place has thick carpet underfoot, dark wood panelling on the walls and high ceilings adorned with detailed plasterwork. Councillors sit at a long L-shaped table, which is faced by several rows of chairs for those in attendance, including council officers, members of the public and their supporters, developer applicants and their representatives, and the occasional ethnographer.

A large painting hangs behind the Councillors. *Construction of the New Freeway over South Melbourne* by Sarah Faulkner (1987) depicts a hard jumble of heavy machinery, construction workers, cars, roads and buildings. In her artist statement, Faulkner (2011) reflects:

> The city was much quieter then with only a few permanent residents; at night, it was like a ghost town. […] On these trips, I saw the building of the new freeway and was inspired to paint the tale. I remember all the heavy road equipment and the road workers, a hive of activity trying to complete what was then such a mammoth task.

The imagery evokes the confidence of modernity. An application for an 80-story apartment building in Little Bourke Street demonstrates that the hard jumble of urban development continues. The council officer in charge of reviewing the application advises that it meets all the requirements of the planning policy. Yet every councillor expresses their dislike of the project, citing concerns from public submissions about overshadowing the small laneway opposite and the qualities of the building that would be demolished to make way for this new development. Despite these objections, councillors concede that rejecting the application would only lead to an administrative appeal and eventual approval at great cost to the council and its ratepayers. The deliberations reflect that Melbourne is a city expanding at pace, but the City of Melbourne has only limited hold over how that development takes shape.

Through the evening, numbers in the public gallery slowly shrink as more development applications are heard until few remain for the last item on the agenda, the City of Melbourne's new climate strategy. There is unanimous support for the climate strategy as a vision that will shape the city over the coming thirty years. Yet the meeting also highlights frictions. The twin imperatives of urban expansion and

climate mitigation are pushing the city in different directions, raising the question of how friction between these forces will alter both trajectories. At the same time, institutions of urban governance and administrative appeal pull decisions away from the trajectory desired by councillors, drawing attention to the different ways that actors are positioned within these institutional systems of urban and climate governance.

7.3.2 Strategic Alliances[20]

Earlier chapters have highlighted that the City of Melbourne is unusually small in terms of its jurisdictional authority, with limited grip on the policy levers that shape systems of energy, transportation, and urban development. Without this grasp, the imaginary for community-scale carbon neutrality has been dragged along by shifts in state and national policy and re-directed by other forces.

The period since the 2014 update of ZNE2020 saw significant changes in climate governance across multiple levels. At the national level, the volatility of climate and energy policies continued, with unstable energy policies and inadequate measures to reduce emissions in line with the Paris Agreement (OECD, 2019). Much of this volatility was focused on the development of market-based carbon trading in Australia. For the City of Melbourne, the role for carbon offsets in its imaginary for community-scale carbon neutrality was gradually diminished, substantially eroding the foundations of that imaginary – its conditions of possibility – in entrepreneurial leadership and carbon trading.

Alongside these shifts, commitments and activities to address climate change gained momentum at other levels. Notably, the Victorian Government introduced state-based targets for renewable energy, and a goal for state-wide net zero by 2050 through the *Climate Change Act 2017*. At the international level, C40 Cities developed a platform for its member cities to reduce emissions in line with the lower threshold of the Paris Agreement's 1.5°C target. Called Deadline 2020, the program coupled top-down modelling of global carbon budgets with assessments of cities' per capita emissions and GDP to define community-scale emissions reduction trajectories and identify priority actions (C40 Cities and Arup, 2016: 10). In these contexts, the City of Melbourne's refreshed climate mitigation strategy bypassed the volatile landscape of national politics to re-anchor the carbon neutral imaginary in relation to the Paris Agreement and the Deadline 2020 program. It was also the first local government in Victoria to pledge emissions reductions through the state's new climate legislation –

[20] An earlier version of the next three sections was published as Pollard S. (2020) Imagining the Net Zero Emissions City: Urban Climate Governance in the City of Melbourne, Australia. In: Hoff J, Gausset Q and Lex S (eds) *Building a Sustainable Future: The Role of Non-State Actors in the Green Transition.* Routledge, p211-229. Available at: https://doi.org/10.4324/9780429280399.

an alignment that seems especially crucial given the state government's grip on the laws, regulations and policies that could be exerted to reduce emissions.

The City of Melbourne was one of eight cities to pilot the Deadline 2020 program as a basis for its new climate strategy (C40 Cities, 2018a). The program requires all its member cities to develop climate action plans before 2020 that are guided by these targets but configured around their specific circumstances. Julia Lipton led this program from the C40 Copenhagen office, working closely with policy actors at the City of Melbourne as they developed their new climate strategy. The Deadline 2020 program plays an important role in city-level advocacy on climate change, especially when the political and legal frameworks that would otherwise shape emissions reductions (by producing friction and redirecting forces) are lacking. Julia reflected,

> This is important in places like Australia, where the national government is actually critical of action by state and local governments to reduce emissions and respond to climate change. Cities can point to the work that others are doing and create more legitimacy and support for their actions (interview, 11 May 2018).

The Deadline 2020 framework creates allies of cities and local governments to justify and promote stronger ambition. By allying itself with this program, the City of Melbourne solidified the foundations of its carbon neutral vision – creating friction through its ties in this international network, and with state-based legislation, that could aid in local efforts to resist the pull of volatile national politics.

7.3.3 Carbon offsets

The entrepreneurially based vision for Zero Net Emissions by 2020 established in 2003 failed to take hold, as this vision – conditioned on the anticipated emergence of global carbon trading – was dragged from its anchorage through shifts in national and international policy and shifting perceptions about the role for purchased offsets in achieving community-scale carbon neutrality.

The new climate strategy rejected an option to achieve net zero emissions by 2020 by purchasing carbon offsets due to high recurring cost (substantially higher than estimated in the 2014 update) and a lack of local benefits (City of Melbourne, 2018: 21). In principle, the City of Melbourne accepts that offsets can be justified where they provide 'important environmental, social and economic benefits for reducing emissions in remote and regional Australia, and in many other countries' (City of Melbourne, 2018: 22). However, in terms of relying on offsets to meet and sustain net zero emissions, 'achieving emissions reductions through purchasing offsets alone will not address the systemic causes of greenhouse gas emissions or achieve the full extent of benefits for Melbourne residents and businesses' (City of Melbourne, 2018: 22).

The City of Melbourne's sociotechnical imaginary of carbon flowing through market-based exchanges has been pulled in new directions. Purchasing offsets from elsewhere does little to address local concerns. On the contrary, it can be seen to

erode local interests by directing limited financial resources elsewhere. However, there was evidence of mixed views on the role for carbon offsets at the Future Melbourne Committee meeting described earlier. Several councillors voiced their support for offsets within the city's climate strategy, with one commenting that 'carbon offsets are part of the mix for sharing benefits with the poorest parts of the world' (field notes, 7 December 2018). Councillor Cathy Oke, who had brought the motion for the new climate strategy, conceded that 'offsets are part of the strategy and play an important role locally and internationally' but added that 'we don't want to get to zero net emissions by relying on offsets alone' (field notes 7 December 2018). Nonetheless, the new climate strategy concedes that small amounts of residual emissions from transport and waste are likely, and anticipates that the viability of offsetting those through purchase of carbon credits may improve over time as the international carbon market develops (City of Melbourne, 2018: 22).

Placing this in a broader context, the Deadline 2020 strategy contains modelling for its member cities to realise their share of emissions reductions needed to meet the 1.5 °C target. The modelling anticipates that negative emissions technologies such as large-scale bioenergy carbon capture and storage will be needed from 2050 and beyond (C40 Cities and Arup, 2016: 88). This assumption, which has potential to shape the climate strategies of cities across the 40 network, raises a set of issues we encountered earlier about scaling up the use of biomass – potential controversies that are prompting the City of Copenhagen to begin planning a transition away from its own reliance on biomass. I asked Julia Lipton at the C40 Cities Copenhagen office about these assumptions in the Deadline 2020 program's modelling, and she acknowledged that it is a tricky area.

> Cities are already struggling to get to net zero by 2050. With current technology, they are not going to get to zero. There will be residual emissions that they need to somehow deal with. For example, New York, Paris and Berlin are each projecting that they can reduce emissions by 80-90, or 95 per cent respectively. We at C40 are promoting that cities focus on realising these emissions reductions and put aside the question of exactly what to do about the residual emissions. […] There are no prescriptions at this stage about how these residual emissions ought to be dealt with. Technology is changing, carbon markets are emerging, and so the possibilities to offset or sequester these residual emissions will change over time, between now and 2050. […] Our approach is that cities must measure and be transparent about what is residual, and commit to measure and report on this, and look to mechanisms to reduce residual emissions further but without necessarily committing to offsets, which remain a contentious issue (interview, 11 May 2018).

Whatever balance is eventually reached between reducing and offsetting emissions will be shaped by frictions between addressing local interests and concerns and contributing to wider social and ecological justice. Acknowledging frictions between local and global – emplaced and abstracted – is crucial to understanding how choices are being made about how and where to balance sources and sinks of greenhouse gases in efforts to imagine and enact net zero emissions.

7.3.4 Shifting boundaries

The rejection of a key mechanism that underpinned the City of Melbourne's early imaginary for the carbon neutral city has required that the City of Melbourne adjust the spatial and temporal boundaries that held that imaginary in place.

Aligning the strategy to the Paris Agreement and state government targets lengthened the timeframe to achieve net zero emissions appreciably from 2020 to 2050. In one sense, adopting this longer time frame can be seen as the culmination of a gradual shift in institutional identity by the City of Melbourne, charted in previous chapters and coming into focus here: from entrepreneurial "first mover" (the basis for its initial proposals for municipal carbon trading, and envisaged in the design of CH2) to "broker" (such as occurred through the process of enacting CH2 and as embodied in the Melbourne Renewable Energy Project). This brokerage role is not so much about leading by example; pulling from the front with associated first-mover risks and advantages. Rather, brokering is about mediating relationships and interactions in order to ease friction; pulling from the middle to steer others in a certain direction. By adopting a longer timeframe to achieve net zero emissions, the City of Melbourne moved from the front of the race and into the peloton, travelling more closely with others to reduce drag and take advantage of shared momentum.

The new climate strategy also recast spatial boundaries around the net zero emissions city across larger and smaller scales, generating new possibilities for the City's municipal carbon accounting practices on several fronts. C40 Cities worked through the City of Melbourne to reconcile the municipal carbon accounts of all 32 of Melbourne's metropolitan councils and establish a community-scale emissions inventory for the Greater Melbourne area (City of Melbourne, 2018: 13). This brokerage is a small step towards easing frictions associated with the fragmented administrative territories of the wider metropolis. The City of Melbourne's participation in international city networks provokes some unease because Melbourne is projected as a "world city" but the City of Melbourne's jurisdiction covers only a small part of that whole. Developing the metropolis-wide account of greenhouse gas emissions establishes a technical rendering of the metropolis as an entity of climate governance. Brokerage is also important here. Although there are already alliances and partnerships between local government authorities, there are also frictions between municipalities in varied contexts, including those with different visions and imaginaries of what a low carbon or net zero future may mean (such as those discursive variations discussed in Chapter Three), and those without any such vision.

The City of Melbourne's new climate strategy has begun to stretch and shift the conceptual boundaries around carbon in relation to local jurisdictions and systems of production and consumption. In terms of actions proposed within the strategy, many are focused on delineations of carbon neutrality at smaller scales and around discrete spaces within the municipality. Given the council's limited grip on the scale and pace

of urban development across the central city as a whole, it has focused efforts on getting the carbon neutral imaginary to take hold at the level of individual buildings and precincts and growing from there. As with the CH2 building examined in the previous chapter, certain urban renewal areas and buildings within the municipality are planned to showcase further possibilities for net zero precincts and developments, guided, for example, by new National Carbon Offset Standard for precincts (Commonwealth of Australia, 2017) and the C40 Cities program for climate positive development (C40 Cities, 2016). Establishing small pockets of low carbon development within the city creates frictions aimed at inflecting the powerful imperatives of urban expansion signalled earlier.

Heralding further possibilities to redefine boundaries around carbon neutrality, the City of Melbourne's new strategy also mentions consumption-based approaches to measuring emissions, as a complimentary alternative to territorially based municipal carbon accounting. Such an approach 'takes into account the upstream and downstream impacts of products and services that Melbourne consumes including imports and exports from the city' (City of Melbourne, 2018: 62). This re-framing of carbon positions the City of Melbourne as a broker between locally situated consumptive activities and extended sociotechnical systems, and resource flows – such as the illustrative example of fictional character "Jo" and her morning commute and coffee purchase, which generates emissions from transport, natural gas, stationary electricity, and waste (City of Melbourne, 2018: 11). There are similarities with the City of Copenhagen in the way practices of consumption may be pulled into efforts to address climate change at local levels. Indeed, many cities are beginning to develop consumption-based approaches to carbon accounting, as highlighted in recent reports by C40 Cities (C40 Cities, 2018b; C40 Cities et al., 2019).

Alternative discourses and practices of carbon accounting begin to modify the frictions between production-based ("nodal") and consumption-based ("networked") spheres of influence. As we have seen in earlier chapters, practices of municipal carbon accounting stabilise objects and scales of climate governance across multiple levels. Shifts in discourses and practices of defining boundaries around carbon – even exploratory shifts – generate frictions. Territorial based carbon accounting can, at times, reinforce narratives of "green growth" – that is, possibilities to decouple greenhouse gas emissions from economic growth. Consumption-based accounts can upend this narrative because they are often much higher than production-based emissions, highlighting connections between wealth, consumption, and emissions and, in some cases, pulling against stories of cities' success in reducing emissions (C40 Cities, 2018b: 6). This raises concerns about emissions-producing activities merely being shifted from one territory to another. On the other hand, consumption-based accounts are being used to argue that local climate governance can influence an even larger set of emissions-producing activities 'by influencing consumption within the city as well as production processes beyond their jurisdiction' (C40 Cities et al., 2019: 131). Such influence might be seen as a form of brokering – facilitating wider

collaboration between multiple actors. These emerging discourses re-position local government actors within wider matrices, with potential effects on the stability of objects and scales of climate governance.

In sum, policy actors at the City of Melbourne have stabilised their imaginary for community-scale carbon neutrality by re-anchoring it in relation to wider networks and scales of climate governance. This has required the conceptual, spatial and temporal boundaries that held the imaginary in place to be redefined. Each of these boundary adjustments has served to reposition the City of Melbourne as a broker between actors across multiple levels of climate governance. Such brokerage holds potential to alter the frictions experienced by the City of Melbourne and other actors in their efforts to enact carbon neutrality.

Thus far, the analysis has focused on interactions in relation to technologies and institutions. As these interactions unfold in unexpected and indeterminate ways, policy actors in the cities of Copenhagen and Melbourne have adjusted boundaries to stabilise their respective imaginaries for community-scale carbon neutrality. In each place, of course, people have been involved in these interactions and adjustments. Climate governance is, after all, about how people make choices about how to govern the human activities, and the social and technical systems and ecologies in which they are embedded, that contribute to climate change. Even so, it can be difficult to see past processes of technological and institutional change to apprehend the way people are positioned within these systems of local climate governance. For this, it is helpful to turn to Byron Shire.

7.4 Bridging local and global in Byron Shire

Byron Shire is a much smaller local government, with fewer staff and resources, than the City of Copenhagen and the City of Melbourne. The people become more visible in this smaller setting, though they are always there in the other settings as well. And as in those other places, technologies and institutions are also a part of interactions here. The analysis in this section is focused on the grip that people have on each other as they negotiate ways of organising local climate governance and enacting processes of sociotechnical change in a context of local and global connection. I open this discussion with a brief vignette of the Cape Byron Lighthouse, an icon of the region that is loved by locals and amongst the most popular attractions for visitors.

7.4.1 Cape Byron Lighthouse

The lighthouse sits at the very top of Cape Byron, perched on the eastern-most edge of the Australian continent and reaching out into the Pacific Ocean to guide ships and seafarers to safety. It is an iconic symbol of Byron Bay appearing on postcards and tourist brochures. The steep walk to the Lighthouse is an activity enjoyed by visitors and locals alike. Although it is possible to drive, it is discouraged by the imposition of parking fees (altering the friction between alternative travel modes, as

with the proposed congestion charge in Copenhagen). Climbing the path from Wategos beach, walkers are met with a sign that congratulates them on 'A cheaper, healthier and environmentally responsible way to go! By choosing to walk the coastal track […] you have saved one kilogram of greenhouse gas from going into the atmosphere!' (field notes, 14 January 2018).

The lighthouse was built in 1901 with a clockwork mechanism to rotate its eight-ton lens. At regular intervals through the day and night, lighthouse keepers would carry steel weights up the circular staircase and fit them to the system of pulleys that dragged the lamp around as the weights slowly descended through the centre of the tower. This task needed to be done even in the daytime, because sunlight shining through a stationary lamp could spark bushfires in the surrounding hinterlands. In 1956 the lighthouse was connected to mains electricity. The vaporised-kerosene mantle burner was replaced by powerful electric lights and an electric motor put an end to the lighthouse keeper's Sisyphean task. I visited the lighthouse on 14 January 2018 and learned about this history as part of a tour run by volunteer group Cape Byron Lighthouse Friends. Speaking with the tour guide afterwards, I learned that they had approached the relevant state government department with a proposal to power the lighthouse on renewable energy, as a symbolic and material expression of local values of environmental sustainability and objectives for carbon neutrality. Unfortunately, at that time, the bureaucrats were not interested in discussing the proposal.

This account reflects, in a small way, constraints on the ability of local actors to enact changes to the sociotechnical systems that shape climate impacts. Individuals may choose to walk to the lighthouse, enjoying the spectacular views down sheer cliff faces and across the ocean, and intimate glimpses of verdant local ecologies. They can reap the health benefits of physical activity and avoid the costs of parking at the summit. The congratulatory sign for walkers suggests other ways to reduce one's carbon footprint, such as buying locally grown and produced food, installing solar power and insulating one's home, or making responsible transport choices. But these choices are all individual, appealing to personal self-interest. Self-interested individuals have little hold on each other, slipping past each other rather than dragging each other along. When it comes to collective action to achieve ends desired by the community, possibilities may be curtailed by other institutions. Intersections and overlaps between individual and collective action are discursively and materially held apart.

7.4.2 Local participation

The sociotechnical imaginary for community-scale carbon neutrality in Byron Shire comprised both a technical imaginary, and a cultural and political imaginary, of the zero carbon future. The former was derived from Beyond Zero Emissions' technical and technology-driven approach to decarbonisation, while the latter project was aimed at establishing the importance of autonomous regional Australian communities

in national climate and energy politics. The visionary commitment was made by Mayor Simon Richardson without the participation of the Shire Councillors and council staff, however, creating a rift in the perceived legitimacy of the project. That rift, over competing visions of what Byron Shire's future ought to be and who should be involved in deciding that future, pulled the project from its original plans.

While the combination of visionary leadership and technical expertise sufficed to catalyse the announcement of a carbon neutral Shire, the project also needed a specific focus on community engagement and social change. As discussed earlier (Chapter Five), volunteers from the local community worked together to compile a baseline greenhouse gas inventory for the Shire. These working groups emerged out of a meeting held at the Cavanbah Sport Centre in June 2015. The event attracted around 80 people. Dr Amanda Cahill, director of the Centre for Social Change, helped to facilitate this event and described it as an important turning point in the Zero Emission Byron project:

> There was a degree of uncertainty about how much the project was about Simon [Richardson, the Shire Mayor], and how much it was about the community. The activities at the forum were about making it less "out there" as a far away and difficult goal, and more graspable by starting where we are at, and identifying all of the activities that are already occurring and contributing. When people started to see this, it really changed the atmosphere. People became energised and wanted to be involved (interview, 12 January 2018).

This event gave community members a grasp on the vision for Zero Emissions Byron, not as a project of the Mayor's or a vision of Byron Shire for others, but as a meaningful set of actions they were already a part of. The groups that came together to develop baseline emissions reports formed around shared interests. According to Vicki Brooke, an early volunteer and now chairperson of the board that governs the Zero Emissions Byron organisation,

> The buildings group attracted interest from architects and designers. The transport group attracted interest from rail advocates and bike hire businesses. The waste group attracted a small number of passionate people. The land use garnered interest from a range of people including agriculturalists and primary producers, waste organics operators or advocates, and forestry protection advocates. Energy was by far the biggest group, attracting a lot of expertise and interest at that time (interview, 17 January 2020).

This adherence between people and activities within the Shire helped to build the vision for carbon neutrality into a sociotechnical imaginary, taking shape through the participation and contributions of the local community.

As volunteers recruited at that meeting channelled their energy into developing baseline emissions reports (Zero Emissions Byron, 2016), Amanda Cahill invited Tiffany Harrison, an experienced community organiser and climate activist, to come on board as project manager and help direct and support those volunteer working groups. Amanda described Tiffany as the "glue" that held everything together,

'someone with knowledge to deal with day-to-day issues as well as look to the longer term, and someone to organise and manage the volunteers in order to get the most from their efforts' (interview, 12 January 2018). An imaginary as big as zero emissions within ten years, involving so many complex parts and challenges, has the potential to unfold in so many different directions all at once as to not move anywhere. The "glue", in this case, is essential to hold these pieces together such that things can move, more or less together, in a given direction.

Tiffany started her role with Zero Emissions Byron in August 2015. Having grown up in the Northern Rivers region, she felt Byron Shire was a place that could make this kind of low carbon transition happen and demonstrate possibilities for communities elsewhere. She described,

> Towns are small enough, and close knit enough, that there are strong networks of people. And people are conscious of environmental issues. There is that history of alternative culture, of people being attracted to the place and wanting to protect it (interview, 2 February 2018).

Connections between people and place are the foundations upon which the Zero Emission Byron imaginary is anchored. Yet these connections are not homogenous, and Tiffany also spoke of the complex politics of the place. Tiffany described her feelings that 'it is both glorious and frustrating that everyone has an opinion, though not everyone does something about it' (interview, 2 February 2018).

The diversity of perspectives and opinions held by community members became apparent to Amanda when she organised, in the second half of 2016, a series of forums to follow up from that first event. Amanda ran a series of exercises for the volunteer working groups to help identify and prioritise potential actions that might be developed towards the carbon neutral goal. She described one of the exercises as a "spectrum walk", where people were asked to stand according to their views on different issues related to that goal, such as where to begin, whether the project was achievable, and what to do about carbon offsets. Amanda described her fascination because there were substantial differences where she had expected everyone to be on the same page.

> Some wanted to start with educating and converting the masses on the importance of climate change. Some were just interested in what was technical and cool. Some thought it would be best to just start with something and learn by doing. Some brought a spiritual view of putting nature first and promoting the rights of nature. Some people agreed that the project was possible, while others didn't and yet still wanted to be involved. Some thought it would have to rely heavily on offsets. There were a lot of discussions about transport, with some concerned that the majority of transport emissions come from the trucks passing through on the Pacific Highway, but these weren't being counted in the inventories (interview, 12 January 2018).

Frictions are evident in this account of how members of one small local community project demonstrate competing ideas for, and expectations of, a low carbon future. These different interests and expectations, not so much opposed as pulling in

different directions, in turn have shaped the trajectories along which the vision and enactment of zero emissions in Byron Shire have unfolded.

7.4.3 Re-arranging local climate governance

While the hold that people have on each other in Byron Shire is important, so too are interactions between organisations. To understand how governance of these local efforts to enact community-scale carbon neutrality has been rearranged, we must look to the relationships between people working within Zero Emissions Byron, Beyond Zero Emissions, and the Shire council.

Amanda Cahill described some of the challenges of translating, into a local and regional context, the national-scale work by Beyond Zero Emissions on how to decarbonise key sectors such as energy, transport, waste, and so on. This included ongoing negotiations over the appropriate balance between defining high-level technical solutions compared to taking small steps and focusing on community engagement and participation. One example was when the group of volunteers working on baseline emissions from land use and agriculture calculated the number of new tree plantings required to offset the Shire's emissions. This calculation helped those involved in the project to see the goal of carbon neutrality as tangible and achievable. However, when the group extended their calculations to include wetlands it also highlighted that the goal could slip away if existing ecologies (which are at times threated by pressures of urban expansion as seen in earlier chapters) are not protected. In Amanda Cahill's words,

> This highlighted the importance of protecting what we already have and recognising the significance of simple and grounded approaches. It can be problematic when these possibilities are overlooked in favour of more high-tech solutions, or solutions that involve building something new at the expense of conserving things that already exist (interview, 12 January 2018).

Amanda's reflections illustrate the frictions involved in stepping through local processes of sociotechnical change. Large steps may hold appeal because they promise to get there faster, wherever that may be. Small steps may seem less sure of the overall direction, but they are also embedded in the local place and meaningful to local actors, taking hold of people whatever their starting point rather than pulling from a more abstracted vision. The approach illustrates the small steps required for "participatory innovation" to work, as discussed earlier, where people are pulled along because they are, in some part, also involved in doing the pulling. The trajectory might seem less certain than grand visions and large steps, but as we have seen in analysis of Copenhagen and Melbourne, large sociotechnical interventions – whether energy infrastructures or price signals – also unfold in indeterminate ways.

Friction was produced in the interaction between Beyond Zero Emissions and the local arrangement volunteers, pulling towards the same vision of community-scale carbon neutrality but with differing emphases on technical expertise and grassroots

collaboration – that is, proceeding by large steps or small steps. Overstretched, Beyond Zero Emissions loosened ties with Byron Shire to focus attention on other zero carbon community projects for which it had secured funding (Beyond Zero Emissions, 2017: 14-15). In a further shift, Beyond Zero Emissions CEO Stephen Bygraves left the organisation in mid-2016. The arrival of a new CEO created an opportunity to work through new interpersonal relationships and renegotiate what each would bring to the partnership, thereby adjusting the friction between the two organisations.

Throughout this period, friction between Zero Emissions Byron and the Byron Shire Council were also being negotiated. Reluctance by the Shire Council to embrace the vision for community-scale carbon neutrality dragged on the project. It also created challenges for policy and program staff within the council administration that were involved (informally) in efforts to engage the community on the zero emissions vision. Eventually overcoming its hesitancy, the Byron Shire Council passed a resolution in early 2017 that it 'commits to achieving a 100% net Zero Emissions Target by 2025 in collaboration with Zero Emissions Byron, and to source 100 per cent of its energy through renewable energy within ten years' (Byron Shire Council, 2017b; Byron Shire Council, 2017a). The resolution included scope for resources and funding for a staff position within the council to work on the project. However, this commitment was later amended and tightened its focus on Council's own emissions, rather than across the broader community (Byron Shire Council, 2019).

In sum, the charismatic leadership of Shire Mayor Simon Richardson anchored the vision for community-scale carbon neutrality, which was lent support by the technical expertise of Beyond Zero Emissions. This partnership gained adherents amongst those calling, from within Byron Shire and across other regional communities, for an ambitious and locally grounded response to climate change. Yet the Mayor's announcement of that vision pulled the Shire Council in a direction it did not want to go. The Shire Council eventually shifted its position on the vision for community-scale carbon neutrality, but subsequently renegotiated that relationship by separating out council activities from other levels of activity across the community – effectively shifting the boundaries of responsibility around these respective visions.

Throughout these rearrangements to local climate governance within the Shire, Zero Emissions Byron began to take shape as more of a strategic planning entity than it had been previously. In late 2016, governance of the project was formally established and vested in a stand-alone entity, Zero Emissions Byron Limited (Zero Emissions Byron, 2020a). This is a not-for-profit environmental organisation with charitable status, overseen by a board of seven directors, and with the Shire Mayor and CEO also represented as ex-officio members. Vicki Brooke has been chairperson of the Zero Emissions Byron Board since the organisation was founded. As a volunteer on the baseline emissions project, she had come to a meeting of the steering committee in early 2016, and 'saw that they were having a nice chat, but not really getting anything done' (interview, 17 January 2018). Vicki led a governance group to look at options,

in particular whether Zero Emissions Byron should be a branch of council or a stand-alone entity. At the time, she described, they felt vulnerable should there be a change of mayor. 'The only support for Zero Emissions Byron within council was from the Mayor […]. We felt that establishing as a stand-alone entity was the better approach to risk-management, to be able to ride out any future changes at council' (interview, 17 January 2018). Zero Emissions Byron foresaw the exposure if they lost their anchorage with the mayor's office – a less supportive mayor could pull Zero Emissions Byron in directions it did not wish to go – and this led it to establish separately from the Shire council.

7.4.4 Enacting local change

Re-anchoring the Byron Shire imaginary for community-scale carbon neutrality more independently from the Shire Council and Beyond Zero Emissions has required some adjustments to the boundaries holding this imaginary in place. This has included boundaries between the organisations involved in climate governance, as described above. It has also involved boundaries around the community-scale; boundaries that are still malleable in relation to the ideal of self-sufficiency in carbon, the flows of people coming into and out of the Shire, the local environmental affordances, and the speed at which processes of sociotechnical change may occur.

Vicki Brooke reflected that the way the Zero Emissions Byron project developed has not been ideal. Asked what advice she would share with others, she said, 'we need to go back and unravel the knitting. […] It needs both grassroots and institutional engagement'. Furthermore, 'The lack of governance, money and support from council were a severe hindrance' (interview, 17 January 2018). In other words, organisations need to pull, more or less, in the same direction, stepping out processes of sociotechnical change that are not so small as to lose direction and momentum, but not so large as to bypass opportunities for community engagement.

On the community side, Vicki had thought they would have had more community engagement on an ongoing basis, but she described that this engagement had flattened out.

> Byron Shire is made up of 33,000 individuals. There is not much homogeneity, and it is going to be challenging. There are some very conservative values in the region. Out on the farms, many people are suspicious of renewable energy, tree planting, anything seen as being "greenie" (interview, 17 January 2018).

Vicki's reflections draw attention to the way various constellations of actors are brought together around the imaginary for community-scale carbon neutrality. Her description resonates with the spectrum of views amongst volunteers working on the baseline emissions recounted earlier by Amanda Cahill. The goal of community-scale carbon neutrality pulls farmers, grassroots activists, and councillors together around a vision that, though not necessarily shared, shifts engagements with climate change, greenhouse gas emissions, and possibilities for sociotechnical change. Sociotechnical

devices, such as renewable energy infrastructures and trees (as vehicles for carbon sequestration) are, perhaps, seen by some as connected with environmentalism and, therefore, alien and "suspicious". Yet attachments to renewable energy and ecologies can also take hold in other ways, as with the imaginary for community owned renewable energy within the Shire, and the social and material engagement with energy technologies by Samsø islanders highlighted by Papazu (2016a).

As an organisation, Zero Emissions Byron recognises that transformative action by local individuals, households and businesses is not enough to achieve the goal of community-scale carbon neutrality. Many have done, and are continuing to do, all they can in their own domains of autonomy and influence. The Repower Byron project illustrates a strategy that builds such individual efforts into a collective approach. Run in partnership between Community Owned Renewable Energy Mullumbimby (COREM), community owned electricity retailer Enova Energy, and Zero Emissions Byron, the project is based on the same principles of community mobilisation that successfully held back the incursion of coal seam gas to the Northern Rivers region (described in Chapter Four). This "house-by-house" and "street-by-street" approach to increasing the uptake of renewable energy in the Shire is based on starting conversations with neighbours about switching to renewable energy providers, improving the energy efficiency of their homes, and, if possible, installing solar panels. COREM's Dave Rawlins has been involved in testing and promoting the approach with his own neighbours.

> There is a fair bit of learning all around, and that was part of the set up for the trial, that the whole street was invited to be part of the journey and would stumble through and learn together (interview, 9 January 2018).

While households may face specific circumstances or wider barriers that challenge their adoption of renewable energy, encouragement and support through the Repower project means they need not face these challenges entirely alone.

To achieve the vision for community-scale carbon neutrality, visitors to the Shire must also be encouraged and supported to take responsibility for their own emissions. Recalling the Cape Byron Lighthouse vignette, the connection to mains electricity may have ended the lighthouse keeper's task of carrying weights upstairs, but other tasks remained. The volunteer guide who led my group's tour of the lighthouse told an amusing story of a former lighthouse keeper who, when guiding tours, would hand out cloths to the tourists before they ascended the spiral staircase. That way, they would polish the brass handrail on their climb and save the lighthouse keeper the effort. The story shows that such contributions could, perhaps, add to a visitor experience rather feel like an imposition.

Transport is one area where impacts from visitors to the Shire are tangible. Driving anywhere in the Shire reinforces this point. Each pothole in the road is a reminder of how visitors impact the place, but the economic injections they bring do not seem to filter through to basic public infrastructure or services. Flows of people and money

into Byron Bay and the surrounding towns and hinterlands bring benefits as well as costs, yet these are distributed unevenly. To address emissions from transportation within the Shire, Zero Emissions Byron shares with the Shire council the aim of introducing more electric vehicle chargers and, by doing so, establish the conditions for wider uptake of electric vehicles as they become more affordable. The Shire council started this effort with the first NSW regional fast-charging station established outside the Byron Bay library in early February 2017 (Byron Shire Council, 2017b). Vicki noted that a charging station at the Macadamia Farm was attracting day-trippers from Brisbane in their Teslas. 'Building the infrastructure will attract the right kinds of visitors' (interview, 17 January 2018). Through these small interventions, electric vehicles are becoming more normal within the region.[21]

In Byron Shire, various publics are engaged with specific issues through which climate change and greenhouse gas emissions come to matter locally. Frictions between various organisations, actors and interests pull possibilities for change in different directions. Strongly held preferences by some in the community for self-sufficiency, community-ownership and local autonomy coalesced around the imaginary for community-scale carbon neutrality. Enacting these possibilities requires that people within the local community act together. This includes visitors to the region being willing to enter into the community spirit at the same time as they enter into the local area. As interactions between actors and organisations involved in the imaginary have shifted, so too have the boundaries that hold the imaginary in place. Tightly conceived boundaries around carbon self-sufficiency and local renewable energy also constrain possibilities, such as where new renewable energy infrastructures might be located. High rainfall constrains access to solar resources though, equally, contributes to the conditions of possibility for ecological resurgence and carbon sequestration. Timeframes for achieving carbon neutrality within ten years have been reframed (as we have also seen with the City of Melbourne's timeframes) to reduce emissions to zero by 2040 (Zero Emissions Byron, 2020b).

The constellations of actors involved in Byron Shire's climate governance form a looser arrangement than that seen in Copenhagen or Melbourne, negotiated through ongoing interactions between people and organisations. These arrangements have been tightening up with the formation of the Zero Emissions Byron board and re-defined boundaries between partner organisations. At the same time, more relaxed governance arrangements offer a broad umbrella that can shelter diverse publics and interests, not only in relation to economics and technologies but also to include different kinds of social and ecological attachments. The grip of these social and

[21] At least two more electric vehicle charging stations have since been installed in the Shire, including at The Farm on Ewingsdale Road and behind the Byron Shire Council chambers in Mullumbimby (along with renewable energy producing "solar car shades" installed in the council car park). Zero Emissions Byron has also organised a series of transport forums in 2019 (with more planned in 2020) with a focus on electric vehicles (Zero Emissions Byron, 2019).

material attachments, ultimately, is what has shaped processes of sociotechnical change in the Shire.

7.5 Conclusion

As policy actors seek to translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality, frictions emerge through encounters across difference. It is these awkward, unequal, unstable, creative qualities of interconnection across difference that hold assemblages of social and material elements together. Rather than thinking of friction as a destructive force, friction is what allows things to move in new and often unanticipated directions, enabling, constraining and inflecting processes of sociotechnical change.

Frictions have emerged through efforts to enact the Copenhagen Climate Plan as encounters between new sociotechnical devices – such as congestion charges, wind turbines, and biomass – are felt differently by those positioned differently in relation to those interventions. The shifting preferences encoded in the City of Melbourne's successive policies for community-scale carbon neutrality can be understood by attending to frictions between institutional positions and interests, which themselves can bring different levels of political force to bear. Byron Shire draws attention to the dynamics of people in negotiating boundaries around carbon neutrality, including contestation over who are the legitimate actors in local efforts to measure carbon and to govern low carbon transitions.

Comparison across the three field sites highlights that, while similar points of friction occur in each locality, processes of sociotechnical change follow different trajectories as a result of the different positions of actors within these assemblages. Friction occurs in encounters between visions of carbon neutrality and material constraints, and between technologies, institutions, and people, to give shape and direction to specific imaginaries for community-scale carbon neutrality. These forms and trajectories are buffeted by shifting political circumstances, policy settings, market conditions, technological innovations, and emergent publics. When social and material elements slip past each other, assemblages fail to coalesce. As friction develops within assemblages it becomes impossible for things to slip past each other. Technologies, institutions, and people are held together. Tensions result when forces are pulling in contrary directions; when things get stuck and cannot move. Friction inflects these movements, resulting in new trajectories. Analysis of the frictions involved in these movements highlights that imagining and enacting sociotechnical change is not only about exerting force, but about finding ways to move things along together – it is about letting go as well as holding on.

As frictions pull assemblages in different directions and as conditions of possibility in which to imagine carbon neutral futures shift, policy actors perform agency by re-anchoring their imaginaries for community-scale carbon neutrality. Whether sowing a vision for a "fossil free" future as in Copenhagen, realigning targets and timetables

with other climate policy actors as in Melbourne, or rearranging local governance as in Byron Shire, policy actors seek to stabilise their imaginaries in response to frictions. This requires adjustments to the boundaries holding that imaginary in place. Adjusting boundaries has wider implications, because delineating boundaries around the community-scale and carbon neutrality helps to co-produce objects and scales of climate governance and legitimise agents and actions of climate governance. Boundaries encircle the idea of community-scale carbon neutrality and situate that goal in relation to the local and the global, shaping patterns of interaction, and thus may enable different assemblages to come together.

These interactions also point us towards frictions between universal and specific – global and local. In the final chapter, I address the abstractions and frictions that shape and grip the efforts of policy actors to translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

Chapter 8. Conclusion: Abstraction and emplacement in climate governance

8.1 Introduction

This thesis has examined how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality. It has been grounded in an ethnographic comparison of three diverse local jurisdictions with such goals: the City of Copenhagen in Denmark, and the City of Melbourne and Byron Shire in Australia. Comparison within and between these places has revealed patterns of relations and situated contingencies that shape actions and interactions in relation to net zero emissions within these situated contexts of local climate governance.

The thesis began by identifying the abstract concept of global net zero emissions as a **universal**, an idea that transcends localities, but is able to move subjects and objects when it captures imagination in specific places and circumstances. The concept has taken hold as a powerful unifying narrative and overarching goal in discourses and practices of **climate governance** – that is, efforts to govern the human activities and the social and technical systems and ecologies in which they are embedded that contribute to climate change. These activities, sociotechnical systems, and ecologies, are always situated. Thus, the concept of global net zero emissions transcends localities but must, still, be engaged with localities in order to move objects and subjects in ways that reduce and remove greenhouse gas emissions. The thesis has navigated this tension between global and local, abstract and emplaced, by tracing circulations of discourses and practices related to the concept of net zero emissions.

The central research question addressed in this thesis, and a key focus of this closing chapter, is: How do policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality? The process of **translation**, following Tsing (2005: 62), is a recursive and ongoing process that involves 'the drawing of one world-making project into another'. In the context of this thesis, translations are involved in the efforts of policy actors to draw the universal concept of global net zero emissions into situated attempts to remake local worlds as carbon neutral. Of course, translation also flows the other way as the efforts of local actors to envision and enact community-scale carbon neutrality are drawn into projects to re-make the entire world as one with a sum total of net zero emissions. Examples of these recursive flows can be seen throughout the thesis, such as when local goals and actions to reduce emissions are thought about in terms of aggregation, replication, and scaling up.

Investigation into these processes of translation – across scales from global to local, and across situated social and material contexts – called for research methods that were engaged with places, processes and relationships in all their complexity.

Accordingly, this thesis has been empirically grounded through an ethnographic comparison of three localities in which policy actors had expressed commitments for community-scale carbon neutrality in the near-term. From the situated vantage points of these places, the study contrasted distinct social and material contexts, and circulating discourses and practices related to community-scale carbon neutrality and net zero emissions. Comparison across these different field sites has helped to amplify patterns of relations that are common in efforts to envision and realise community-scale carbon neutrality, while highlighting situated contingencies that shape these processes in particular places.

I approached the central question of this thesis through four research sub-questions that focused, in each of the three field sites, on how carbon neutral futures are collectively imagined; how boundaries are delineated around carbon and the community-scale; which assemblages of people, technologies, and nature are reconfigured towards carbon neutrality; and what frictions arise to shape, constrain, and inflect these ongoing processes of sociotechnical change. The analytic devices that I applied to address these questions, drawn together from scholarship in anthropology and STS, have helped to distil mutually interconnected processes to imagine and enact community-scale carbon neutrality.

In this concluding chapter, I first synthesise the contributions to knowledge – the interrelated methodological, empirical and conceptual, and theoretical conclusions – that have emerged in this thesis. I reflect on the main ethnographic findings and conceptual tools used to draw out those findings. Based on these insights, I draw together the four conceptual devices into an analytic scaffold to address the central research question posed in this thesis. I also offer some reflections on how this thesis adds to, and challenges, existing literature in the fields of anthropology, STS, and multilevel climate governance. Following this, I discuss some key limitations of this research, and then highlight areas for further research and improved research practice that may address these limitations. Finally, I address the implications of this research, in particular for policy actors involved efforts to imagine and enact low carbon futures and navigate complex processes of sociotechnical and ecological change.

8.2 Contributions to knowledge

8.2.1 Methodological

The methodological contributions to knowledge made through this thesis have emerged from deliberate choices about research design. In particular, I elected to: investigate localities with near-term targets for community-scale carbon neutrality that had expressed clear boundaries around their goals; undertake in-depth ethnographic research to reveal locally specific social, economic and political landscapes; and juxtapose places that were clearly different, rather than attempt to smooth out variables through research design. The intent of these methods was to

develop understandings, rather than explanations, by focusing on patterns of relations revealed through techniques of discourse analysis, in-depth ethnographic fieldwork, and ethnographic comparison across difference. Through these deliberate choices, the study contributes to ongoing methodological discussions concerning ethnographic and comparative approaches in social scientific inquiry, as I draw out below.

The thesis has been empirically grounded in an ethnographic comparison of three localities where policy actors had expressed commitments for community-scale carbon neutrality and were undertaking efforts towards these goals. In-depth research in each place provided distinctive vantage points from which to explore how such processes have unfolded (and continue to unfold) in specific localities while remaining attentive to wider interconnections. These methods have been used to generate a series of overlapping local perspectives on global issues while making explicit the situations and relationships that shape these perspectives. Adoption of such vantage points is well-established in anthropology and STS, by way of in-depth investigation into a situated sociocultural realm that locates the researcher explicitly within that realm. Situating research in a specific locality does not prevent a view on global issues but, rather, recognises that knowledge of the globe is always situated, even as the collaborations through which such knowledge is generated are elided and erased (Ingold, 2000; Tsing, 2005).

Studies of single places, people, histories, and connections generate substantial insights into locally situated responses to climate change, and processes of ecological and sociotechnical change more broadly. Such studies also involve comparisons within and between social and material elements and over time. For example, Papazu's (2016b) investigation of Samsø Renewable Energy Island demonstrates the value of in-depth ethnographic study of a single place within the fields of STS and political science. Although at one scale of analysis the island is a single entity, at other registers it is a constellation of social and material elements, with actors in shifting alliances in relation to processes of industrial, economic, and ecological change. Tsing's studies of global connections are grounded in specific places and particular objects such as forest products (2005) and matsuke mushrooms (2015), but always explore outwards across multiple registers and scales. Situating inquiry through in-depth ethnographic research in a particular place also calls for engagement with wider processes of knowledge production and meaning making. Choices about which objects of analysis to focus on shape the kinds of understandings that can be generated.

This thesis has approached the three field sites at its core through multiple registers and scales, with the frame of analysis shifting through the four empirical chapters. In Chapter Four the focus was on historic, social, and material contexts and circumstances in each of these places, situating imaginaries of the future in relation to past histories and present circumstances. The analysis in Chapter Five stepped back to situate the boundaries delineated around specific goals for community-scale carbon

neutrality in relation to national and international practices to produce knowledge of greenhouse gases. Chapter Six developed an analysis of a specific urban development project in each field site in order to narrow in on situated efforts to reassemble social and material elements around carbon. The focus in Chapter Seven was on shifting social and material interactions and the frictions that are generated through encounter and exchange. In-depth ethnographic engagement in each of the field sites established the groundwork for analysis that has shifted between scales and registers, reinforcing that the objects of analysis at the core of this study are not stable and fixed but have been shaped through research engagements.

Comparison between different social and material settings, and institutional and political structures, is a crucial methodology in STS and anthropology, as well as disciplines related to multilevel climate governance such as political sciences, political ecology, and critical urban studies as considered in Chapter Two. Approaching the concept of global net zero emissions as a universal, as I have done in this thesis, calls for consideration of how this concept moves and takes hold in different situations. While studies of abstract claims about the world may focus on a specific constellation (such as, in Tsing's work, a forest or mushroom) these assemblages always extend open-endedly. Such studies invite comparisons of the different ways in which ideas and practices travel. Investigating how the concept of net zero emissions takes hold as a sociotechnical imaginary calls for comparison into the different ways that future possibilities are shaped by specific circumstances and interactions (Jasanoff and Kim, 2015: 35). Comparing local efforts to enact carbon neutrality by reconfiguring social and material relations helps to draw out both situated contingencies and common patterns of action and interaction.

With this in mind, **comparison across difference** was fundamental to the insights generated through this inquiry. This was purposeful comparison of apples and oranges (recalling discussion in Chapter Two) in order to generate understandings of how the general category of fruit is brought into being. That is, comparison across different places, goals, boundaries, and actions generated insights into how general categories of carbon neutrality and the community-scale are established, stabilised and destabilised. The selection of field sites at the core of this study was informed by scoping research (outlined in Chapter Three) and curiosity about the difference that varied historic, social, and material contexts of each place would make in efforts to imagine and enact low carbon futures. Comparison within and between the three field sites generated insights into what aspects change as situations change, and what stays the same, in these situated processes to achieve carbon neutrality. Contrast and juxtaposition lent the study momentum as different social and material relations emerged as salient through field work in each place, prompting investigation into the salience of those interconnections in the other places.

Ethnographic comparison of local climate governance allows us to learn from and imagine other ways of pursuing low carbon futures in response to climate change. In each place, starting points and pathways of change were shaped by different

affordances of, and connections between, social and material elements. Research engagement with Copenhagen highlighted the way actors are positioned in relation to technologies within sociotechnical systems, in particular urban systems of energy and transportation that shape and pervade the city and help to pattern daily life. The processes of trying to enact changes to these sociotechnical systems that underpinned the City of Copenhagen's carbon neutral goal prompted me to explore similarities and differences in sociotechnical relations in the other two places. In Melbourne, the position of actors in relation to structures of authority and power to effect changes to sociotechnical systems came strongly into view. The emphasis on carbon trading in the City of Melbourne's early strategies, and its diminishing role over time, encouraged me to consider how shifting expectations and circumstances reshape possibilities for community-scale carbon neutrality. In Byron Shire the focus developed around how people are positioned in relation to each other. The interpersonal and organisational dynamics within Byron Shire provoked my interest in how communities emerge through and in relation to processes of sociotechnical change, contrasting against the abstracted "community-scale" as a category of climate governance. In each of the field sites there are actions and interactions involving technologies, institutions, people, and natures. Different engagements in each place brought these interactions into focus in different ways.

Undertaking this ethnographic comparison was a reflexive process that involved ongoing consideration of the relationships between the places, people, institutions, technologies, and ecologies at the core of this study – the subjects and objects of this inquiry. Boundaries specified around local geographies, sociotechnical systems, human activities, greenhouse gases, were a key focus throughout the investigation. In the end, however, this study was not a comparison of boundaries themselves. Rather, ethnographic comparison brought processes of boundary making into view – and the importance of boundaries in the efforts of policy actors to imagine and enact community-scale carbon neutrality. The objects of comparison in this study thus took shape as the four key concepts employed in the empirical analysis – that is, sociotechnical imaginaries and their conditions of possibility, boundary making processes (involving co-production), assemblages focused around carbon, and frictions arising through interactions between these interconnected elements.

Underpinning this reflexivity was the decision to develop this study, primarily, as a dissertation rather than a series of articles. This approach allowed the writing and analysis to take shape iteratively. The core ideas presented in this thesis were developed over a longer period of time than may have been possible had the primary focus been on generating research publications. As a result, the focus and structure of this thesis has emerged through exploratory and open-ended engagement with the research material. Articles published through the course of the research project informed the development of the thesis as a whole and were a way to share works in progress, experiment with writing styles, and develop analysis of empirical materials and conceptual devices with a clear focus. Re-working these articles into chapters of

the thesis enabled a deeper exploration of the concepts and empirical materials framed within those articles, and the interconnections between them.

Over the course of conducting this research, situations and circumstances have continued to change. Some of these changes have been conveyed through the thesis – such as those changes to targets, timetables, boundaries, policies and preferences examined in previous chapters. Other changes are still unfolding with uncertain implications, including Australia's catastrophic 2019-20 summer of bushfires and the COVID-19 pandemic that has arisen as I finish writing this thesis through the first half of 2020. The bushfires have added weight to declarations of a "climate emergency" by a growing number of local governments and communities, as mentioned in Chapter Three. The pandemic is rapidly and radically reshaping human activities, social norms, and sociotechnical systems, highlighting the global interconnectedness between places and people while also exposing vulnerabilities in the way social and material relations are organised, an observation that I will return to shortly. The key point here is that the methodology of this study is relevant and important because contexts and circumstances within which policy actors are situated as they seek to imagine and enact low carbon futures will continue to change.

In sum, the methodological approach developed through this inquiry reinforces the importance of in-depth ethnographic research and comparison as a reflexive research engagement. It is through such engagement that objects of analysis can emerge and take shape reflexively, rather than those objects of inquiry being presupposed too firmly at the outset. The methods are not only valuable for scholars, but also for policy actors involved in their own efforts to imagine and enact net zero emissions, whether in relation to the community-scale or within and across some other set of specified boundaries.[22] I develop this point further through the next section as I turn to the four research sub-questions addressed in the empirical chapters at the core of this thesis.

8.2.2 Empirical and conceptual

New research and practices are emerging all the time with respect to addressing the challenges of climate change and achieving the goal of global net zero emissions. This includes continued attention on how the concept of net zero emissions may be made meaningful at local registers, and how viewing this global objective from local vantage points may change what it means (see for instance Hopkins, 2019; Norberg-Hodge, 2020). This thesis makes a substantive empirical and conceptual contribution to knowledge of (1) how processes to imagine and enact community-scale carbon neutrality have unfolded in three specific places, and (2) the interactions and connections between social and material elements that shape these processes more

[22] Continuing dialogue with my research participants support this reflection, with many giving positive feedback and encouragement on articles and draft chapters of this thesis.

generally. The thesis applied a set of four analytic devices drawn together from scholarship in anthropology and STS to distil these mutually interconnected processes of imagining and enacting. These applications were grounded in, and emerged from, in-depth ethnographic comparison across the three field sites at the centre of this study.

The concepts of **sociotechnical imaginaries** and **co-production** were applied to draw out how low carbon futures are envisioned and how these visions are situated in relation to a specific place. The concepts of **assemblages** and **friction** were applied to draw out how these carbon neutral imaginaries are enacted through processes of sociotechnical change. These concepts were applied, in turn, through four research sub-questions as interrelated steps towards addressing the central concern of the thesis – that is, how policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality.

- **Chapter Four** addressed the question: What are the conditions of possibility in which particular sociotechnical imaginaries of community-scale carbon neutrality are seen as viable and desirable (and seen so by whom)?

In that chapter, I applied the concept of **sociotechnical imaginaries** to examine how, and by whom, collective representations of desirable futures are shaped in relation to the three field sites at the core of this thesis. The analysis focused on the historic, social and material contexts of each field site, including through descriptive vignettes of histories, places and people.

In each place, future-oriented visions and policy commitments for community-scale carbon neutrality take hold, to varying degrees, as sociotechnical imaginaries within shifting social and material histories – uniquely situated starting points that enable and constrain future possibilities. These conditions of possibility might be thought of as contingent lineages (Tsing, 2005: 127), a form of assemblage that draws attention to the ways social and material elements are brought together in continually unfolding processes. Conditions of possibility in which to imagine low carbon futures are shaped by past and present circumstances, and the perceived affordances of emplaced social and material forms and possibilities for human action – that is, by the collectively negotiated perceptions of the actors involved in doing the imagining.

Comparison across the field sites revealed alignments between existing cultural and political ideals and values to be a key means by which policy goals for community-scale carbon neutrality gain adherents. These ideals and values are negotiated and contested. Policy actors must frame the vision for community-scale carbon neutrality in such a way that they are seen as viable and desirable by a constellation of actors and institutions that is powerful enough to sustain the imaginary, in order that it may take hold and that other actors may be pulled along by it. Emphasis shifted between the three field sites in relation to collective action by the community (Byron Shire), action by authorities towards the public good (Copenhagen), and action to nudge

private individuals towards different behaviours (Melbourne). In each place, sociotechnical imaginaries for community-scale carbon neutrality build upon established foundations of how social relations are seen to be, and desired to become, reflected in different conceptions of "community". This is a key area where structures and relations of knowledge and power come into view, shaping engagements with carbon neutrality in terms of underlying assumptions about, and preferences for, social order.

Measures designed to neutralise greenhouse gas emissions that occur from activities within a specified locality might also be shaped by perceived social and material affordances in other places, such as the prospect of land-based carbon sequestration, harvesting of carbon neutral biomass, and investments in and installations of new renewable energy infrastructures. Visions for community-scale carbon neutrality in one place can thus involve interventions in other places. The analysis demonstrates that sociotechnical imaginaries of community-scale carbon neutrality become most specific through the interconnections they establish with other places. Looking closely at the features of a particular vision for carbon neutrality leads to connections with other places and levels of climate governance, yet these shared discourses and practices also take on unique forms in a specific local context and set of circumstances.

- **Chapter Five** addressed the question: How do practices to define boundaries around community-scale carbon neutrality co-produce objects and scales of local climate governance?

In that chapter, I applied the concept of **co-production** to examine relationships between knowledge of greenhouse gases and actions to govern those gases (that is, efforts to govern the human activities, and the social and technical systems and ecologies in which they are embedded, that contribute to climate change). The analysis in that chapter situated the three field sites within wider structures of multilevel climate governance in relation to important moments in the development of carbon accounting practices: from the Kyoto Protocol in the late 1990's and early 2000's (Melbourne), to the 2009 international climate conference (Copenhagen), and the 2015 Paris Agreement (Byron Shire).

Carbon accounting methods have been developed through dialogues and interactions with actors and institutions over time, and across different sites and circumstances, to shape consistent approaches to measuring and managing greenhouse gases. Standardised principles and techniques of carbon accounting render greenhouse gases as a governable object in the form of CO_2-e and stabilise this object across multiple levels of climate governance. Practices of municipal carbon accounting define greenhouse gases in relation to discrete administrative territories, contributing to the production of the "local" (defined as the "community-scale") as a discrete and abstracted scale of climate governance. Through these practices, the legitimacy of

local actors (in particular local governments) as agents to do the governing is also stabilised and reinforced across wider networks of climate governance.

Possibilities for carbon neutrality are fashioned and curated by delineating spatial and conceptual boundaries around the greenhouse gas emissions, human activities, sociotechnical systems, and ecologies that are entangled in visions for community-scale carbon neutrality. These boundaries enable stocks and flows of greenhouse gases to be abstracted from the human activities and sociotechnical systems and ecologies in which they are embedded, in order to be rendered legible and thus governable. Such equivalences can enable actors to balance their carbon accounts and neutralise emissions, for instance through market based trading mechanisms (Melbourne), by calculating avoided emissions as a result of generating surplus wind energy (Copenhagen), and by developing strategies to sequester carbon through the regeneration of local ecosystems (Byron Shire). Yet a prevalent tension across all three field sites is the issue of taking action to reduce emissions within that locality compared to removing (or avoiding) emissions elsewhere. This tension continues to be negotiated in each of the field sites, as is demonstrated by the redefinition of boundaries around community-scale carbon neutrality examined in Chapter Seven.

Yet boundaries delineated around carbon neutrality and the community-scale must always, to some extent, conform to local circumstances. These particularities – collaborations across difference – are elided as carbon and the community-scale are rendered as general categories and stabilised as abstracted objects and scales of climate governance. Boundaries hold sociotechnical imaginaries for community-scale carbon neutrality in a specific place and, at the same time, underpin and reinforce envisaged pathways of sociotechnical change. Boundaries shape, from the outside, conditions of possibility in which particular sociotechnical imaginaries of community-scale carbon neutrality could be achieved.

- **Chapter Six** addressed the question: How are efforts to enact carbon neutrality negotiated and contested as policy actors attempt to assemble new connections between people, technologies, and nature?

In that chapter, I applied the concept of **assemblages** to examine "carbon assemblages" focused around CO_2-e and reconfiguring relations between social and material elements within and across abstracted boundaries. The analysis in that chapter turned to situated efforts to reduce and remove greenhouse gases in relation to each of the three field sites. It centred on a specific urban development project in each place, each of which reflected key dimensions of wider efforts towards community-scale carbon neutrality and urban sustainability. Focusing in on the concrete sites of the Council House 2 (CH2) office building in Melbourne, Habitat village in Byron Shire, and the Nordhavn precinct in Copenhagen drew attention to locally situated concerns and controversies that have emerged in efforts to enact sociotechnical change in each field site. Thinking through these projects as assemblages encouraged consideration of the multitude of interconnections that sit

within, permeate and cut across the boundaries delineated around community-scale carbon neutrality.

Carbon neutrality is enacted by forging new connections between people, technologies and natures in ways that reduce and remove greenhouse gas emissions. Contestation and negotiation emerge in efforts to enact carbon neutrality as connections between these social and material elements are disassembled and reassembled, such as with existing patterns of urban development (Melbourne), patterns of cosmopolitan consumption (Byron Shire), and patterns of urban mobility (Copenhagen). Obduracy plays a role; it difficult to disassemble strong attachments between social and material elements. Such entrenched patterns can be thought of as inflexible institutions and infrastructures displaying "path dependencies" and "system lock-ins" that (as discussed in Chapter Two) assume the stability of sociotechnical systems unless they are dislodged by some other force. However, such perspectives tend to overlook that the social and material attachments that shape such patterns must be continually maintained and stabilised.

Acknowledging existing connections, and engendering meaning in new attachments between people, technologies, and places prove important each of the field sites – such as with City of Melbourne employees and the stairwells, green walls, and fresh air of their workplace, the organisation of communities in Byron Shire around social and energy commons, and the relationships between Copenhageners (and Danes more broadly) with cars and wind turbines. Yet technological interventions on their own have not been enough to determine processes of sociotechnical change in any of the field sites. Efforts to enact sociotechnical imaginaries certainly entail changes to physical infrastructures and to social structures. However, these are not only processes of technological innovation but, rather, exhibit the potential for responses to climate change to foster local attachments and social innovations. Equally, ambivalence, detachment, and contestation also feature in processes to disassemble and reassemble social and material elements. The analysis demonstrated that carbon assemblages are always contingent, open-ended and continually unfolding such that processes of sociotechnical change may play out in unforeseen (and unforeseeable) ways.

- **Chapter Seven** addressed the question: What frictions emerge in processes of imagining and enacting community-scale carbon neutrality and how do these enable, constrain and inflect processes of sociotechnical change?

In that chapter, I applied the concept of **friction** to examine interactions between social and material elements being reconfigured as carbon assemblages. The analysis focused on shifting circumstances within, and in relation to, each of the field sites to highlight conditions of possibility as dynamic and contingent.

Friction shapes encounters between abstract and situated elements as assemblages of people, technologies, and natures grip and slip past each other. To understand how

processes of sociotechnical change have unfolded in each field site, it was essential to address the frictions that hold together, destabilise, decentre, and transform assemblages. Similar points of friction were seen to emerge in all three field sites, though these were foregrounded differently in each place with respect to the introduction of new sociotechnical devices (Copenhagen), interactions between institutional layers of climate policy and governance (Melbourne), and between actors negotiating the boundaries that define the community-scale and carbon neutrality (Byron Shire). These frictions have resulted in different trajectories of sociotechnical change because of the different ways that actors are positioned in relation to these policy interventions, institutional dynamics, and interposed boundaries.

Analysis of the frictions involved in these movements underscores that efforts to imagine and enact sociotechnical change involves finding ways to move things along together, thus allowing new trajectories to emerge through interaction. As frictions pull carbon assemblages in different directions, and as conditions of possibility for community-scale carbon neutrality shift, policy actors must re-anchor their imaginaries in relation to these continually shifting social and material histories. As the boundaries around these re-imagined low carbon futures are adjusted, objects and scales of climate governance may also be stabilised or destabilised.

Such dynamism is evident with the assemblage of CO_2-e, in the sense that calculated equivalences between greenhouse gases (in particular carbon dioxide, methane, and nitrous oxide) are revised by the scientific community at regular intervals. The equivalences between these gases is also negotiated and contested in the form of policies, such as for carbon offsets and renewable energy as examined through the thesis. So too, the boundaries defined around the "community-scale" are not permanent and stable but, rather, are open to ongoing negotiation and re-conceptualisation as dialogues and interconnections shift over time.

In sum, addressing the four research sub-questions through this thesis contributes to the foundations for a **place-based approach** to climate governance and net zero emissions. That is, the four key concepts brought together in this thesis – sociotechnical imaginaries, boundaries, carbon assemblages, and friction – provide an interconnected set of tools for scholars and policy actors to think through goals for, and actions towards net zero emissions in relation to a given place and set of circumstances. Approaching carbon neutrality through the concepts developed in this thesis, as relational and contextually specific, reveals multiple pathways and possibilities for ecological, social and technical change. As such, governing human activities and sociotechnical systems towards community-scale carbon neutrality is not only about steering processes of change towards a preconceived ideal but also involves ongoing performances of place and community. These practices require reflexivity towards past histories and current contexts, and flexibility to adjust to shifting circumstances.

Taken together, the analysis developed through this thesis helps to address key ambiguities with the framing of cities as important sites, and local governments as important actors, in the multilevel governance of climate change. Engaging with the intersection between local and global, node and network, through these empirical and conceptual lenses helps to draw out dynamic and recursive interconnections in multilevel climate governance. Approaching goals and visions for community-scale carbon neutrality as sociotechnical imaginaries generates understandings of who speaks (claims to speak) on behalf of particular localities, and networks of localities, as low carbon futures are collectively imagined. Examining processes of boundary making in climate governance reveals how boundaries are delineated and stabilised around the global and the local with respect to climate governance. The concepts of assemblages and friction generate insights into the interactions and encounters across difference through which processes of sociotechnical change play out – shaped, without being determined, by local contexts and global connections.

Through this thesis, applying those four concepts highlights ongoing dialogues and circulations between abstract and emplaced, and between imagining and enacting. These tools also help to think about the interconnections between climate governance in a given place in relation to other places, networks, and layers of climate governance. In the next section, I synthesise the interconnections between these four concepts as an analytic scaffold to address the central research question of this thesis.

8.2.3 Theoretical

This thesis has focused on locating discourses and practices of net zero emissions – that is, on the dialogues and circulations through which efforts to redirect human activities and sociotechnical systems towards net zero emissions move between abstract to emplaced, and back again. The study has sought to trace interactions and interconnections as policy actors translate the concept of net zero emissions between universal and situated, global and local. The analysis, grounded in an ethnographic comparison of situated efforts to envision and enact low carbon futures, has drawn attention to patterns of action and interaction between people, institutions, technologies, and nature. Through this comparative analysis, the thesis has highlighted ongoing dynamics, contingencies, and shifts in efforts to imagine and enact formulations of net zero emissions. It has also revealed a set of interconnected processes that underpin the efforts of policy actors to envisage and realise low carbon futures – in the form of the analytic scaffold of sociotechnical imaginaries, boundaries, assemblages, and friction.

Taken together, the analytic scaffold developed through this thesis and empirically grounded in the ethnographic comparison of the three field sites, addresses the central research question: How do policy actors translate the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality?

Sociotechnical imaginaries for net zero emissions take hold by being situated and made meaningful amongst a collective of actors. These processes of collective imagination are oriented towards the future but originate from specific social and material starting points – continually unfolding assemblages. Thus, sociotechnical imaginaries are shaped, from the outside, by the delineation of boundaries around abstracted objects and scales of climate governance. Equally, these imaginaries are shaped, from the inside, by frictions within these situated social and material assemblages.

Boundaries hold sociotechnical imaginaries for net zero emissions in specific places, and at the same time stabilise abstracted objects (such as CO_2-e) and scales (such as the "community-scale") of climate governance across wider matrices. As imaginaries change, boundaries must be redefined. Boundaries shape sociotechnical imaginaries of net zero emissions from the outside, interposing abstracted categories across complex and interconnected sociotechnical and ecological systems in order to render those systems governable. As boundaries shift, different sociotechnical imaginaries and carbon assemblages become possible.

Carbon assemblages come together around carbon as a focal point but extend open-endedly. Efforts to enact carbon neutrality are negotiated and contested as policy actors attempt to disassemble and reassemble interconnections between, people, technologies, and nature to focus around carbon. These assemblages are shaped by abstracted boundaries, and by emplaced frictions.

Friction is an inevitable part of these encounters between global and local, and within assemblages of people, technologies and natures. Qualities of friction shape the way these elements slip past, or grip onto, each other, enabling and constraining interactions and inflecting trajectories of sociotechnical change.

In sum, translations between the universal concept of global net zero emissions and situated goals for, and actions towards, community-scale carbon neutrality are shaped, from the outside, by abstracted boundaries and, from the inside, by emplaced frictions. These recursive interactions between global and local, and between imagining and enacting processes of sociotechnical change, can be expressed in the following schematic:

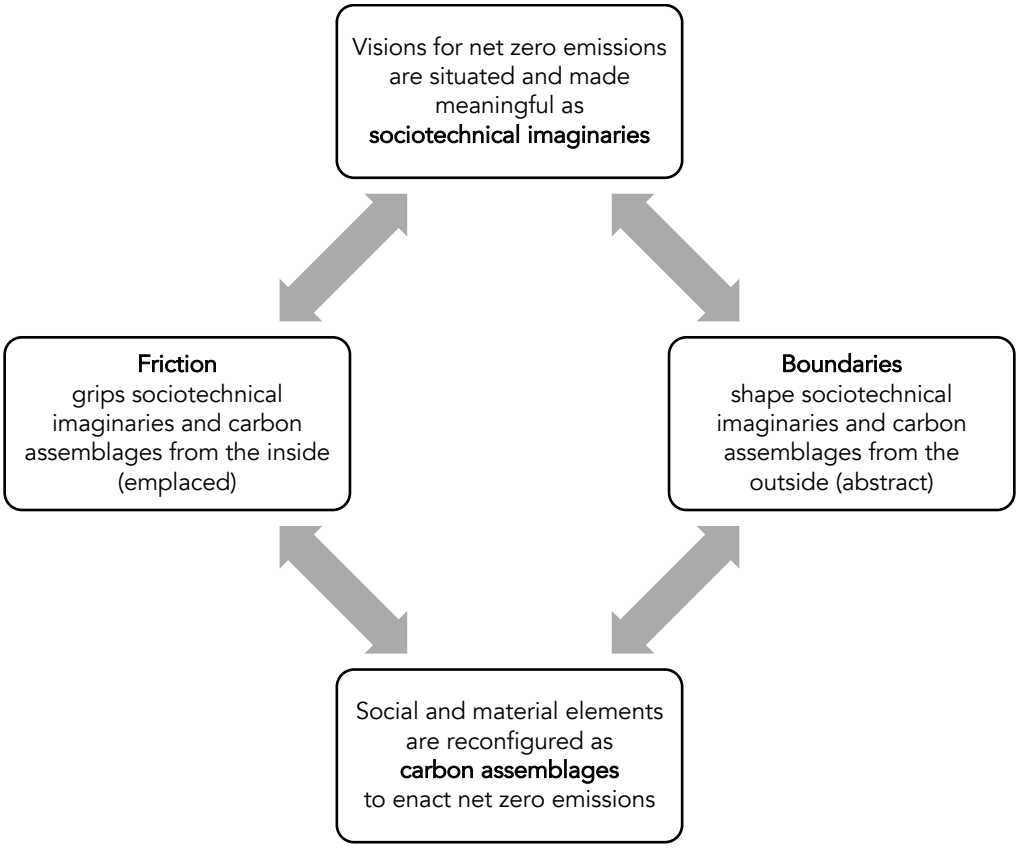

Figure 1: Analytic scaffold of sociotechnical imaginaries, boundaries, carbon assemblages, and friction

A key contribution of this analysis is to highlight the processes through which categories of multilevel climate governance – objects such as CO_2-e, scales such as the "local", subjects such as "community" – are not fixed, but are negotiated, stabilised, and destabilised through ongoing actions and interactions. Processes of abstraction are important in these delineations, but so too is the recognition that these boundaries are always negotiated with respect to specific circumstances. That is, general categories are made to conform with local specificities through emplaced collaborations across difference, and those specificities are elided to stabilise the general category.

Thinking of imaginaries and assemblages through this analytic scaffold shifts the way these conceptual framings are situated alongside each other. This thesis demonstrates, empirically and conceptually, the interconnections between these conceptual framings as akin to two sides of the same coin. This is an important point with respect to scholarship in STS, in which dialogues between these concepts of sociotechnical imaginaries and assemblages are often held apart as inhabiting different ontological and epistemological domains. Put simply, the former is often thought of as engaging with different perceptions of a fixed reality open to varied interpretation, while the latter may be thought of more in terms of an engagement with multiple overlapping worlds. This thesis has developed an empirically grounded

appreciation of how imaginaries express an intention directed towards the future but must also be anchored within a continually unfolding social and material present – an assemblage conveyed through Tsing's (2005: 127) concept of contingent lineages. As these social and material elements are disassembled and reassembled, imaginative possibilities also change.

Thinking of boundaries and frictions through this analytic scaffold draws attention to interactions between these concepts. Within the literature the concept of sociotechnical imaginaries is closely entwined with that of co-production – the idiom that knowledge of the world and action in the world are mutually shaping. However, there is a sense in which co-production, as it is often applied (including in this thesis), emphasises abstracted scientific knowledge such as global knowledge (as in Miller and Edwards, 2001), more than emplaced and embodied knowledge. Yet all forms of knowledge are shaped through social and material interactions, so it is fruitful to bring this concept into dialogue with the emplaced assemblages and frictions that also shape knowledge and action. In the same way that Sneath et. al (2009) argue for engagement with technologies of the imagination (as discussed in Chapter Two), bringing sociotechnical imaginaries and co-production into dialogue with assemblages and friction can help to ground these concepts in situated social and material realities. Thus, the thesis contributes to the grounding of sociotechnical imaginaries, in practice, as a concept that is inextricably entangled with past histories and achievements, and normative understandings of space and social order (Jasanoff and Kim, 2015: 32). It does so by bringing together these collectively imagined (abstracted) futures with emplaced presents and their perceived affordances, and tracing these through historic pasts.

Recognising such emplaced entanglements may also help to understand the dynamic circulations through which sociotechnical imaginaries exist and interact across multiple sites and scales. Jasanoff (2015: 5) has described how powerful institutions may elevate one imaginary above others. At the same time, the analysis presented in this thesis also demonstrates the importance of emplaced material relations, as well as social and political structures and ideals. Put another way, the capacities of (and restraints put upon) powerful institutions to advance or demote particular sociotechnical imaginaries are shaped and constrained by situated relationships and frictions.

Bringing these observations together, this thesis draws attention to relationships of knowledge and power in two important ways. Firstly, it highlights interactions across multiple levels of climate governance through which underlying categories of climate governance are shaped; in particular to render CO_2-e legible as a governable object and the local as a discrete and abstracted scale of climate governance. Power relations shape the arrangements and interactions of those constellations of actors involved in efforts to shape collective visions and imaginaries of low carbon futures. Underlying processes through which knowledge of the climate is produced, maintained, and contested play an important though often understated role in

shaping the kinds of low carbon futures that might be imagined in the first place. Secondly, enacting changes towards such futures involves assemblages and frictions. The analysis developed through this thesis highlights that climate governance is not only about possessing or exerting power to move objects and subjects in ways that reduce and remove emissions. It is also about accepting frictions – that is, letting go in ways that allow trajectories of change to be mutually shaped and inflected by other actors and in response to shifting circumstances.

8.3 Limitations

While this thesis makes important contributions to studies of climate governance and understanding its practices, the approach taken has certain limitations with respect to methodological, empirical and conceptual, and theoretical concerns.

The methods of ethnographic comparison employed in this study shaped my engagements with the field in specific ways and, as such, shaped the understandings that were generated through these engagements. The selection of field sites at the core of this study offer only a partial and incomplete view of how policy actors engage in efforts to imagine and enact community-scale carbon neutrality. Interactions between technologies, institutions, people, and natures that were brought into focus within this thesis do not reflect the full extent of possible interactions that shape translations between global and local when it comes to net zero emissions. For instance, the scoping research that informed the selection of study sites (summarised in Chapter Three) offered only a snapshot of those local jurisdictions with explicit commitments for community-scale carbon neutrality. As previously noted, this cohort comprised mainly of jurisdictions from the global north, highlighting the importance of future research to undertake ethnographic comparison across conceptual, social, and material categories of developed and developing worlds.

The empirical and conceptual engagements with the places and processes at the core of this thesis are limited. They have been focused primarily on policy actors while only partly tracing what such goals and actions may mean for others who live in, or have connections with, those other places where emissions are reduced and neutralised – such as through building renewable energy infrastructures, producing and harvesting biomass, and undertaking afforestation. Given time, my research engagements might have extended further to encompass people involved in these kinds of carbon offset projects such as participating in tree-planting in Byron Shire, interviewing people that live adjacent to the City of Melbourne's wind turbines in regional Victoria, or observing forestry practices in the places from which the City of Copenhagen's biomass is sourced. While the analysis in this thesis might indicate processes of abstraction and suggest points of friction in these interactions, the insights generated are only partial.

Regarding conceptual concerns, the framing of sociotechnical imaginaries proved useful for inquiry into how policy actors engage in processes to collectively imagine and enact low carbon futures. People and technologies are at the centre of this conceptual lens, situated in a future-oriented modernity that, without overdetermining human agency and technological drivers of change, nonetheless emphasises these interactions. The future thus tends to be thought of in positive terms, such as with "challenges" turned to "opportunities" as seen in the discourses of net zero emissions and community-scale carbon neutrality. This orientation, however, means that the thesis has not engaged substantively with a vein of rich anthropological inquiry into the Anthropocene – including from a "capitalocene" or "plantationocene" perspective (Haraway, 2015; Moore, 2017; 2018; Tsing, 2017) – that pull against the somewhat heroic undercurrent of the sociotechnical imaginary conceptualisation.

Building on the above concerns from a more theoretical stance, more-than-human relations and multispecies entanglements clearly feature in these processes to imagine and enact low carbon futures. Yet these are largely absent from the frames of analysis applied in the thesis, which has tended to focus more on sociotechnical relations. Where ecologies and natures have entered the picture, such as by thinking through assemblages, it has been in somewhat one-dimensional forms as policy actors bring ecologies into their projects to remake local worlds as carbon neutral. My focus on carbon assemblages – that is, assemblages configured around the object of CO_2-e (rendered abstract as a general object of climate governance and, at the same time, a specific assemblage of heterogeneous social and material elements) – is a key reason for this narrow view. The tendency in this thesis has been to consider how natures are rendered as objects within sociotechnical projects and systems. Of course, a universal Nature (Tsing, 2005) features in the background of these efforts to enact net zero emissions in the form of global climate change. However, this can also be seen as the "natural" set apart from the sociotechnical – that is, the human activities and sociotechnical systems that are the cause of, and response to, the climate crisis.

Australia's severe summer of bushfires in 2019-20 has had, as mentioned earlier, a profound effect on discourses of climate change. This is so not only in those parts of the country directly impacted by the blaze, but also among the millions of inhabitants in major cities that were affected by the smoke and pollution – destroying lives and homes, transfiguring landscapes, and altering relationships with the very air we breathe. So, too, entanglements with the novel coronavirus are rapidly and radically reshaping social and material relationships around the world. To overlook these more-than-human and multispecies entanglements is to elide assemblages that dramatically shape conditions of possibility in which to imagine and enact net zero emissions.

8.4 Areas for further research

This thesis has focused on policy actors involved in translating the concept of global net zero emissions into local goals for, and actions towards, community-scale carbon neutrality in three particular places. Key limitations of the approach taken in this study, outlined above, draw attention to a range of interconnected areas for further research.

Given the open-endedness of efforts to enact net zero emissions, an important issue arising from this thesis that warrants further attention is the hold that discourses and practices related to net zero and negative emissions are gaining across an increasingly wide range of social and political structures. Discourses of negative emissions are becoming more prevalent, such as in scientifically modelled pathways of emissions reductions needed to meet the 1.5°C target (IPCC, 2018: 19), and in relation to C40 Cities' Deadline 2020 program that was examined in Chapter Seven. A key question, therefore, is how such practices intersect and overlap across domains of public and private, multinational and national, global and local, and with what implications for shaping social and material relations in particular places. Continued inquiry into these domains of action and patchworks of boundaries will be important to better understand the situated processes, practicalities, and implications of efforts to achieve the goals of the 2015 Paris Agreement.

Considering the limitations to this study outlined beforehand, such research might seek to engage more directly with power relations and capitalist structures and their involvement in maintaining or displacing greenhouse gas intensive activities such as fossil-fuel based energy production, industrial agricultural practices, and urban development. Key findings from this thesis about the ways in which structures and categories of climate governance are brought into being, stabilised, and destabilised will be crucial to examine how constellations of governments and corporations are involved in negotiating and contesting objects and scales of climate governance, definitions of net zero and negative emissions, and policy interventions towards such goals.

A further research imperative is to consider imaginative capacities that are not always positive and utopian, perhaps as a way to question and counter the underlying hubris of sociotechnical progress often contained in the concept of a sociotechnical imaginary. The growing discourse of "climate emergency" (mentioned in Chapter Three) may offer a handle on this issue because it foregrounds the existential challenge, rather than the opportunity, of acting to reduce emissions. Discourses of emergency are often underpinned by a set of assumptions about social order to befit an emergency response such as mass social and economic mobilisation, but may also be accompanied by consolidations of power with limited transparency and oversight of decision-making. This is an interesting point, since for the most part climate emergency declarations are being led by community groups and local councils in their advocacy towards state and national levels of government. These potential

discrepancies suggests an important area of inquiry following the kinds of comparative ethnographic methods developed through this thesis, and one that may cast a different light on sociotechnical imaginaries and socio-ecological relations.

A final point of reflection is that, in order to draw more-than-human and multispecies entanglements into research engagement with issues of net zero emissions, it may be necessary to decentre the abstract object of carbon from the frame of inquiry. For this task, there is much to learn from scholarship and practices focused on emplaced practices and assemblages related to renewable energy, community economies, regenerative agricultures, and ecological resurgences. This thesis engaged with sociotechnical imaginaries and boundaries, in the first instance, yet made sense of these abstractions by grounding them in specific places. Inquiry geared the other way around may help to focus on the ways in which emplaced assemblages and practices might reshape meanings and practices related to more abstract concepts of community-scale carbon neutrality and global net zero emissions.

8.5 Implications

This thesis has developed a set of tools to help understand the dialogues and interconnections between abstracted boundaries and emplaced assemblages that shape, from both outside and inside, efforts to imagine and enact low carbon futures. Tools such as these are important because they are about trying to deal with a radically uncertain world – a world that is being renegotiated in unpredictable ways. The approach developed through this thesis assist with understanding these renegotiations and, by generating new kinds of insights, can inform decisions and actions. The thesis has not developed a set of generalisable explanations that can be used to plan and predict what will happen. Rather, the tools set out earlier in the form of the analytic scaffold are useful for dealing with the complexities and indeterminacies of sociotechnical change towards low carbon futures. This is not to deny the importance of plans and predictions. Rather, it is to offer a complementary frame of analysis that may be used by scholars and policy actors to think through, in new ways, continuing efforts to influence and respond to ongoing processes of change, including those that face towards low carbon futures.

The investigation on which this thesis is based took shape through a focus on processes of boundary making in relation to the global concept of net zero emissions. A key focus within this thesis has been the different ways that boundaries had been defined around community-scale carbon neutrality in the three field sites at the core of this study. Boundaries have served as an entry point into this study of how policy actors translate the concept of net zero emissions from global to local, abstract to emplaced, universal to situated. Understanding processes of boundary making in relation to the concept of net zero emissions required an engagement with situated efforts to imagine and enact this concept, in the form of community-scale carbon neutrality. Abstracted boundaries shape possibilities for net zero emissions, but these abstractions are always shaped in dialogue and connection with situated assemblages.

Emplacements are just as important as abstractions. Emplaced assemblages and frictions shape, from the inside, possibilities to imagine change just as boundaries shape, from the outside, possibilities for action.

I come back to boundaries at the conclusion of the thesis because policy actors are continually involved in processes of boundary making. As I write this chapter, the impacts and implications of COVID-19 are playing out. Boundaries interposed around greater metropolitan Melbourne have been "locked down" to restrict movements of people and enforce physical distancing in order to contain escalating outbreaks of the virus. Boundaries between cities, regions, and countries are being performed differently, challenging patterns of mobility in various sectors, and making it incredibly difficult to make sense of what is going to happen next. New assemblages of people, technologies, and natures are taking hold – social interactions, face masks and hand sanitisers, and micro-organisms – disassembling norms and expectations and reconfiguring our social and material engagements in the world. Of course, frictions are also evident in these upheavals, such as between abstracted daily coronavirus cases and situated lockdowns. Shifts between social and material elements, and with multispecies entanglements, are radically reshaping the conditions of possibility in which low carbon futures might be imagined and enacted.

While this dissertation is focused on carbon neutrality in relation to local jurisdictions, its findings concern processes and relationships that are also relevant to other kinds of social and spatial settings. The findings have implications for thinking about global net zero emissions – not as an abstract and stable future planetary state, but as a heterogeneous and dynamic patchwork of social and material assemblages that connect people, technologies and natures in new ways. Spatial and conceptual boundaries delineated to anchor and guide these pathways are not fixed and determinate but negotiated and contested. The analytic scaffold and ways of thinking through interconnections developed through this thesis will be enormously important as we come to grips with the dramatic shifts that are happening now. These are shifts in relation to collective imaginaries, boundaries, assemblages, and frictions.

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Appendix 1. Scoping research and interview themes

1a. Review of local government emissions reduction targets of 80% or more[23]

Table 2: Review of local government emissions reduction targets of 80 per cent or more

Adelaide, Australia	100% by 2025
Bendigo, Australia	100% by 2026
Byron Shire, Australia	100% by 2025
Darebin, Australia	100% by 2020
Melbourne, Australia	100% by 2020
Moreland, Australia	100% by 2045
Queenscliff, Australia	100% by (unspecified)
Graz, Austria	80% by 2050
Antwerp, Belgium	100% by 2050
Ghent, Belgium	100% by 2050
Caledon, Canada	83% by 2021
Calgary, Canada	80% by 2050
Colwood, Canada	80% by 2050
Halifax, Canada	80% by 2050
London, Canada	80% by 2050
Maple Ridge, Canada	80% by 2050
North Cowichan, Canada	80% by 2050
Richmond, Canada	80% by 2050
Toronto, Canada	80% by 2050
Vancouver, Canada	80% by 2050
West Vancouver, Canada	80% by 2050
Rizhao, China	100% by (unspecified)
Aarhus, Denmark	100% by 2030
Copenhagen, Denmark	100% by 2025
Hoeje-Taastrup, Denmark	98% by 2050
Sønderborg, Denmark	100% by 2029
Helsinki, Finland	90% by 2050
Tampere, Finland	100% by 2050
Turku, Finland	100% by 2040
Vantaa, Finland	100% by 2050
Berlin, Germany	85% by 2050
Frankfurt, Germany	95% by 2050

[23] Source: Author desktop review, December 2016

Hamburg, Germany	80% by 2050
Bolzano, Italy	80% by 2030
Yokohama, Japan	80% by 2030
Himeji, Japan	82% by 2050
Kofu, Japan	80% by 2050
Kumamoto, Japan	80% by 2050
Nagahama, Japan	80% by 2050
Naha, Japan	80% by 2050
Nara, Japan	80% by 2050
Niigata, Japan	80% by 2050
Saitama, Japan	80% by 2050
Sapporo, Japan	80% by 2050
Shimonoseki, Japan	80% by 2050
Tokorozawa, Japan	80% by 2050
Yao, Japan	80% by 2050
Puebla, Mexico	90% by 2050
Wellington, New Zealand	80% by 2050
Arendal, Norway	90% by 2017
Gothenberg, Norway	80% by 2050
Haninge, Norway	90% by 2050
Huddinge, Norway	85% by 2050
Oslo, Norway	100% by 2030
Guédiawaye, Senegal	80% by 2050
Jämtland, Sweden	100% by 2030
Östersund, Sweden	100% by 2030
Stockholm, Sweden	100% by 2040
Uppsala, Sweden	94% by 2050
Växjö, Sweden	100% by 2030
Västerås, Sweden	80% by 2050
Zurich, Switzerland	82% by 2050
London, UK	80% by 2050
Milton Keynes, UK	100% by 2050
Ann Arbor, USA	90% by 2050
Asheville, USA	90% by 2030
Atlanta, USA	80% by 2040
Austin, USA	90% by 2050
Antioch, USA	80% by 2050
Aspen, USA	80% by 2050
Berkley, USA	80% by 2050
Boston, USA	80% by 2050
Boulder, USA	80% by 2050

Burlington, USA	80% by 2050
Charleston, USA	83% by 2050
Charlotte, USA	100% by 2050
Cincinnati, USA	84% by 2050
Chicago, USA	80% by 2050
Cleveland, USA	80% by 2050
Des Moines, USA	80% by 2050
Edmonton, USA	80% by 2050
Hayward, USA	82% by 2050
Hillsboro, USA	80% by 2050
Kansas City, USA	80% by 2050
Los Angeles, USA	80% by 2050
Minneapolis, USA	80% by 2050
New York City, USA	80% by 2050
Oakland, USA	83% by 2050
Orlando, USA	90% by 2040
Philadelphia, USA	80% by 2050
Portland, USA	80% by 2050
Salt Lake City, USA	80% by 2050
San Diego, USA	80% by 2050
Santa Fe, USA	100% by 2040
San Francisco, USA	80% by 2050
Santa Monica, USA	80% by 2050
Seattle, USA	100% by 2050
Somerville, USA	100% by 2050
St. Louis, USA	80% by 2050
Tacoma, USA	80% by 2050
Urbana, USA	80% by 2050

1b. Summary of key information about local jurisdictions with commitments for community-scale carbon neutrality

Table 3: Summary of local jurisdictions targeting community-scale carbon neutrality (arranged by target year)

Jurisdiction	Country	Emissions target text	Target year	Emissions baseline (tCO_2-e)	Baseline year	First strategy published	Population	Land area (ha)
Melbourne	Australia	Net zero emissions by 2020	2020	4,942,630	2008	2003	122,207	3,736
Darebin	Australia	Zero net GHG emissions target for the Darebin community by 2020	2020	2,200,000	2005	2009	148,728	5,347
Byron Shire	Australia	Zero GHG emissions by 2025	2025		2016	2016 (draft)	32,119	56,585
Copenhagen	Denmark	CO_2 neutral by 2025	2025	2,240,000	2010	2009	1,246,611	8,825
Adelaide	Australia	Zero net carbon emissions by 2025	2025	1,180,000	2007	2015	22,690	1,557
Bendigo	Australia	Zero net carbon	2036			2016 (draft)	148,360	299,998
Sønderborg	Denmark	CO_2 neutral by 2029	2029	472,188		2009	75,423	496,600
Oslo	Norway	Carbon neutral by 2030 / Reduce community-wide CO_2-e emissions by 100% from 1991 to 2050	2030		1991		647,676	45,400
Jämtland	Sweden	100% GHG reduction by 2030	2030		1990		126,765	4,934,100
Växjö	Sweden	100% CO_2 reduction by 2030	2030	300,000	1993	2014	87,212	191,400
Aarhus	Denmark	CO_2 neutral by 2030	2030				319,680	9,100
Östersund	Sweden	Reduce CO_2-e emissions from the community by 100% by 2030 based on 2010 levels	2030				60,674	250,108

Stockholm	Sweden	100% GHG reduction by 2040	2040	3,700,000	1990	2012	902,000	38,163
Santa Fe	US	100% GHG reduction by 2040	2040			2008	67,947	96,900
Turku	Finland	Reduce community-wide CO_2.e emissions by 100% from 2012 to 2040	2040		2012		177,504	243,400
Moreland	Australia	Getting on track to zero carbon by 2020 (net zero by 2045)	2045	1,491,000	2011	2014	163,488	5,095
Antwerp	Belgium	Reduce CO_2 emissions from the community by 100% by 2050 based on 2005 levels	2050		2005		503,138	20,450
Austin		Net zero GHG emissions by 2050, 80% or more GHG reduction	2050	14,500,000	2005	2015	885,000	70,400
Seattle	US	Reach zero net GHG Emissions by 2050	2050		1990	2013	66,240	21,700
Charlotte	US	100% GHG reduction by 2050	2050				792,862	77,100
Ghent	Belgium	Pushing for city-wide carbon neutrality 2050, powered by locally-sourced renewable energy	2050		2007	2014	248,242	15,800
Milton Keynes	UK	Near zero carbon by 2050	2050			2014	265,000	
Somerville	US	100% GHG reduction by 2050	2050		2014		78,901	3,800
Tampere	Finland	Carbon neutral by 2050	2050				223,292	497,700
Vantaa	Finland	Carbon neutral by 2050	2050				215,813	
Queenscliff	Australia	The Community Carbon Neutral Action Plan will help our community achieve its carbon neutral goals	Unspecified				3,027	862
Rizhao	China	Climate neutrality	Unspecified				1,148,000	531,000

1c. Key themes and prompts to guide interviews

- What is your role in relation to local climate change policy?
    - What do you like about it?
    - What are some of the challenges?
- What does success (of the strategy / policy / project) look like?
    - How do you evaluate success?
- What counts as zero carbon?
    - As an organisation, how do you decide?
    - Who is involved in deciding?
    - What were the most difficult elements to decide upon?
    - What are the issues with measuring / evaluating this?
- How do you deal with elements outside of your control?
    - For example, elements that cross geographical boundaries, like transport, waste, visitors, electricity
    - Elements that cross government / social boundaries like jurisdictional authority, individual / household behaviour,
- What are the most important activities you spend your time on?
    - Where are your efforts expended?
    - Who do you spend time working with on this?
- What are the different priorities and perspectives you've seen brought to bear on this?
    - Where have these differences arisen?
    - How have you managed these differences?
    - Where are these processes taking place, and can I observe?

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Appendix 2. Imagining the net zero emissions city: Urban climate governance in the City of Melbourne, Australia

Stephen Pollard[24][25]

ORCID: 0000-0001-6627-2373

Abstract

This chapter examines situated practices of imagining and seeking to enact a city of net zero emissions through an historic and empirical account of urban climate governance in the City of Melbourne. It traces the City's goals for community-wide carbon neutrality from its 2003 initial strategy *Zero Net Emissions by 2020* (ZNE2020) to its *Climate Change Mitigation Strategy 2020 to 2050*. The City's overriding political commitment to realize net zero emissions across the municipal territory has remained consistent through this period. However, the policy narratives, timeframes, geographies, technologies and scales framing this objective have changed substantially, shifting most notably from carbon offsets to renewable energy. The analysis traces whom the net zero emissions city is imagined for, and who is doing the imagining using the concept of sociotechnical imaginaries to explore how social, technological and ecological assemblages of emissions sources and sinks come to be known and organised through successive strategies for the net zero emissions city. These moves towards an urban green transition reshape conceptual boundaries around the city and reconfigure relationships within and beyond the city in varied ways.

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[24] Melbourne Sustainable Society Institute, Faculty of Architecture, Building and Planning, University of Melbourne, Australia

[25] Climate and Energy College, University of Melbourne, Australia

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Introduction

The target of net zero emissions has emerged as an ideal and imperative response to climate change through multiple levels of climate governance, including local government. This chapter examines political commitments and pragmatic shifts in the City of Melbourne's successive strategies to become a net zero emissions city. The launch of *Zero Net Emissions by 2020* (ZNE2020) in 2003 marked the City of Melbourne as one of the first local governments anywhere to commit to 'community-wide' carbon neutrality (used interchangeably with net zero emissions) (City of Melbourne, 2003). Periodic updates to the strategy saw the City's initial emphasis on carbon trading switch towards accelerating the transition from fossil fuels to renewable energy. With the 2020 timeframe drawing near, the City recently updated *Climate Change Mitigation Strategy to 2050* maintains the political commitment net zero emissions but reframes the policy narratives, timeframes, geographies, technologies and scales framing this objective. Charting these phases against a backdrop of shifting circumstances – political, technological and environmental – unveils persistent tensions between local government ambition and authority to act, and between conceptions of the net zero emissions city as locally discrete and globally networked.

In this chapter I explore how the City's successive imaginaries of the net zero emissions city, and the mechanisms designed to achieve it, are framed as both politically imperative and socially and economically beneficial. The concept of 'sociotechnical imaginaries' (Jasanoff and Kim, 2015) is used to trace envisaged and actual reconfigurations of urban socio-technological systems, and the forms of knowledge and power that shape these as viable and legitimate within local contexts and wider networks. Underlying urban green transitions are questions of whom the imagined city of net zero emissions is for, and who is doing the imagining. Cities are not self-contained but rely on extensive systems of sociotechnical infrastructure and resource flows to enable their reproduction, and notions of urban sustainability are inevitably tied up with wider issues of social and ecological unevenness within and beyond cities (Marvin and Hodson, 2010). Asserting the target the net zero emissions city relies on establishing and maintaining conceptual boundaries around the municipality in order to balance carbon across those edges (Kenis and Lievens, 2017). Attending to these interfaces draws out certain tensions between mundane and ubiquitous urban activities, technical knowledge of carbon, and wider networks of sociotechnical infrastructures and resource flows.

The analysis is based on documents related to ZNE2020 and updates to this strategy in 2008 (City of Melbourne, 2008) and 2014 (City of Melbourne, 2014), through to the City of Melbourne's *Climate Change Mitigation Strategy to 2050* (City of Melbourne, 2018). Analysis of discourses contained in these documents is guided and supported by informal meetings and interviews with a range of key actors involved in the City's climate policies at various stages. The analysis is focused on the City's mitigation

strategies with particular attention to possibilities and practices of balancing carbon across the conceptual edges of the city. The Australian context provides an opportunity to examine urban climate governance amidst a backdrop of uncertainty and upheaval over climate and energy policy. Tracing the City of Melbourne's efforts to maintain its political commitment to the net zero emissions city while responding to this turbulent context circumstances reveal instances of making, and remaking, conceptual boundaries around the municipality. Exploring how these boundaries are asserted and maintained over time, and with whom, offers insights into complex dynamics of sociotechnical change in urban green transitions. Through the text, 'City of Melbourne' and 'City' refer to the city administration, while 'city' refers to the municipal area. While this analysis offers a critical perspective, my overall aim is to acknowledge the City of Melbourne's ongoing commitment and invention in responding to climate change.

The chapter is structured as follows. First, I introduce concepts of net zero emissions, municipal carbon accounting and sociotechnical imaginaries in relation to processes of boundary making in urban climate governance. These concepts are used to explore ways in which climate threats and accountabilities are re-scaled between global and local levels, and how locally bounded targets for net zero emissions are established as legitimate and beneficial. Next, I describe some key characteristics of the City of Melbourne, and then turn to a sequential analysis of the ZNE2020 strategy and its 2008 and 2014 updates. This chronology charts the City's shifting preferences from developing a local market in carbon trading, to investing in renewable energy. Underneath these shifts, the analysis explores ongoing tensions across municipal boundaries. These relate to the ambition of the City's net zero emissions imaginary and its reliance on actors outside the municipality to realize the target, and to managing flows of carbon outside the municipality, via carbon trading and renewable energy, to reduce and offset emissions within those boundaries. Turning last to the 2018 climate strategy, these tensions are restrung as the City of Melbourne reframes the temporal and spatial boundaries of its net zero emissions target, and in doing so repositions itself in relation to neighbouring metropolitan municipalities, the Victorian State Government, and other world cities through the C40 Cities. In conclusion, the analysis demonstrates the situated, partial and contingent nature of the City of Melbourne's political commitments to the net zero emissions city. Asserting, stabilizing and maintaining the conceptual boundaries around this target involves ongoing tensions concerning limits to local government authority, and actions to manage carbon within and outside local areas.

Boundary making in urban climate governance

Net zero emissions and urban climate governance

The overriding objective of the international 2015 Paris Agreement on climate change is to achieve global net zero emissions – a balance of greenhouse gas (GHG) emissions sources and sinks – by the second half of the Century in order to avoid

dangerous climate change (UNFCCC, 2015). While the concept of net zero emissions appears straightforward enough as a technical measurement, the assessment of GHG sources and sinks towards this end is complex. There are substantial difficulties involved in deciding what a 'safe' level of climate change is and for whom, what this end state will comprise, how to get there, and even where we are starting from (Geden and Beck, 2014; Knutti et al., 2016; Schleussner et al., 2016). Such uncertainties and indeterminacies are not a reason to doubt the truth or seriousness of climate change. They rather highlight the complexity of issues at the intersection of scientific knowledge, science-based technologies, and risk (Jasanoff et al., 1998; Miller and Edwards, 2001; Thompson and Rayner, 1998).

Notwithstanding these ambiguities, nation states around the world have endorsed the ambition of global net zero emissions, although to date there is an underwhelming lack of firm commitments and actions through which to realize it (UNEP, 2018). Coupling these imperatives with pressures of globalization and urbanization, cities have been identified as key sites to contribute to the Paris Agreement goals and realize visions of desirable urban futures (Acuto, 2016; Agarwala, 2015; Broto, 2017; Jordan et al., 2015). Amongst urban sustainability narratives, a growing number of local governments are setting targets and timetables for net zero emissions across the cities they represent. These targets describe a situation where GHG emissions have been reduced as much as possible within a discrete geographic area, such as municipal territory, and any emissions that remain are counteracted by reducing or capturing an equal amount of GHG emissions elsewhere. The idea has taken hold through several transnational municipal networks, which offer powerful platform for cities, or those speaking on their behalf, to actively participate in world politics (Acuto and Rayner, 2016; Betsill and Bulkeley, 2006; Bulkeley et al., 2014). For example, the Carbon Neutral Cities Alliance represents 20 municipal governments from around the world with commitments to reduce emissions by 80—100% and become carbon neutral by 2050 (Carbon Neutral Cities Alliance). The C40 Cities network is supporting its almost 100 member cities to become carbon neutral by 2050 under its Deadline 2020 program (C40 Cities and Arup, 2016).

Rescaling climate change through municipal carbon accounting

Fundamental to making the concept of net zero emissions operational at local scales is the technical knowledge generated through municipal carbon accounting. Municipal carbon accounting not only renders carbon visible, but also re-scales concerns about global climate change to local levels and frames accountabilities and responsibilities of local actors (Callon, 2009; Kuch, 2015; MacKenzie, 2009). Following Blok (Blok, 2013: 6) municipal carbon accounts, and the discourses of urban climate governance they support and are shaped by, can be understood to rescale knowledge of global ecological risks into situated city-making practices. At the same time, municipal carbon accounting offers the potential to aggregate the impact of local emissions reduction efforts and re-scaling urban city-making practices to global importance.

For municipal governments, the Global Protocol for Community-scale GHG Emissions Inventories (GPC) has emerged as the standard approach to calculating territorial emissions within discrete local areas (Greenhouse Gas Protocol, 2016). Municipal carbon accounts seek to localize GHG emissions within territorial boundaries and administrative control by delineating emissions 'scopes'. These assign emissions according to where they are generated, including from direct fuel combustion (scope 1), from outside municipal boundaries such as stationary energy generated to meet local demand (scope 2), and embodied in supply chains and waste (scope 3) (Greenhouse Gas Protocol, 2016). These spatial definitions are useful, but emissions also traverse complex and overlapping regimes of political authority and domains of social and economic life. Defining different system boundaries results in significant differences between calculated emissions, potentially redirecting mitigation efforts in varied ways (Davis and Caldeira, 2010; Liu et al., 2015).

Managing carbon towards a defined end point is not only a technical exercise but involves certain judgements about which emissions sources and sinks to include and exclude, how to value and aggregate different types of emissions, how to make comparisons over time, and how to use the information to inform policy (Callon, 2009; MacKenzie, 2009). Such issues play into disputes about how much cities, broadly defined, are to blame for climate change, such as which cities, and what structures and agents within and beyond those cities ought to be held to account for urban emissions (Dodman, 2009; Satterthwaite, 2008). While cities concentrate many of the human activities, institutions and systems of infrastructure that generate GHG emissions, their reproduction relies on extensive networks of sociotechnical infrastructure and continued flows of resources (Marvin and Hodson, 2010). Thus efforts to measure and manage urban GHG emissions involve negotiating boundaries around complex and interconnected ecological and socio-technical systems.

The net zero emissions city as a sociotechnical imaginary

Conceiving the net zero emissions city as a sociotechnical imaginary is a way to explore processes of boundary making within urban climate governance. Political commitments and policy strategies to realize net zero emissions cities bridge between local and global issues and encompass visions of desirable social and technological order that extend within and beyond cities. Jasanoff and Kim define sociotechnical imaginaries as "collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects" (Jasanoff and Kim, 2015: 120). The concept helps to draw out how collective representations of desirable futures are shaped, especially with respect to new and reconfigured sociotechnical assemblages such as systems of energy provision, transport, food production or habitation. Such imagined futures express implicitly notions of the public good, and are used to inform and legitimize policy actions. And while sociotechnical imaginaries relate to a sense of national political identity, they are also embedded in and produced by individual or collective accounts of potential futures across scales (Jasanoff, 2015). This prompts us to ask how sociotechnical

imaginaries operate across scales to shape and justify responses to climate risk, preferred pathways of social and technological change, and visions of a desirable future in the context of climate change.

By asserting the boundaries of the city as well as the flows of carbon that cross those edges, sociotechnical imaginaries of the net zero emissions city shape and reinforce performative and political dimensions of knowledge production, while at the same time reshaping ecological, social and technological relations. Hodson and Marvin (Hodson and Marvin, 2017) argue that the dominant framings of urban sustainability are based on assumptions of 'green growth', where economic growth is used to ecologically modernize urban environments. These heroic narratives have become increasingly narrowed towards elements of urban environments with economic and market potential, marginalising traditional concerns with social justice and equity within, and beyond, cities themselves (Gleeson, 2014). In this context, it seems important to consider the conditions under which consent and trust are generated in imaginaries of the net zero emissions city, using what knowledge, amongst which networks and actors, and how uneven and fragile these conditions are. This includes the extent to which local imaginaries of urban low carbon transition shaped by, or able to influence, wider contexts of state and national policies and influence dominant interests in emissions-intensive sectors of energy, transport, construction, retail and so on. To examine these processes empirically, we turn to consider the City of Melbourne, and its successive efforts to define, enact and maintain its objectives for a net zero emissions city.

Situating the City of Melbourne

The City of Melbourne covers an area of 37.7 square kilometres at the geographic centre of Greater Melbourne, one of 32 municipal governments within this metropolis of almost 10,000 square kilometres and 4.8 million people (City of Melbourne, 2018: 10). At present, over 158,000 people live within the municipality, but the daily population grows six-fold with workers, students and visitors (City of Melbourne, 2019).

The municipality is located on the lands of the Wurundjeri people of the Kulin nation, and encompasses the densely developed city centre and 11 surrounding suburbs. Its central business district comprises wide boulevards laid out on a grid, interspersed with small laneways celebrated for their lively food, music and street art. Skyscrapers tower overhead presenting a formidable skyline. Corporate headquarters and government agencies, universities and medical precincts, galleries and museums, festivals and events, position the city at the centre of the State of Victoria's productivity and innovation. The central city is fringed by the Yarra River, Birrarung Marr in the local indigenous language, and surrounded by parklands and sporting arenas including the iconic Melbourne Cricket Ground. These give way to an assortment of forms including the Port of Melbourne's heavy industry, sites of urban renewal, gentrified inner suburbs and public housing estates, shopping strips

and public parks, interspersed with networks of road, rail, footpaths and cycling paths.

As these assorted urban forms suggest, activities in the city are diverse and varied. The City of Melbourne has authority over planning and building, rates, local roads, waste management, parks and gardens, amongst other things. However, as a former executive in the city administration described, "the ability of cities to influence varies dramatically. Some cities run a lot of big buildings, schools, bus fleets. The City of Melbourne is unusually small in terms of its jurisdictional authority" (Interview, November 2017). The most emissions intensive activities sit outside the domain of local government authority. Emissions from stationary energy, or scope 2 emissions, are very high due to Victoria's reliance on brown coal for electricity. The state government also powerfully shapes the urban environment through land-use zonings, planning and building controls for large developments, and major infrastructure and services including toll roads and public transport. Thus, the city administration is one actor amongst many involved in shaping the future direction of the central city and wider Melbourne metropolis. As the following sections explore, its efforts over time to frame and realize the net zero emissions city reveals complex dynamics of collective action towards urban green transitions.

Zero Net Emissions by 2020: A roadmap to a climate neutral city

The City of Melbourne's net zero emissions city imaginary emerged in part as a political and ethical commitment to alleviate the municipality's contribution to global environmental problem of climate change. It was also designed to elicit support from local businesses and residents with its positive portrayal of the economic and social benefits that would flow from these actions by carefully situating these benefits within the city and neighbouring Victorian municipalities.

In 2002, the City of Melbourne announced its commitment to reduce greenhouse gas emissions and achieve net zero emissions by 2020, both for its own operations and 'community wide' across the municipality. It published its first strategy towards this objective in 2003, *Zero Net Emissions by 2020: A roadmap to a climate neutral city* establishing the municipality as an early mover in efforts by cities to respond to climate change. ZNE2020 frames climate change as a matter of global environmental risk requiring cities, and their citizens, to contribute a fair share towards collective action. In this respect, the strategy sets out to "end the city's contribution to climate change", encompassing the local government and the commercial, industrial and residential inhabitants of the city (City of Melbourne, 2003: 3).

Alongside its objectives on climate change, the City was advancing multiple plans to position Melbourne on the world stage. As one former Councillor explained, "the trends of globalization were taking hold, and there was a sense that Melbourne could occupy its own niche in this global context if it could develop the capacity to attract finance, investment, knowledge, and people from around the world" (Interview,

February 2018). Alongside climate risks, the strategy frames rapid urban growth in Australian cities and overseas as threats to the urban environment and the quality of urban life, and globalization as changing the nature of competition between cities for investment. These risks are cast as opportunities to position Melbourne as an attractive centre for 'green' productivity that couples "productive, knowledge-based industries with a quality lifestyle and environment" (City of Melbourne, 2003: 3), and establish a 'blueprint' to export knowledge, skills and technologies to other cities.

The edges of the imagined net zero emissions city were defined, at least in part, by the territorial boundaries of the municipality, and the jurisdictional authority of local government. The City's first municipal carbon accounts delimit an area aligned with the administrative boundary of the municipality, identifying total emissions of 3.75 million tonnes of carbon dioxide equivalent (CO_2^{-e}) across commercial buildings, industry, residents and waste (City of Melbourne, 2003: 15). Demand for stationary energy was identified as the major source of emissions from activities within the municipality. The accounts excluded transport and embodied energy, noting their small contribution to total emission and Council's limited influence over these areas (City of Melbourne, 2003: 5). The strategy set out actions for the net zero emissions city in three core areas: 'leading edge design' to reduce energy demand, 'decarbonising electricity' by influencing the renewable energy generation, and 'carbon sequestration' to counteract remaining emissions with carbon offsets (City of Melbourne, 2003: 4). And although corporate emissions from the City of Melbourne's own operations account for less than one per cent of total 'community wide' emissions, the City was keen to leverage its authority and leadership to demonstrate emissions reduction strategies (City of Melbourne, 2003: 9).

From the outset, the strategy anticipated measures to reduce emissions outside the municipal boundaries and beyond Council's direct control, indicating limits to local government power and agency in matters affecting GHG emissions. The City of Melbourne's net zero emissions imaginary rested, in large part, on its perception of the inevitability of global carbon markets and the emergence of policy and legal frameworks to participate in these markets. Discourses around carbon trading and carbon markets had been emerging through the international climate regime as a viable, low cost and 'optimal' response to climate change (City of Melbourne, 2003: 3). Conditions for such markets to emerge were being established both locally and internationally with the concept of carbon offsets (Bumpus and Liverman, 2008). At a state level, the Victorian Government had amended the *Forestry Rights Act 1996* to encourage investment in forest plantations as carbon sinks by disaggregating legal rights to land, trees and carbon and allowing carbon held in certain trees to be traded. Nationally, carbon trading was emerging as the preferred response to climate change with the *Bush for Greenhouse* program developing tools to account for the carbon content of certain types of land use and forestry, and work on legal instruments, standards and guidance that would later provide the structure for carbon trading in Australia (Kuch, 2015). These technical details were not all

straightforward. A former technical adviser to this program recounted negotiating over whether trees that kangaroos could jump over could still be counted as trees (Interview, November 2017).

Rather than waiting for these markets to emerge from above, the City envisaged a local carbon trading market to provide a "least cost, flexible and effective collective response" while preparing the city administration and resident businesses for "eventual international trading in carbon credits" (City of Melbourne, 2003: 3). Achieving net zero emissions would rely on establishing these flows of carbon as viable and legitimate. The 2003 strategy proposed a pilot to offset a portion of Council's own emissions by purchasing the carbon rights for blue gum mallee eucalypts, identified as a carbon sink and a profitable investment (City of Melbourne, 2003: 54). The pilot would see 10 per cent of corporate emissions sequestered in a particular municipality in the north of the state, increasing to 50 per cent by 2010. The eucalypts would store carbon in their roots, while the growth above ground would be used as feedstock for power generation with eucalyptus oil as a valuable by-product (City of Melbourne, 2003: 41). "Combined with the 50 per cent target in the City of Melbourne's use of renewable energy, sequestration will deliver net zero corporate emissions" (City of Melbourne, 2003: 41). While this action was designed around the City's corporate emissions profile, the longer term would see the pilot developed into a carbon trading scheme for the city's businesses, residents and industries as a way to encourage these actors to "shoulder their own responsibility" for GHG emissions (City of Melbourne, 2003: 53).

The narrative of ecological modernization resonates strongly in this framing of individual responsibility, technological innovation and market opportunity as a way to address environmental ills and reap economic and social benefits. If the City of Melbourne moved fast enough in implementing the proposed strategy, it could potentially create a competitive advantage similar to the City of London, which was "already positioning itself as a global hub for greenhouse gas emissions trading" (City of Melbourne, 2003: 15). The 2003 strategy envisaged a combination of local carbon trading, coupled with investments in facilities and expertise to position Melbourne as a key city in 'green productivity and emerging global carbon markets.

Although the ZNE2020 strategy framed a market-based solution as logical and natural, it also placed limits on how far that solution ought to extend. The strategy asserted that the location for carbon trading "must be in Victoria – it would be inappropriate for the City of Melbourne to partner with an organization from another State" (City of Melbourne, 2003: 43). Although not fully explained, the strategy suggested that pre-existing relationships with the municipality proposed to host the eucalypt plantation would help to develop the trust needed to start the scheme. It also suggested that rural and urban communities would be encouraged to "learn of the wider impact of their simple day-to-day actions on their household, the environment and the wider community" (City of Melbourne, 2003: 46). Though based in market exchange, these envisaged trades in carbon were also hoped to encourage exchange

of other values, including the repercussions of everyday activities and dependencies between city and its hinterlands.

The City's net zero emissions imaginary predicted carbon markets as an inevitable and preferred response to climate change, and carbon offsets as an opportunity for local leadership and economic development within the city and its hinterlands. Carbon trading was designed to elicit support for the net zero emissions city by responding to local and global threats and creating numerous 'goods' – counteracting urban emissions and generating investment returns in the city, producing electricity and generating income and wider regional benefits, and strengthening relationships between urban and regional communities.

Stabilizing net zero emissions: carbon offsets to renewable energy

The City of Melbourne updated its ZNE2020 strategy in 2008 and again in 2014. The updates continued to assert the net zero emissions city objective, even as emissions within the municipality climbed. By 2006, estimates of community-wide emissions had grown to 6.4 million tons, projected to increase to almost 8 million tons by 2020. The 2008 update set a goal to reduce these by around 1.5 million tons by 2020 with the remainder to be offset (City of Melbourne, 2008: 22). However, in response to anticipated shifts in national climate policy, the City abandoned its proposed municipal carbon trading scheme.

National commitments to establish emissions trading and renewable energy targets were expected to significantly contribute to this. The national government was seen by many as the appropriate level to deliver economically optimal strategies to reduce emissions with limited duplication and overlap (City of Melbourne, 2014: 2). These expectations were reinforced by economic analyses from the UK and Australia that underlined the opportunities and benefits of proactive and early measures to reduce emissions and the costs of delayed action (Stern, 2007; Garnaut, 2008). The update considered it "highly likely" that new market conditions created by these policies would result in "investment to support the most economically viable, locally sourced, renewable and low-carbon technologies within the boundaries of the City of Melbourne" (City of Melbourne, 2014: 2). Expectation of action by others reshaped the City of Melbourne's prospects for lowering emissions within municipal boundaries.

In terms of carbon accounting and offsetting, national methods and standards were further developed to generate trust in carbon markets, aligned to the Kyoto Protocol and the emergence of voluntary carbon trading. The National Carbon Offset Standard (NCOS) established an orthodox approach to carbon accounting for organisations including local governments, and criteria for purchasing offsets generated in Australia and overseas that met basic criteria for accountability (Department of Environment and Energy, 2010). This standard, alongside other developments in carbon accounting and reporting such as the *National Greenhouse and*

Energy Reporting Act 2011, came to define the technical benchmarks against which the City of Melbourne and most other Australian local governments assert their carbon neutral status (City of Melbourne, 2016).

Against these developments, the City of Melbourne abandoned its pilot to sequester carbon in regional Victoria in favour of purchasing carbon offsets via voluntary markets. In the 2011-12 financial year, it was certified as a carbon neutral organization under NCOS. To meet this certification, the city administration purchased almost 10,000 MWh of 'Greenpower' under the national renewable energy target (negating over 13,000 tons CO_2^{-e}), and over 44,000 tons of carbon offsets. These were mainly carbon credits from capturing landfill gas under the national government's *Carbon Credits (Carbon Farming Initiative) Act 2011*, and also included 200 tons CO_2^{-e} of offsets from a small scale hydropower project in China accredited under the international Verified Carbon Standard program. While continuing efforts to reduce its corporate emissions, the City continued to offset remaining emissions each financial year with from a range of projects in countries including Indonesia, Mali, Turkey, Zimbabwe, Uganda and China (City of Melbourne, 2016; Department of Environment and Energy, 2019).

While these offsets related to corporate rather than community-wide emissions, they show that the City of Melbourne's preferences to trade urban carbon to a known and specific hinterland and organized with trusted partners were supplanted by a more commoditized approach. The City's ability to carry out this change relied on a global system of standards, verification, regulation and oversight to generate trust between market participants largely unknown to each other. The City's participation in these global markets displaced urban carbon to further away, and mediated these trades through impersonal relationships, making the environmental, social and economic impacts and implications of these trades much harder to discern.

In 2014, The City of Melbourne again updated ZNE2020 during a period of significant upheaval in the Australian landscape of climate and energy policy. Measures to price carbon pollution and invigorate renewable energy investments did not provide the policy stability that many were hoping for. Australia's emissions trading scheme was repealed in July 2014 followed a year later by cuts to the national renewable energy target (Talberg and Workman, 2016). The 2014 update to acknowledged that the first update "was written with the assumption that Australia would put a price on carbon and international policy would be in place to drive significant emissions reductions" (City of Melbourne, 2014: 3). It stressed that action by the City of Melbourne alone would not achieve the target for zero net emissions, and "the actions outlined in this strategy must be accompanied by fundamental changes to our energy supply which is subject to Australian and Victorian Government policy" (City of Melbourne, 2014: 2). This stresses the extent to which local government actions are constrained by the decisions and actions of state and national governments.

Although the actions of those outside the municipality failed to deliver expected emissions reductions within the city, the 2014 update reasserted the commitment to carbon neutrality. Looking beyond national politics, it asserted the "inevitability of the low carbon economy" and emerging opportunities to manage carbon within and beyond municipal boundaries (City of Melbourne, 2008: 10). In this regard, the 2014 update demonstrated a range of approaches to lowering Council's own emissions and across key sectors in the municipality. Notably, the City established environmentally sustainable building and retrofitting practices with its offices and community buildings, and supported others to do the same.

Carbon offsets remained a central part of the 2014 update, albeit with some reservations. The 2014 update estimated that offsetting community-wide emissions in 2020 would cost around AUD$30 million (City of Melbourne, 2014: 3). This would be a recurring cost, and would vary depending on the success of other measures such as renewable energy uptake, cutting emissions from transport and waste, and the cost of carbon offsets into the future. Offsetting urban carbon at such a scale would also defer more fundamental changes to socio-technical systems, lifestyles and behaviours in favour of crediting actions taken elsewhere. This awareness served to dilute economic imperatives for action defined in earlier iterations of the strategy. Despite their continued place in the City's climate strategy, carbon offsets appeared to be in tension with the net zero emissions city imaginary.

In contrast, policy actions concerned with 'decarbonizing the energy supply' were strengthened in the 2014 update. The City of Melbourne scaled-up its renewable energy target for council operations to 25 per cent by 2018. To meet this target, it formed a consortium with other inner-city organizations to purchase renewable energy directly from a new wind farm in regional Victoria. Called the Melbourne Renewable Energy Project (MREP), a dozen large organisations negotiated to contract power directly from the proposed 80MW Crowlands wind farm, enabling the proponent to secure finance and start construction. The City achieved 100 per cent renewable energy for its corporate operations when the wind farm came on line in January 2019 (Vorrath, 2019). Policy makers within the City of Melbourne described how the MREP circumvented the local government's lack of authority by taking a 'demand-driven' approach, whereby large energy consumers influence the composition of energy supply and mediate their energy demands through energy efficiency measures (Meeting notes, March 2017). They recognised that "local government has no policy levers to influence the composition of the grid, so they started looking at the demand side for options to bring new renewable energy generation online" (Interview, December 2017).

The MREP project was developed at a time when the dominant industry generators and retailers were reluctant to contract new renewable energy because of uncertainties over the future direction of national energy policies, especially in regard to regulating GHG emissions. It enables "cities, corporations and institutions to take an active role in securing renewable electricity supply and taking action on climate

change" (City of Melbourne, 2017: 6). It also helps these customers "mitigate the risk of increased energy costs in a volatile market" with long-term price certainty" (City of Melbourne, 2017: 6). The project positioned the City of Melbourne in a leadership role within this uncertain landscape, facilitating complex arrangements between large organisations with widely varying needs (Interview, December 2017).

The MREP also re-established envisaged relationship between the city and its hinterlands in managing urban emissions, this time through renewable energy rather than carbon offsets. Tenders for the electricity contract were extended to sites in regional Victoria but not elsewhere. The project was presented as a way to share the wealth and prosperity of the city through regional development, while at the same time producing 'home grown' power and 'local' energy (City of Melbourne, 2017: 9). This reflects a persistent desire to recognise dependencies between the city and its hinterlands. Even so, the City and its partners in the project were unable to direct specific preferences for the location of the wind farm, instead adhering to a tender process. The Crowlands site was selected from a range of proposals put by the market so that all the suppliers were treated fairly (Interview, December 2017).

Through the 2008 update to ZNE2020, the development of technical standards and global markets in carbon trading reconfigured the way the City of Melbourne achieved carbon neutrality for its corporate emissions. However, the accounting standards that established carbon as a tradeable commodity also limited possibilities for more relational displacements of carbon. The particular relations underpinning municipal carbon trading envisaged in the 2003 strategy – with rural municipalities and eucalyptus trees – was altered as carbon itself was alienated from these tight relational bonds. Arrangements for renewable energy appear somewhat different with the project bringing together particular actors in urban and regional settings, though mediating these relations through complex energy market contracts and large-scale electricity infrastructure.

Re-imagining the net zero emissions city

While the MREP enabled the City of Melbourne to realize zero net emissions for its own operations, achieving net zero emissions by 2020 across the entire municipality has seemed increasingly unlikely. In 2017, emissions across the municipality were over 4.6 million tonnes CO_2^{-e} (City of Melbourne, 2018: 12). In November 2018 the City released its new *Climate Change Mitigation Strategy to 2050: Melbourne together for 1.5°C* (City of Melbourne, 2018). The new strategy reasserts the City's commitment to community-wide net zero emissions but shifts the timeframes to act and mechanisms to achieve the goal, while also opening up possibilities for new approaches to municipal carbon accounting.

The period since the 2014 update of ZNE2020 saw several significant changes in climate governance across regional, national and international registers. At the national level, the turbulence of Australia's climate and energy policy landscape

continued with unstable energy policies and unsatisfactory measures to reduce emissions in line with the Paris Agreement (OECD, 2019). Against this, commitments and activities at sub-national and local levels gained momentum. Notably, the Victorian Government introduced state based targets for renewable energy and a goal for statewide net zero by 2050 through the *Climate Change Act 2017*. At the international level, C40 Cities developed a platform for its member cities to reduce emissions in line with the Paris Agreement's 1.5°C target. Called Deadline 2020, the program couples top-down modelling of global carbon budgets with assessments of cities' per capita emissions and GDP to define community-wide emissions reduction trajectories and identify priority actions (C40 Cities and Arup, 2016: 10). The program requires all its member cities to develop climate action plans before 2020, guided by these targets but configured around their particular circumstances.

The City of Melbourne was one of eight cities to pilot the Deadline 2020 program as a basis for its new climate strategy (C40 Cities). Deadline 2020 coordinates narratives of action in relation to the common target of 1.5°C, defining emissions reduction pathways of C40 member cities based on a 'contract and converge' model of equal per capita of emissions by 2030 (C40 Cities and Arup, 2016: 7). In one sense, the Deadline 2020 program abstracts the city from its setting to situate it in relation to other cities around the world. This lets local governments benchmark against other cities and raise the bar on their own climate governance, justifying and promoting stronger ambition. The actions required to meet these targets are expected to vary from one city to the next, but the overarching frame is one of ecological modernization, where urban socio-technical infrastructures are transformed and resource flows secured in response to the risks of climate change.

The City's *Climate Change Mitigation Strategy to 2050* extends and adjusts the temporal and spatial boundaries of the net zero emissions city imaginary. Notably, aligning the strategy to the Paris Agreement and state government targets lengthens the timeframe to achieve net zero emissions appreciably from 2020 to 2050. The City of Melbourne's alignment to state government targets and timeframes seems especially crucial given its limited policy levers to change wider systems of energy, transport, buildings and waste. The emissions reduction targets "can only be achieved through collaborative action with all three levels of government" (City of Melbourne, 2018: 19). Coupled with support from C40 Cities, the strategy established the city within a wide network of collective actors. A shift in language reflects this position. The political commitment to net zero emissions has moved from an "end to the city's contribution to climate change" (City of Melbourne, 2003: 3) to "part of international efforts to avoid a 1.5°C increase in global temperatures…[aligned] with the science-based targets in the Paris Climate Agreement" (City of Melbourne, 2018: 10). In this respect the new strategy places the City of Melbourne as a broker between multiple actors within and outside of the municipal boundaries. From local residents,

businesses, workers and community groups, to neighbouring municipalities, state and national government, and other cities around the world.

Similar to previous strategies, the new strategy enlists economic modelling to assert that "if we do not act decisively to reduce emissions as part of the global effort, the impacts of climate change and missed economic opportunities of transitioning to a low carbon economy will cost the community $12.6 billion from 2020 to 2050" (City of Melbourne, 2018: 5). Compared to this estimate, the net economic benefits of taking 'significant' or 'accelerated' action to reduce emissions are modeled at $3 billion and $5.6 billion respectively (City of Melbourne, 2018: 5). The strategy rejects an option to achieve net zero emissions by 2020 by purchasing carbon offsets based on high recurring cost (higher even than estimated in the 2014 update) and lack of local benefits. "The estimated cost to the City of Melbourne of the Purchasing Offsets Scenario would be AU$240—480 million per year and would not address the underlying causes of emissions in the municipality" (City of Melbourne, 2018: 5). In principle, the City accepts that offsets can be justified where they provide "important environmental, social and economic benefits for reducing emissions in remote and regional Australia, and in many other countries" (City of Melbourne, 2018: 22). However, in terms of relying on offsets to meet and sustain net zero emissions, "achieving emissions reductions through purchasing offsets alone will not address the systemic causes of GHG emissions or achieve the full extent of benefits for Melbourne residents and businesses" (City of Melbourne, 2018: 22).

Thus the role of carbon offsets in the City of Melbourne's net zero emissions imaginary has been largely dismissed since its first iteration in 2003. The new strategy concedes that small amounts of residual emissions from transport and waste are likely, and anticipates that the viability of carbon offsets may improve over time as the international carbon market develops (City of Melbourne, 2018: 20). Placing this in a broader context, the Deadline 2020 models of carbon budgets for its member cities to meet their share of the 1.5°C target envisage the need for negative emissions technologies such as large scale bioenergy carbon capture and storage from 2050 and beyond (C40 Cities and Arup, 2016: 102). In the shorter term, these assumptions appear immaterial to the development of C40 cities' climate action plans that stress the need for urban emissions to peak and decline within the next five to ten years (C40 Cities and Arup, 2016: 31), and emphasise the use of offsets as a last resort after concerted effort to reduce emissions (Ernst and Young, 2018: 2). Even so, carbon offsets emerging in a somewhat new form of negative emissions technologies remain an enduring part of the imagined future of net zero emissions cities.

Just as the City of Melbourne's new climate strategy reconfigures temporal boundaries, it also recasts conception of spatial boundaries around the net zero emissions city across larger and smaller scales. The strategy opens up new possibilities for the City's municipal carbon accounting practices on several fronts. C40 Cities worked through the City of Melbourne to reconcile the municipal carbon accounts of all 32 of Melbourne's metropolitan councils to establish a community-

wide emissions inventory for Greater Melbourne area (City of Melbourne, 2018: 13, 61). Coupled with this, the City was the first local government to pledge emissions reductions under the C*limate Change Act 2017*. These moves position the City of Melbourne as a key broker between local and state government with respect to urban climate governance.

The new strategy mentions a consumption-based approach to measuring emissions as an alternative to territorial carbon accounts. This approach "takes into account the upstream and downstream impacts of products and services that Melbourne consumes including imports and exports from the city" (City of Melbourne, 2018: 62). Although this alternative method gains just a small reference, the impacts of consumption are discussed throughout the strategy through the idea of the circular economy with respect to reducing waste and inefficiency and thus securing continued resource flows (City of Melbourne, 2018: 17).

While these new carbon accounts stretch the conceptual boundaries around carbon in the city, many of the proposed actions establish boundaries of carbon neutrality around discrete spaces within the municipality. Certain urban renewal areas and buildings within the municipality are planned to showcase possibilities for net zero precincts and developments, guided for example by new NCOS standards for precincts (Commonwealth of Australia, 2017) and the C40 Cities programs on climate positive development (C40 Cities, 2016). A proposed virtual power plant or solar garden (City of Melbourne, 2018: 26) would reshape relations between certain residents and small businesses within the municipality by enabling electricity (and thus carbon) to flow in new directions.

Conclusion

This chapter has explored ongoing tensions involved in urban climate governance through the City of Melbourne's successive imaginaries of the net zero emissions city. The City's efforts to assert and stabilize its political commitments to the community-wide net zero emissions target have involved pragmatic and continual adjustments to shifting circumstances at multiple scales.

The City's initial 2003 strategy for zero net emissions proposed a local carbon market built on established relationships. Preferences to displace urban carbon to regional Victoria were eclipsed with the emergence of national and international standards for carbon neutrality and carbon trading. Yet spatial preferences re-emerged through the MREP that explicitly set out to see new wind farms built in regional Victoria. This suggests a persistent desire by the City to balance the carbon accounts as locally as possible, if not by trading carbon between urban and regional municipalities then by procuring renewable energy within the State. The 2018 strategy reframes the net zero emissions city in relation to sub-national and international efforts towards global net zero emissions by 2050, and positions the City of Melbourne as a key actor and broker within the envisaged green transition of the greater Melbourne metropolis.

Through successive iterations of the City of Melbourne's climate strategy, targets for the net zero emissions city have largely been framed in techno-economic terms. National and international standards of carbon accounting and offsetting are used determine and legitimise carbon neutral certification. Science-based targets have been used to allocate global carbon budgets to discrete cities and entities. Cost-benefit analyses have framed and guided policy decisions. However, shifts in the City's preferences for policies and technologies to meet its target suggest underlying tensions involved in asserting and stabilizing the boundaries around that target to varied audiences.

The City's ambition to lead on climate change has been tempered by its limited authority to effect changes to the extensive sociotechnical systems through which urban GHG emissions are generated. Opportunities to take actions outside the municipal boundaries through carbon offset strategies and renewable energy investments have been balanced against preferences to reduce emissions as locally as possible. The City's narratives of green urban transition have been pitched inwards towards urban businesses and residents, but also outwards to other municipalities, levels of government, investors, city networks and so on.

These tensions articulate complex and dynamic relationships between the city and its hinterlands, and varied interpretations of how far these relationships extend. In this sense, practices of accounting for, and allocating, carbon towards an ideal of a net zero emissions city are not only technical, but also establish relationships, allocate responsibility, and reconfigure space in particular ways. The conceptual boundaries delineated to measure and manage carbon emissions are partial and permeable. Highlighting these conceptual boundaries more explicitly rather than burying assumptions in technical and administrative processes may open up possibilities for more nuanced and locally situated economies to emerge around carbon – whether through trees, wind turbines, or other means – that acknowledge and add layers to these strands of connectivity.

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Appendix 3. Cities as Forerunners: Local Climate Governance and the Carbon Neutral City

Stephen Pollard[26][27]

Abstract

Climate change threatens major disruption to cities around the world, including from extreme weather events, as well as impacts on infrastructure and resource flows. Simultaneously, cities are framed as sites that offer innovative solutions to climate change via transitions from carbon intensive to low carbon systems of energy, habitation, transport, food, water and waste. In this paper, I explore how knowledge of global climate change is re-scaled to local levels through city making discourses and practices such as municipal carbon accounting, and conversely how local experiments in low carbon transitions are framed as mobile and replicable solutions to a suite of urban and climate related issues. Specifically, I ask how carbon neutrality is being scaled, negotiated and contested in two concrete sites and situated practices of sustainable city making in the cities of Melbourne and Copenhagen. The *CH2* office building in Melbourne, and the *Nordhavn* precinct in Copenhagen, are sustainable building projects aligned with wider municipal goals for community-wide carbon neutrality. Although not commensurate in terms of size, cost, duration and the like, these projects both embody wider visions of the carbon neutrality city held by the respective local governments. My analysis of these projects as 'urban carbon assemblages' draws attention to relations between people, ecologies, and technologies as spaces of disruption and innovation, rather than in technologies themselves. These relations are fundamental to how local experiments in low carbon transition play out, underlining the importance of fostering (rather than ignoring) local attachments in local climate governance.

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[26] Melbourne Sustainable Society Institute, Faculty of Architecture, Building and Planning, University of Melbourne, Australia

[27] Climate and Energy College, University of Melbourne, Australia

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Keywords: local climate governance, municipal carbon accounting, sustainability transitions, urban carbon assemblages

Introduction

> *'Cities are where the climate battle will be won or lost'*
> – Patricia Espinosa, Executive Secretary of the United Nations Framework Convention on Climate Change, quoted in Suliman, 2017.

Climate change threatens major disruption to cities around the world. This includes through interference and damage from extreme weather events and resulting impacts on infrastructure and resource flows, and also from imperatives to transition from carbon intensive to low carbon systems of energy, habitation, transport, food, water and waste (Rosenzweig *et al.*, 2018). Cities are especially vulnerable to these impacts because they concentrate socio-technical infrastructures, resource flows and human activities (Satterthwaite, 2008, Revi *et al.*, 2014, Rosenzweig *et al.*, 2018). These concentrations frame urban areas as holding significant potential to reduce greenhouse gas (GHG) emissions. The refrain that cities contribute as much as 70 per cent of energy-related emissions has become common place and, coupled with trending population and urbanisation, provides fuel for statements such as the opening quote (Satterthwaite, 2008).

Notwithstanding this heroic narrative, the precise contribution of cities to climate change is open to debate. Put simply, this is because GHG emissions, and the socio-technical systems and human activities in which they are embedded, cut across categories of the city, the urban, and wider processes of urbanisation (Dodman, 2009, Hodson and Marvin, 2010b, Bulkeley, 2013a, Gleeson, 2014, Rice, 2014). These ambiguities make cities important places to examine how global climate change is framed as a local 'matter-of-concern' (Latour, 2004, Callison, 2014) and simultaneously how local experiments in low carbon transitions are represented as mobile and replicable (Blok, 2013).

The City of Melbourne (2003, 2008, 2014, 2018) and the City of Copenhagen (2009, 2012, 2016b) are amongst a growing number of local governments taking steps to anticipate, adapt and absorb climate impacts. They are also at the forefront of efforts to reduce GHG emissions across their municipal areas and achieve what is commonly called 'community-wide carbon neutrality' (Greenhouse Gas Protocol, 2014). In this paper I ask how carbon neutrality is scaled, negotiated and contested in two concrete sites and situated practices of sustainable city-making in Melbourne and Copenhagen. The *CH2* office building in Melbourne and the *Nordhavn* precinct in Copenhagen are both sustainable building projects that (although far from equivalent in terms of size, cost, and duration) encapsulate, symbolically and materially, their local government's respective visions for community-wide carbon neutrality. My analysis explores *CH2* and *Nordhavn* as 'urban carbon assemblages' that inscribe and reconfigure various socio-material elements in order to reveal, reduce and neutralise

carbon emissions. In each case, carbon neutrality is assembled in different ways, often through very experimental approaches to design and technology.

My analysis draws on ethnographic fieldwork in Melbourne and Copenhagen between mid-2017 and mid-2019, supported by an Australian Government Research Training Program Scholarship, and an Australian Endeavour Research Fellowship. This included a series of semi-structured interviews with staff in the City of Melbourne's Low Carbon Futures team and the City of Copenhagen's Technical and Environment Administration. In addition, I participated in guided tours of *CH2* and *Nordhavn*, which I convey in the form of brief ethnographic accounts. I supplemented these primary sources with publicly available documentation about the projects, and the local climate strategies of which they are part. I also benefited from in-depth examinations of the *CH2* and *Nordhavn* design processes by Hes (Hes and Bayudi, 2005, Hes, 2007) and Blok (2012, 2013, Blok and Meilvang, 2014) respectively.

To begin, I briefly outline the ambiguous role of cities in climate governance and low carbon transitions, complementing insights from critical urban theory with perspectives from anthropology and Science, Technology and Society (STS) studies. Next, I introduce the concept of urban carbon assemblages as a framing device to explore key technological, social and ecological elements of *CH2* and *Nordhavn*. Following this, I analyse how carbon neutrality is scaled, negotiated and contested through each project.

Under the Paris Agreement, the task of governing the global climate has opened up to a variety of non-state actors at multiple levels, including local governments (Bulkeley, 2013a, Jordan *et al.*, 2015, Acuto and Parnell, 2016, Davidson *et al.*, 2019, Hoff *et al.*, 2019). In this emerging landscape, the moral geographies of climate change – mapped against ambitious pledges to reduce GHG emissions – are crystallising around many 'world cities' (Hodson and Marvin, 2010b, Blok, 2012). In this context, municipal carbon accounting is an important framing technique linking local commitments to global scales, but one that also raises questions about how the territorial and conceptual limits of the city are drawn to delineate the edges of urban systems (Rice, 2010, Bulkeley, 2013b, McGuirk *et al.*, 2014).

Alongside ambitious climate pledges, cities are garnering attention as key sites to experiment with transitions from high to low carbon socio-technical systems, such as for energy, habitation, transportation, water and waste (Bulkeley *et al.*, 2010, Hodson and Marvin, 2010a, McGuirk *et al.*, 2015, Moloney and Horne, 2015). Much of this experimentation favours an 'ecological modernisation' approach to environmental sustainability, where technology is viewed as a key driver of social change, and technological innovation is thought capable of overcoming environmental crises (Hajer, 1995, Curran, 2009, Geels, 2011, Hodson and Marvin, 2017, Hoff *et al.*, 2019). Urban transitions thus tend to be framed in terms of 'how fast and how far', with little attention to divergent views of 'where from and where to' (Smith *et al.*, 2005, Jasanoff and Kim, 2015, Scoones *et al.*, 2015).

In spite of these new forms of city-level diplomacy in tackling global climate change, and local experiments in low carbon transition, cities continue to be the domain of strong political, economic and material path-dependencies (Hodson and Marvin, 2010b, Acuto and Parnell, 2016, p. 873). Critical urban studies have generated important insights into the ambiguous and contested role of cities as both contributing to the causes of climate change and offering potential to avert its threats (Harvey, 2010, Merrifield, 2013, Whitehead, 2013, Gleeson, 2014). Bulkeley (2013a) summarises the paradox thus: 'Cities are not merely a backdrop against which global processes of climate change unfold, but are central to the ways in which the vulnerabilities and risks of climate change are produced, and to the possibilities and challenges of responding to these issues' (p. 4).

Discourses and practices through which cities are framed as sites for climate governance also construct and perform boundaries and scales (Tsing, 2005). Tsing argues that scale is not just a neutral frame for viewing the world. 'Scale must be brought into being: proposed, practiced, and evaded, as well as taken for granted. Scales are claimed and contested in cultural and political projects' (Tsing, 2005, p. 58). This perspective raises questions about macro-narratives of cities as either climate heroes or villains, the possibilities of climate solutions in one setting being replicated in another, the appropriate scale of low carbon experiments (and whether bigger is always better), and the relationships between knowledge and power in envisioning and enacting desirable urban futures.

One way to apprehend how knowledge and power play out through socio-material realities, advocated by Blok (2013) in his studies of urban sustainability design practices, is through the STS (and in particular actor-network-theory (ANT)) inspired approach of assemblage urbanism. This view conceives of cities as ensembles of heterogeneous actors and gives analytic priority to the active dynamics of arranging and re-arranging socio-material elements (see also Latour, 2005, Brenner *et al.*, 2011, Farías and Bender, 2012). From this perspective, cities can be understood as enormous socio-technical artefacts, heterogeneously engineered by a range of competing actors and institutions (Aibar and Bijker, 1997, Cronon, 2009), a view that also resonates with Tsing's ethnographically informed 'contingent lineages' of urban development (Tsing, 2005, p. 127). Most of these ensembles of urban ecology are largely unnoticed in everyday life, shaped by inflexible socio-material infrastructures of buildings, electricity, water, transportation and waste (Star, 1999, Hommels, 2005). Under certain conditions, however, these socio-material relations are re-articulated as local 'matters-of-concern' (Latour, 2004, Callison, 2014). In these respects, discourses and practices of urban sustainability are an important domain to observe processes of reassembling of nature, technology and society, and invite new ways of thinking about sustainable urbanism as a particular mode of knowledge production (Blok, 2013, p. 5).

In this vein, Blok puts forward the notion of urban green assemblages as a 'new ontology of city metabolisms', in order to articulate the ways in which urban green

knowledge is produced, translated and contested across specific urban sites, scales and relations (Blok, 2013, p. 6). He defines urban green assemblages as: 'ensembles of heterogeneous actors, human and non-human, which orient themselves to the gradual redesign of urban eco-socio-technical relations in 'green' (or 'sustainable') directions' (Blok, 2013, p. 10). These assemblages emerge as actors forge urban ecological connections, and open up new spaces of democratic experimentation around ecological 'matters of concern'. This view of green architecture sees buildings and eco-districts not as static objects but as 'movable projects' (Latour and Yaneva, 2008), emerging through a complex ecology of contentious knowledges, material practices, and value commitments (Blok, 2013, p. 13-14).

Taking this concept in a slightly different direction, in this paper I put forward the notion of 'urban carbon assemblages' as ensembles oriented towards the redesign of ecological and socio-technical relations specifically around carbon. I turn now to explore these assemblages through ethnographic encounters and empirical observations.

Assembling carbon neutrality through CH2

> *'The building needed to be greenhouse neutral; a lighthouse project; improve employee wellbeing; and analogous to industry transfer.'*
> – Lead designer Mick Pearce, quoted in Hes and Bayudi, 2005, p. 236.

In its inaugural strategy for *Zero Net Emissions by 2020*, the City of Melbourne (2003, p. 4) identified 'leading edge green design' as a core strategy to meet its emissions reduction targets. Under this initiative, the council redeveloped its 'Council House 2' administration building on the corner of Swanston Street and Little Bourke Street to the highest environmental standards (City of Melbourne, 2003, p. 13). The opening quote conveys that net zero emission was one of several objectives that the council and its partners on the project set out to achieve. They pursued carbon neutral operations with energy and resource efficiency, and maximising the use of on-site renewable energy. Turning first to these through an ethnographic encounter with *CH2*, I subsequently examine how carbon neutrality has been assembled through these elements, and other measures that extend beyond the city.

Assembling CH2

Liam Henderson, a sustainability officer with the City of Melbourne, greeted me in the ground floor foyer of *CH2* on Tuesday afternoon, 11 June 2019. Liam conducts public tours each year for events like *Melbourne Open House*, and regularly guides new council employees through the building. He describes these partly as orientation sessions to help people get the most from the building, such as with the cycling facilities, and energy efficient features. He also uses these tours to demonstrate the whole suite of council's sustainability and climate policies.

We begin the tour outside in Rainbow Alley, the hum of the city punctuated by the sound of trams rumbling along Swanston Street. Above us, wooden louvers on the western aspect distinguish the building from its surrounds and shade the glass-walled elevators and stairwells that rise 9-floors above the foyer. It is dark in the laneway, but a vertical garden of vines, creepers and flowers splinters the gloom on the northern elevation. Liam describes the green façade, and the rooftop garden above as capturing the essence of council's strategy for *Nature in the City* (2017b). While the green elements of the building are not exactly thriving, he tells me that issues with its design and maintenance have directly informed Council policies and engagement on green infrastructure. This includes through its partnership with the state government and other inner metropolitan councils on the *Growing Green Guide* (Department of Environment and Primary Industries, 2014), and the Council's own *Green Our City Strategic Action Plan* (City of Melbourne, 2017a).

Alongside the balconies, understated chimneys vent warm air from the interior through four micro-turbines on the roof, which were designed to recapture some of this energy. Liam points out how the windows taper with elevation to allow more light to enter the lower levels where the building is overshadowed by its neighbours. Staff can open the windows for fresh air, and in hot weather they open automatically during the night to purge the warm interior. On the southern elevation above bustling Little Collins Street, air is drawn into the building and cooled through four 'shower towers' using rainwater caught on the roof. While these elements contribute to *CH2's* energy and resource efficiency, Liam conveyed that they also reflect Council's desire to integrate environmental sustainability, resource efficiency, and water sensitivity into urban development.

Moving inside, the open plan office is a comfortable temperature, and the overhead lighting is subdued. It was designed to be half as bright as other office environments to reduce energy use, supplemented with natural light and desk-lamps. The most distinctive feature is the waffle-shaped ceiling. Its thermal mass helps maintain interior temperatures, and the undulating curves channel the warm air that rises from bodies and computers to the chimneys we saw from the alley. Simultaneously, cool air enters through floor vents at each workstation to create a cylinder of fresh air around each employee that is intended to improve health and well being and, ultimately, boost productivity.

As with all of Liam's tours, ours ended on the rooftop. 'How lucky are we, reflects Liam, 'to have this outside space in the middle of the city'. From this rooftop oasis, Liam directed my gaze out across the city where there is hardly a hint of green amidst the towers of glass, steel and concrete. For the new employees who also end their tour here, this is a moment that, in Liam's experience, often evokes reflection. 'There is so much work to do, but it's also a call to action'.

Assembling local government leadership

A key goal for *CH2* was to demonstrate environmentally sustainable design and technological innovations, paving the way for adoption by Melbourne's development industry. Councillor Cathy Oke reported how important it is for the City of Melbourne, as a capital city, to promote good urban design and sustainability outcomes (Interview, 8 December 2017). In this respect, the 'analogy' to industry transfer defined in the opening quote was an important drive behind *CH2's* experiments with design and technology. Liam reflected during the guided tour, and in our other conversations, that *CH2* 'intentionally pursued innovations such as black water treatment, wind turbines, shower towers, and phase change materials that weren't proven technologies at the time, in order to show the development community new possibilities and to reduce the innovation costs for those that followed' (Personal communication, 28 February 2019).

As I learned on the tour, many of these experiments have failed. Maintenance of the micro wind turbines proved more costly than the energy they generated, the black water treatment did not have enough water flowing through to operate properly, and the phase change materials were not replaced at the end of their lifespan, causing them to rust. Even the interior lighting has been retrofitted several times, with employees working on the design floor, for instance, installing brighter lights to support their vision-intensive duties. Liam related the negative commentary that surrounded these failures, with some in the urban development industry writing the project off as a 'white elephant'. But as with the green infrastructure mentioned earlier, these lessons have helped to improve policy development, industry engagement and community outreach by council officers (Field notes, 11 June 2019).

The 'green' qualities of *CH2* have also been quantified in various ways. Upon its completion in 2006, the Green Building Council of Australia rated *CH2* Australia's first 'as built 6-star Green Star' office building, pushing the industry standard considerably (City of Melbourne, 2008; Hes, 2007). The tool encourages designers to set specific sustainability targets and manage these alongside costs and other constraints. It also acts a marketing tool to help compare and communicate a project's 'greenness' with other developments (Hes, 2007, p. 255). The building's passive ventilation has also been evaluated, with assessments of employee health and well being supporting the case for higher up-front costs on the basis of improved productivity and fewer employee sick days (Hes, 2007, Paevere and Brown, 2008). Adding experience to this claim, for Liam the fresh air is the single best thing about the building. 'I feel better being inside all day because I'm breathing fresh air' (Field notes, 11 June 2019).

Commercial office developments in Melbourne have shifted towards more energy efficient and environmentally sustainable design, and the City of Melbourne is justifiably proud of *CH2* as a pioneering development. Weighing on this buoyancy, building regulations have not tightened to the extent anticipated in Council's 2003

climate strategy, and a gap remains between this kind of 'best practice' and business-as-usual (City of Melbourne, 2008, p. 6, 13, City of Melbourne, 2014, p. 17).

Assembling carbon neutrality beyond the city

GHG emissions are often intangible to the material elements of the urban environment, even while they are embodied in the most mundane and everyday things and activities. Bringing *CH2* into being as carbon neutral has required carbon to be traced and inscribed beyond the building and the city. There have been two key steps along this path: the City of Melbourne's certification as a carbon neutral organisation under the National Carbon Offset Standard (NCOS), and renewable energy procurement through the Melbourne Renewable Energy Project (MREP).

Some five years after *CH2* was completed, the City of Melbourne was certified as a carbon neutral organisation, the status inscribed in the files of the government department that regulates the scheme (Department of Environment and Energy, 2018). These files show that electricity purchased under the Australian Government's 'GreenPower' program for corporate investment in renewable energy, and verified carbon credits from Australia and overseas, offset emissions from the City of Melbourne's operations. As with the 'Green star' rating, NCOS allows council to communicate its 'greenness' to others. While the relatively low cost of carbon offsets has made this market-based approach to carbon neutrality feasible from an organisational perspective, expanding the approach to meet the community-wide target (as anticipated in the 2003 *Zero Net Emissions* strategy) has not proven viable. In 2018 the City of Melbourne revised its timeline for community-wide carbon neutrality to 2050, acknowledging that reliance on carbon offsets would entail high ongoing costs, and would not encourage more fundamental changes to urban socio-technical systems (City of Melbourne, 2018, Pollard, 2020).

At the same time, the City of Melbourne has also developed alternative strategies to meet its corporate objectives for carbon neutrality. MREP is a council-led consortium with other large energy consumers in the central city organisations (City of Melbourne, 2017c). By pooling their demand, they collectively contracted renewable energy from a new wind farm in regional Victoria. When the wind farm came on line in January 2019, the City of Melbourne achieved 100 per cent renewable energy for its corporate operations (Vorrath, 2019). The lead sustainability officer on the project, Adam Zaborsczyck, described how MREP positioned the City of Melbourne in a brokerage role within a highly contested and uncertain landscape of national energy and climate policies, with council negotiating complex arrangements between large organisations that had widely varying needs (Interview, 18 December 2018).

In this regard, *CH2* and MREP both demonstrate the City of Melbourne's efforts to reduce the risks of in investing in new technologies and enterprises for the private sector. Taken together, the socio-material assemblage of the building, the NCOS

derived inscriptions of carbon neutrality, and the flows of green electricity secured through MREP reveal *CH2*'s carbon neutrality as a moveable project that continues to unfold.

This discussion has taken us some way towards appreciating how carbon neutrality is scaled, negotiated and contested through sustainable city-making projects. Since the goal to establish *CH2* as carbon neutral largely concerns council's own operations and employees, it offers little purchase on the question of how citizens are enrolled in local climate governance. To examine this further, I now turn to Copenhagen's *Nordhavn* precinct, and the various ways it has sought to shape technologies and citizens into a carbon neutral neighbourhood.

Shaping carbon citizens through Copenhagen's *Nordhavn*

> *'Our city planning already integrates climate challenges. In the development areas of Nordhavn, Carlsberg and Amager Fælled, we are committed to creating carbon neutral neighbourhoods of the future.'*
> – Copenhagen Climate Plan, City of Copenhagen, 2009, p. 22.

An industrial and port area to the north of the city centre, *Nordhavn* contains one of the largest urban development projects in Scandinavia and is envisioned as the sustainable district of Copenhagen. Within the Copenhagen Climate Plan, *Nordhavn* is one of several 'lighthouse projects' that encapsulates in a single precinct the vision of Copenhagen as the world's first carbon neutral capital city (City of Copenhagen, 2009). *Nordhavn* has been designed around expectations that citizens will accommodate low carbon technologies within the precinct. In this respect, the precinct is explicitly framed as a site for urban experimentation, including in environmentally sustainable design and smart city technologies. These include everyday technologies such as bicycles, industrial-scale energy infrastructures such as wind turbines, and more obscure technologies such as sensory equipment and smart building control systems to moderate energy consumption.

Assembling the car-free city

Copenhagen is known as one of the best cities in the world for cyclists (City of Copenhagen, 2009; 2017a). Amongst other things, the city is fairly small and concentrated, the terrain is reasonably flat, the network of bike paths is fine-grained and seamless, and cyclists feel safe with physical barriers of kerbs and parked cars between them and moving traffic. *Nordhavn* promises to be a predominately car-free precinct, simultaneously reducing emissions from urban transportation while tackling congestion and acute shortages of inner-city housing (City of Copenhagen, 2009, p. 22). The cover of the *2016 Copenhagen Climate Projects* report features a photo of *Nordhavn* that conveys this compact ideal, depicting a rooftop playground and outdoor gym that has been built in the centre of the new precinct (City of Copenhagen, 2016a). Intrigued with this image, I visited the precinct on Friday 6

April 2018. Because first impressions can be revealing (Tsing, 2005, p. 101), I offer an ethnographic encounter with *Nordhavn*.

It is a sunny day but it is also very windy. Rugged up against the biting wind, I cycle across town along wide bike lanes. Forced away from the harbour for an arterial road, cars and trucks race by as I turn into *Nordhavn* past a mosaic of temporary fences and piles of dirt that marks the next stages of construction. Towards the centre of the precinct, funky cafés and galleries line the street while apartments and offices tower above. Finding the rooftop playground, I discover that it sits atop a five-storey car park. On the surface, this building is a landmark of sustainable design. The rusted metal facade evokes the areas industrial history, while the vertical garden signals 'greenness'. It has parking for bicycles and electric vehicle charging points. A small co-generation plant and batteries send clean energy to surrounding buildings. There is even a pop-up community centre where people can swap unwanted goods. On the rooftop I find in-ground trampolines, climbing frames, swings and seating, but no people on this particularly cold day. There are sweeping views across the harbour, from the majestic *Øresund* Bridge to *Malmö*, the iconic arc of 20 wind turbines on the *Middelgrunden* Reef, the *Amagerværket* combined heat and power plant, the *Amager Bakke* waste-to-energy plant with its 'ski-slope' roof, and the neighbouring *Maersk* terminal where automated cranes load containers on and off ships in elegant choreography. Within the vision of the carbon neutral city, a five-story car park feels out of place. The car park signals the obduracy of car-based transport in the city, but strong markers of sustainability and liveability mute the signal. In respect of urban transport, *Nordhavn* feels suspended between past and future, and the vision of a car-free district remains a work in progress.

Assembling renewable energy

The desire to integrate wind turbines into the material fabric of the city, and the social identity of its citizens, was epitomised in *Nordhavn's* design and planning. The new district was envisaged to be energy self-sufficient with four wind turbines in the adjacent harbour. However, these intentions were derailed by resistance from residents in surrounding neighbourhoods, in concert with powerful allies in Denmark's national parliament. Blok (2013, Blok and Meilvang, 2014) has examined how local resistance to *Nordhavn's* proposed wind turbines entailed deep, place-based concerns about heritage, ecology, and amenity that were dismissed as a not-in-my-backyard, or NIMBY, response. Yet these concerns also reflected local knowledge and appreciation of existing values, and the turbine plans did not feature any role for locals in the maintenance and protection of these values. As such, local resistance emerged over claims as to which knowledge is considered important in shaping visions for the future. Localised concerns spilled into mobilised forms of resistance to the planned turbines and, in an awkward alliance, merged with the national government's resistance to the wind turbines in favour of developing the container port in the area (Blok, 2013, p. 16). Thus, local and national actors mobilised to

subvert the wind turbines, only for local concerns to be overridden in favour of a container terminal that, arguably, reflects even less concern for local values.

Looking more broadly, Hans Christian Soerensen from the Danish Wind Turbine Owner's Association reported that there are virtually no corporate-led wind projects getting off the ground near existing communities. Wind farms are being pushed further away from people to remote areas and offshore (Interview, 29 May 2018). Where existing turbine projects have been established in the city, such as at *Middelgrunden*, they were developed with much more participatory planning. Hans shared his view that 'politicians and planners have not understood that power plants have a big impact, and locals need to be involved in how that impact is felt and managed. But it seems easier [to them] to develop wind away from people, such as offshore (Interview, 29 May 2018). This is the situation that the City of Copenhagen finds itself in, both for *Nordhavn* and for its wider strategy to achieve carbon neutrality that includes a target to build 360MW of wind energy by 2025 through its subsidiary utility company HOFOR (City of Copenhagen, 2016b, p. 19).

The City of Copenhagen's environmental economist, Morten Højer, described how these targets include enough surplus renewable energy to counteract residual emissions within the city, such as from transport (Interview, 18 June 2018). This approach to municipal carbon accounting was developed by Denmark's national government to encourage local government investments in wind energy. Yet locating turbines is proving a challenge. With land within the municipal boundaries heavily contested, the City's lead planner on energy production in the Climate Plan, Niels Kristensen, explained that the city is increasingly looking to develop wind energy in large offshore wind farms (Interview, 30 May 2018).

Assembling energy consumers

Attempts to increase the supply of renewable energy to Copenhagen have been synchronous with efforts to recalibrate energy demands. The *Nordhavn Energy Lab* is central to this task, reassembling various elements of the *Nordhavn* precinct towards a vision of the smart city of the future (EnergyLab Nordhavn, 2015). Many residential and commercial tenancies in *Nordhavn* require tenants to participate in *Energy Lab* trials to develop cost effective smart energy systems, providing the energy flexibility needed to maximise the use of renewable energy, as I learnt on a public tour of the precinct conducted as part of Nordic Clean Energy Week (Field notes, 21 May 2018). The trials being run through the *Energy Lab* are testing how to shift consumer behaviour in order to better calibrate energy demand for when renewable energy is abundant, and so integrate more wind and solar power into the energy system. To this end, a mix of technologies and financial incentives are being used to 'persuade residents and businesses to surrender control of parts of their energy consumption. Instead, the consumer will specify certain comfort levels' (Christoffer Greisen, quoted in City of Copenhagen, 2015, p. 31).

Placing this in a larger context, the greatest portion of energy use in Copenhagen is for electricity and heating, which is where city planners are looking to make the largest emissions reductions (City of Copenhagen, 2016b, p. 16). The district-heating network, supplied by several Combined Heat and Power (CHP) plants within the urban area, covers all but 2 per cent of Copenhagen's heating requirements. Replacing coal with biomass in these power plants has contributed almost half of the emissions reductions achieved through the Climate Plan (Interview, 30 May 2018). In that calculation, biomass is considered a carbon neutral fuel, and while this status is not without controversy, the 2025 target for carbon rests on maintaining this assumption. Beyond 2025, Niels Kristensen explained, city planners are thinking about how to replace biomass in the CHP grid with increasing levels of wind, solar and geothermal energy, store energy using batteries and electric vehicles, deliver heat with heat pumps, and even store heat in buildings (EnergyLab Nordhavn, 2015, City of Copenhagen, 2016b, p. 20, 35). The experiments in *Nordhavn* directly inform these technical questions of technology substitution and optimisation, but they can also be seen to limit people's agency when it comes to their engagement with these socio-technical systems.

Scaling, negotiating and contesting carbon neutrality

Exploring *CH2* and *Nordhavn* as urban carbon assemblages draws attention to how carbon neutrality is scaled, negotiated and contested as actors forge new connections between technologies, people, and nature. The main technological, social and ecological elements of these assemblages are summarised at Table 1. In each project, GHG emissions are delineated and reduced within specific boundaries, and then residual emissions are balanced against actions taken elsewhere to establish carbon neutrality. I now compare these urban carbon assemblages and analyse how the boundaries around carbon neutrality construct and perform scales, with whom these boundaries are negotiated, and what kinds of contestations occur as socio-technical systems are reassembled.

Scale

In each project, boundaries delineated GHG emissions around specific urban forms and geographic territories. Using fairly similar methods of carbon accounting, commitments for carbon neutrality are rescaled to discrete envelopes of building and precinct. In both cases, GHG emissions are attributed to specific domains and activities over which local governments seek to exert control over carbon, and from which they seek to influence wider change.

CH2 was developed as a 6-star green star office building in order to influence commercial office development, primarily within central Melbourne but with relevance to other Australian capital cities. Yet without coordinated tightening of

planning and building regulations from other levels of government, the project has had arguably little material impact on the 'business as usual' of Melbourne's urban development.

Nordhavn is projected outwards as an exemplar development for cities around the world, taking shape at a precinct scale and promoted to influence ambitions and processes of city-making to other 'world cities' at a global level. For example, the rooftop playground is both an attempt to construct a place of attachment for local residents and visitors to the district, and an exercise to present Copenhagen to the world as a place where low carbon solutions can be found. Nonetheless presenting the vision as fully formed elides the unexpected challenges involved in reconfiguring urban socio-technical systems from high to low carbon forms.

Negotiation

In each project, the socio-technical changes anticipated to reduce GHG emissions within these projects has involved some unexpected turns and renegotiations. We can even identify contradictory pathways where *CH2* has engendered powerful social attachments despite certain technological failures, and *Nordhavn* has seen social resistance in despite previous proven technological successes, such as with cycling and wind turbines.

In *CH2*, negotiations have primarily been between council staff and the wider development industry. The building was designed to reconfigure flows of air, water and energy through novel technologies and, by doing so, reduce carbon emissions associated with the building's operations. The failure of certain technologies has raised questions, for some in the development industry, about the value of these experiments. Yet the material and symbolic significance of *CH2* to council employees and the public demonstrates that low carbon experiments can evoke important social innovations and ongoing attachments.

The analysis of *Nordhavn* reinforces this point from another direction, where car parks, wind turbines, and building control systems each illustrate gaps between the imagined carbon neutral city and socio-material circumstances in which these visions are shaped into reality. The design of *Nordhavn* as a car free and energy self-sufficient district with optimised consumption is dominated by technologies, while neglecting, to a certain extent, the social contexts and relations in which these new technologies are embedded.

Contestation

Expectations about how carbon sources and sinks would be balanced, such as through carbon offsets or surplus renewable energy, have been contested in both projects. Decisions about how to balance carbon across the edges of *CH2* and *Nordhavn* raise important questions about the appropriate extent of measures to offset

carbon compared to efforts to reduce emissions within the locality. This issue relates to the distribution of benefits and impacts of urban climate governance within and beyond urban settings.

For *CH2*, efforts to realise the goal of a building with net zero emissions have relied on procuring carbon offsets and renewable energy, which rest on equivalences asserted through industrial, legislative, and regulatory ensembles. In practice, carbon neutral certifications offer council staff little to grasp apart from branding. The socio-material changes wrought by corporate investments in carbon sequestration and renewable energy are experienced elsewhere, with the local implications of these re-configurations difficult to apprehend from powerful urban centres. This point underlines the City of Melbourne's decision to redefine its targets for community-wide carbon neutrality from 2020 to 2050, including de-emphasising the role of carbon offsets in favour of pursuing more fundamental (but longer-term) changes to socio-technical systems within the city.

Copenhagen's *Nordhavn* project has been designed around powerful ideals for energy self-sufficiency, car independence and carbon neutrality, and assumes a climate citizen that will fit in with these ideals. Yet the lack of attention given to local resident's attachments to place in the plans for *Nordhavn's* wind turbines contributed to their undoing. Realising the carbon neutral status of the precinct will depend on installing sufficient wind turbines in neighbouring municipalities and offshore to generate enough surplus renewable energy to counteract local emissions. In the longer term, the value of these offsets is expected to decrease as more renewable generation comes on line. Coupled with this, questions raised about the longer-term role of biomass in the CHP network is encouraging new thinking about how to meet the city's energy needs. Technical efforts to reconfigure energy consumption will allow more wind energy to be used locally. However at this stage, these experiments appear ambivalent to the knowledge and values energy consumers themselves might attach to their consumptive practices.

Table 1. Technological, social and ecological elements assembled towards carbon neutrality in *CH2* and *Nordhavn*

Assembled elements	CH2	Nordhavn
Technological	• Novel technologies improve energy and resource efficiency. • Off-site wind turbines supply renewable energy for council operations.	• Smart building controls create more flexible energy systems. • Wind turbines generate renewable energy, with surplus to counteract residual emissions.

Social	• 'Green-star' design process and NCOS certifications signal 'greenness' to staff, public and local development industry. • Building tours induct staff into resource and energy efficient practices. • Technology failures lead to policy lessons and new social attachments. • MREP establishes new partnerships between large urban energy consumers.	• Urban design, transport integration and rooftop playground signal 'greenness' to citizens and other 'world cities'. • Residents enrolled in smart building control systems. • Citizens expected to accept new energy infrastructures and systems, but respond with ambivalence and resistance.
Ecological	• Natural materials and green infrastructure signal 'greenness' to staff, public and industry. • Energy, water and air are integrated through design. • Carbon credits from activities such as tree-planting offset emissions from council operations.	• Green infrastructure signals 'greenness' to citizens and other 'world cities'. • Wind and organic biomass assembled into energy production.

Conclusion

In this paper, I have explored knowledge of global climate change is re-scaled to local levels through two specific sustainable city-making projects, and conversely, how these local low carbon experiments are framed as mobile and replicable solutions to a suite of urban and climate related issues. In particular, I have addressed how carbon neutrality is scaled, negotiated and contested in the City of Melbourne's *CH2* building and the City of Copenhagen's *Nordhavn* precinct. Tracing *CH2* and *Nordhavn* as urban carbon assemblages helps to reveal the processes of boundary making and scale-making that give shape to these city-making projects.

Each of these projects rescales global climate change and the imperative task of reducing emissions by delineating conceptual boundaries around carbon, socio-technical systems, and extended flows of resources and people. Boundaries delineate carbon as something that can be measured and managed within and across their edges, but they also delineate domains in which authority and influence are exerted, negotiated and contested. Expectations about how carbon sources and sinks would be balanced for *CH2* and *Nordhavn* have been renegotiated in both projects, and the

boundaries around carbon neutrality remain open to further shifts as efforts to reconfigure socio-technical systems unfold.

Rather than pre-designed and optimal configurations, *CH2* and *Nordhavn* are moveable projects that assemble carbon neutrality through bricolage, fitting together various social and material elements in unstable configurations. In these cases of local low carbon experimentation, disruption and innovation emerge in unexpected ways. As such, crafting carbon neutral cities and climate-conscious citizens appears to involve much more than downscaling global climate change and carbon budgets to local municipalities, precincts and buildings, or developing low carbon technologies that can be replicated, relocated and enlarged. These are not only processes of technological innovation, but evince the constructive potential (Hulme, 2009) of climate change to foster local attachments and social innovations. While *CH2* and *Nordhavn* each assemble various material and inscriptive elements around objectives for net zero emissions, they also assemble new relationships and attachments between people and places.

Viewing local low carbon experiments through the lens of urban carbon assemblages draws attention to relations between people, ecologies, and technologies as spaces of disruption and innovation, rather than in technologies themselves. This suggests the importance of fostering (rather than ignoring) local attachments in projects of local climate governance that seek to reconfigure technology, society and nature around carbon.

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Appendix 4: Imagining the future: Resistance and change in Byron Shire

Introduction

This piece traces stories of resistance and change in Byron Shire with respect to community, energy and climate. At issue are questions of who has the power to shape change, and how are changes at the local level constrained and enlarged with respect to prevailing legal and regulatory systems. The stories are in four parts: Belonging, Creative Resistance, Imagining Change, and Local Vantage.

Part one: Belonging.

The Arakwal people call Byron Bay 'Cavanbah', which means meeting place. Tides of exchange and change run deep here, where the eastern-most point of Australia folds into the sea. Timber cutters first came to the area via the Brunswick River, and when the forests were cleared settlers started farms and dairies. On the coast, Byron Bay boomed with shipping, whaling and sand mining. As industries declined, surfers discovered the waves off shore, and waves of new settlers came to the hinterlands. Tourism and population growth promised social and economic renewal, but recent years have seen visitors and development surge putting pressure on housing, damaging roads, threatening fragile ecologies and, at least to some, eroding values of community and place. Who belongs is always a matter of perspective.

Part two: Creative Resistance.

Former Mayor Jan Barham holds that "Byron Bay is beautiful because of the people that fight daily to keep it that way". Sometimes resistance confronts ruling elites head on while at other times uses regulation in resourceful ways. An endangered orchid helped to stop development at Paterson Hill, in concert with one thousand protesters and a local Councillor who established his office on top of the excavator under a local bylaw, giving Council time to issue a stop work notice. With the threat of coal seam gas in 2010, people came together against a common enemy. Innovative community surveys verified near-total opposition to gas field development. When local and state government disregarded the message, the people behind those voices blockaded the drill sites, culminating at Bentley in 2015 where 10,000 protesters stopped the rigs and their 800-strong escort of NSW police. These contests over what belongs, and who gets to decide, highlight the power of a common enemy to forge a collective sense of identity and place.

Part three: Imagining Change.

A constellation of local organisations has emerged in Byron Shire charting new pathways for energy, climate and community. Mentioning only two, a key dynamic lies between ideals of local self-sufficiency and contributing to sustainability more broadly.

Resisting coal seam gas as out of place catalysed COREM to imagine a desirable energy future of community owned renewable energy, with profits and benefits recirculating locally. COREM is encouraging those seeking energy independence with solar and batteries to stay on the grid, arguing that every kW of solar energy they export avoids a kW from fossil fuels burnt elsewhere. The argument carries weight because the federal government's 'small scale renewable energy scheme' requires retailers to purchase surplus energy from small systems, in addition to their other targets. This local self-sufficiency generates a surplus benefit beyond the local, but its dependence on national energy policy leaves it exposed.

Zero Emissions Byron imagines the Shire with net zero emissions by 2025, and seeks to lower local emissions as much as possible and to sequester enough carbon within Shire boundaries to counteract any residual emissions. The vision reflects a moral imperative to do "all that we can" by becoming carbon self-sufficient, coupled with a desire to lead other communities and provoke state and national governments into greater action. However, it is a challenge to conceptualize self-sufficiency when there are more than two million visitors to the region each year, to highlight just one area where flows of people, patterns of consumption and systems of infrastructure traverse spatial and jurisdictional borders. Prevailing orthodoxies of carbon accounting make certain actors and emissions more accountable than others, foregrounding systems of production over practices of consumption and underlying structures of wealth. Efforts towards local net-zero emissions thus evoke tensions between the limits of local climate governance and the imagination needed to blur and stretch our conceptual boundaries.

Part four: Local Vantage.

Byron Shire and its region are the local vantage point in efforts to imagine and enact desirable energy and climate futures, but the horizon of these visions extends much further. Tracing stories of belonging in the Shire highlights how communities are made and remade. Charting struggles of resistance exposes the power of a common enemy to define collective identity. Imagining change, on the other hand, generates friction between multiple, often conflicting, perspectives and values. As we consider these issues, a local vantage reminds us that no single value characterises a place, no uniform culture defines a community, and no distinct knowledge counts as local. But new possibilities can emerge from the clash and slide between different imaginaries of the future.