Urban Decarbonization:
Politics and Practices of Carbon Neutrality

by

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Abstract

Urban transformation for decarbonization is a significant challenge. Despite widespread and growing adoption of local goals to reduce greenhouse gas emissions, climate change mitigation action in cities has taken a piecemeal rather than systemic approach. This dissertation examines how urban low carbon transformations are being imagined, implemented and evaluated. The research design uses a mixed methods approach, including discourse analysis of policy storylines, textual network analysis of planned urban carbon neutrality configurations, and three in-depth urban case studies of Stockholm, London and San Francisco. First, the research examines how urban decarbonization is being imagined by identifying visions for the built environment in carbon neutral urban futures and the storylines driving those urban imaginaries. Key findings include that the developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice and that different imaginaries of energy futures are sending cities down divergent sociotechnical paths. Second, the research analyzes the implementation of urban decarbonization. Using a material politics approach, the dissertation examines patterns in which aspects of buildings and energy infrastructure are made to matter as actors implement low carbon measures in the case study cities and finds that emerging patterns in practice carry implications for whether or not cities are on trajectories toward decarbonization.
Third, the dissertation contributes to methods of evaluating urban decarbonization by applying a different measure for assessing the effectiveness of urban climate measures – transformative capacity. Using this approach, the dissertation concludes that transformative capacity is under development for new urban space in the case studies, but the effort to change the existing built environment has faced challenges that have limited implementation. This research makes two main contributions to climate governance literature. First, it advances new ways to consider successful progress in urban carbon governance. By combining an examination of the material politics of implemented decarbonization efforts in cities with a policy scaling and entrenchment lens, this dissertation opens up the consideration of progress in carbon governance to encompass the messy, materially embedded and contested transformation of infrastructure. Second, this research develops a deeper understanding of urban carbon neutrality, which represents a new scope of urban action that is aiming for transformative change. The dissertation not only breaks down the building blocks of planned decarbonization, but also considers the ways that these elements are woven together to become narratives that tell an engaging story about the future of cities. Responding to the climate crisis means disruptive change to many of society’s systems in order to avoid catastrophe. While the scope of the transformation is daunting, the process of reimagining and reconfiguring cities can also open the door for new possibilities.
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To achieve the immense scale of greenhouse gas emission reductions required to avoid catastrophic climate change, we must reimagine and remake cities (Seto et al., 2014). In some cities, there has been action for decades to try to address climate change (Bulkeley & Betsill, 2013; Castán Broto & Bulkeley, 2013; Reckien et al., 2013; Romero-Lankao, 2012). Local governments have set greenhouse gas emission reduction targets and adopted climate change response plans (Hughes, 2017) and business, government and community sector actors have used both social and technical means to intervene in urban systems in response to climate change (Bulkeley & Castan Broto, 2013). Local governments have also banded together in transnational networks focused on municipal climate governance and have tried to use these new political spaces to facilitate low carbon transitions (Acuto & Rayner, 2016). However, urban climate governance has faced many barriers that have proven difficult to overcome, which has prompted mainly incremental rather than systemic change to urban systems (Bulkeley & Betsill, 2013; Burch, 2010; Romero-Lankao, 2012).

Nonetheless, there is urban experimentation with low carbon transformation. Urban climate governance features diverse and multi-scalar innovation instigated and implemented by actors from across government, industry and non-profit sectors. Research has shown what kinds of climate change policies are being implemented (Castán Broto & Bulkeley, 2013) and that there are an increasing number of climate change policies in cities (Bulkeley & Betsill, 2013). But what kinds of results are being achieved by these efforts? Many carbon governance practices are experimental and uncertain in their impact (Castán Broto & Bulkeley, 2013; Hoffmann, 2011), which means that we do not know which policies are actually addressing climate change by overcoming carbon lock-in (Unruh, 2000). Furthermore, the pathway to urban decarbonization is anything but clear since different urban areas will use different low carbon transformation strategies (Seto et al., 2014) and urban low carbon transitions are multiple, non-linear and rhizomatic (Luque-Ayala, Bulkeley, & Marvin, 2018). Not only is the nature of urban decarbonization underexplored, but we also lack adequate tools to evaluate progress towards
decarbonization. We need a better understanding of whether attempts to govern carbon are transforming cities.

This dissertation examines how urban decarbonization is being imagined and accomplished and evaluates whether urban carbon governance is catalyzing progress toward urban decarbonization. Using buildings as a point of entry into carbon governance, I analyze what the low-carbon future is imagined to be in documents produced on behalf of cities striving for carbon neutrality, critically interrogate how carbon governance is materially rendered through buildings in three urban case studies, and evaluate whether carbon governance efforts are putting cities on transformative decarbonization trajectories. I take a novel approach in the study of urban climate change response by examining the slice of urban carbon governance purportedly aiming for transformative decarbonization. The research question I address is: How are urban actors governing carbon in cities that are striving to become carbon neutral and are those efforts putting cities on decarbonization trajectories? My analysis focuses on answering the following sub-questions:

1) What are the visions for the built environment in carbon neutral urban futures and what are the narratives driving those urban imaginaries?

2) How is carbon governance rendered through the material landscape of urban buildings in cities striving for carbon neutrality? What types of governance facilitate these changes?

3) Are practices of urban carbon governance putting cities striving for carbon neutrality on potentially transformative trajectories?

4) What can other cities learn about urban carbon governance and decarbonization?

To answer my research questions, I used a mixed method research design that employed discourse analysis of policy storylines, textual network analysis of planned urban carbon neutrality configurations, and three in-depth urban case studies. The discourse analysis and textual network analysis focused on a set of deep decarbonization planning documents produced by the 17 local governments that founded the Carbon Neutral Cities Alliance, which is a transnational municipal network. I then conducted interviews, participant observation and
infrastructure site visits over 5-week field seasons in three urban case studies – Stockholm, London and San Francisco.

This dissertation examines the ways that urban decarbonization is imagined, implemented and evaluated. My argument fits into this three-part framework. First, I analyze discourses through which people are imagining decarbonization. I argue that the developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice and that different imaginaries of energy futures are sending cities down divergent sociotechnical paths. Second, I examine the implementation of decarbonization. I use a material politics approach to examine patterns in which aspects of buildings and energy infrastructure are made to matter as actors implement low carbon measures and I argue that emerging patterns in practice carry implications for whether or not cities are on trajectories toward decarbonization. Third, I contribute to methods for evaluating urban decarbonization. I argue that we can evaluate success in progress towards urban decarbonization by considering the politics of the development of urban transformative capacity. Using this approach, the dissertation concludes that transformative capacity is under development for new urban space in the case studies, but the effort to change the existing built environment has faced challenges that have limited implementation.

This research makes two main contributions to climate governance literature. First, it advances new ways to consider progress in urban carbon governance. It delves into the material politics of implemented decarbonization efforts in cities, which opens up the consideration of progress in carbon governance to encompass the messy, materially embedded and contested transformation of infrastructure. By combining this with a policy scaling and entrenchment lens, this research examines the material and political translation of carbon governance into urban buildings and examines whether experimental carbon governance is setting urban areas on long-term trajectories towards decarbonization. In essence, these approaches broaden the toolkit available to consider effectiveness in urban carbon governance implementation. Second, this research develops a deeper understanding of urban carbon neutrality. While urban actors have worked towards climate response in the past, this research studies a new scope of urban action that is aiming for transformative change. This research therefore unpacks the meaning of carbon neutrality using the novel application of textual network analysis and concept maps to examine the socio-technical constitution of ‘carbon neutral’ in urban deep decarbonization planning documents. It not only breaks down the building blocks of planned decarbonization, but also
considers the ways that these elements are woven together to become policy storylines about the nature of urban carbon neutrality. These narratives tell a story about the future of cities that will be reinforced as sociotechnical imaginaries of carbon neutrality are performed in the on-going construction, demolition and maintenance of urban areas.

In the following sections of the introduction, I first introduce a transnational municipal network called the Carbon Neutral Cities Alliance that I focus on in this research, then set the context for research on urban carbon governance and buildings, and finally outline the plan for the dissertation.

1.1. About the Carbon Neutral Cities Alliance

In 2014, representatives from seventeen local governments gathered in Copenhagen to start a network called the Carbon Neutral Cities Alliance (CNCA). The network is made up of local governments that are, as they describe it, adopting “the most aggressive GHG reduction targets undertaken by any cities across the globe” (Carbon Neutral Cities Alliance, 2015:p.ii). The founding members are listed in Table 1. While it is not uncommon for local governments to participate in transnational climate governance networks to support their efforts to reduce greenhouse gas emissions (Bulkeley, Andonova, Betsill, et al., 2014), the Carbon Neutral Cities Alliance is distinctive from other networks because its members aim to achieve greater emissions reductions. As self-described forerunners pursuing “deep decarbonization” (Carbon Neutral Cities Alliance, 2015), the founding members of the Carbon Neutral Cities Alliance are establishing what it means pursue urban carbon neutrality. In this research, I use the founding members of the CNCA as the universe of cases of urban decarbonization.

<table>
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<tr>
<th>Berlin, Germany</th>
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The CNCA positions their deep decarbonization approach as a step forward from the piecemeal and incremental urban climate change response practices often characteristic of local governments (e.g. a focus on interim targets like 20% GHG emission reduction). A statement produced at a founding meeting of the CNCA illustrates this approach:

“It is possible to achieve many of the interim carbon reduction targets through continuous improvement in existing systems. But achieving [80% GHG reductions by 2050] will require transformative and systemic changes in many core city systems.” (Carbon Neutral Cities Alliance, 2015: p.125)

However, there are also challenges associated with networked urban climate governance. While transnational climate change networks strengthen municipalities’ authority and abilities through strategic partnerships, these partnerships can also limit the action taken by member cities since action is potentially influenced by accountability to other players (Gordon & Acuto, 2015). It should also be noted that the CNCA congregates urban carbon governance efforts under the term ‘carbon neutral’ but, as this research will clearly show, the meaning of ‘carbon neutrality’ is not necessarily consistent across the CNCA members.

The Carbon Neutral Cities Alliance has a clear geographic bias in membership towards North America and Europe. Postcolonial critiques of urban theory, particularly of global and world city theories, have justly criticized the overemphasis on North American and European cities in urban theory development (Parnell & Robinson, 2013; Robinson, 2006). I think that scoping the research to the Alliance is justified, however, for three reasons. First, it is not expected that carbon neutrality be a current goal for all cities around the world. One of the central tenants of global climate politics has been that industrialized countries bear responsibility to reduce greenhouse gas emissions first before developing countries. This logic has shaped the kinds of actions pursued by cities. Therefore, decarbonization is currently a publicly held goal mainly in cities in industrialized countries. Second, carbon lock-in is most pronounced in industrialized countries, therefore the process of decarbonization (as opposed to brand new low-carbon infrastructure development) is most relevant there. Third, as the first cities trying to intentionally achieve carbon neutrality, these cities may define what counts as practices of decarbonization. This scope is important, therefore, because a limited geography of cities may set the tone of decarbonization, which would have far-reaching implications. In acknowledgement of postcolonial critiques of urban theory, however, I will make no claims to have the full picture of
urban decarbonization based on this study and I recognize that different urban contexts will further build theories of urban low-carbon transition.

1.2. Urban Carbon Governance and Buildings

Urban decarbonization will require wide-reaching transformations to urban material, political and institutional infrastructure systems to achieve new low-carbon configurations (Bulkeley, Castán Broto, & Maassen, 2011). Decarbonization is the reversal of the entrenchment of fossil-fuel energy systems that has resulted from the co-evolution of technological and institutional systems in industrial economies or “carbon lock-in” (Unruh, 2000). Explicit effort to decarbonize the city is called urban carbon governance (McGuirk, Bulkeley, & Dowling, 2014), but this process is challenging since carbon lock-in creates a policy inertia that makes it difficult to make systemic change (Unruh, 2000). Urban decarbonization can also be called urban low-carbon transition. The term ‘low-carbon’ refers to practices or outcomes of climate change mitigation to restructure society and the economy to reduce the production of greenhouse gas emissions (carbon dioxide, methane, nitrous oxide and ozone). In technical and social discourses, these gases are often converted into standard units of carbon dioxide equivalent, which creates a standard to regulate and gives rise to general terms like ‘low-carbon’ and ‘carbon management’ to describe efforts to control greenhouse gas emissions and decarbonize society and the economy. To be clear, the focus of this research is placed on greenhouse gas mitigation activities as opposed to activities supporting adaptation to the effects of climate change. These key terms – decarbonization, urban carbon governance, and low-carbon – are used throughout this thesis.

For decades, the global level was considered to be the only appropriate level for climate governance. Increasingly since the 1990s, however, a number of different of non-state actors, sub-national governments, and private actors have constructed roles as climate governors and are attempting to address climate change (Hoffmann, 2011; Ostrom, 2012). This new political space emerges from the rescaling of the state and an increase in non state-based political authority, but it is also predicated on a redefinition of hierarchies of political authority (Bulkeley, 2005). Urban actors have built a role for themselves as climate governors and expressed that role through new authorities and transnational networks of governance (Acuto & Rayner, 2016). The practices that have constructed urban actors as legitimate climate governors have changed over time. In early urban climate governance, mostly small and medium sized municipal governments took a self-
governing approach and responded to climate change through transnational networks that were focused on gathering knowledge and building shared purpose toward common goals (Bulkeley & Betsill, 2013). More recently, climate change responses have been incorporated into wider urban agendas. Cities are seeking to raise their profiles using climate action and are pursuing action even in the absence (or in direct contradiction of) national policies (Bulkeley & Betsill, 2013). In fact, the new emphasis on carbon reduction may be changing interurban competition and the politics of urban development (Jonas, Gibbs, & While, 2011).

Research has given us some understanding of the evolving nature of urban carbon governance and who is involved. The physical elements of the urban targeted by carbon governance have been broadly identified as the production and consumption of energy, urban infrastructure, urban sprawl, the built environment, and transportation (Castán Broto & Bulkeley, 2013; Romero-Lankao, 2012). In addition, geography, the economic base of the city, and urban form and density are considered to be important underlying factors driving emissions in specific urban contexts (Romero-Lankao, 2012). Carbon governance practices typically focus on individual sectors (e.g. building insulation) as opposed to more systemic changes (e.g. urban planning) (Reckien et al., 2014). In these efforts to respond to climate change, actors are clearly intervening in a range of urban socio-technical systems using innovations focused on both technical and social elements (Bulkeley & Castan Broto, 2013). Local government actors are increasingly important not only in global climate governance discussions, but in the implementation of climate change responses that reshape the fundamental underpinnings of urban areas (Hughes, 2017). The climate change governance tools employed by municipal governments can be placed into four categories: 1) self governing using funds and lands under the municipal government's direct control, 2) delivery of infrastructure and services, 3) regulation and planning laws, and 4) enabling or encouraging governance (Romero-Lankao, 2012). However, it is essential to look beyond local government to note that urban climate response is multi-scalar and also involves the private sector and civil society (Bulkeley & Betsill, 2013; Emelianoff, 2014; Peng & Bai, 2018). Finally, much of the urban climate governance research has been based on policy representations of climate governance, which has led to calls for increased engagement with the material implications of low carbon practices (Bulkeley, Castan Broto, & Edwards, 2015; Hodson, Burrai, & Barlow, 2016; Lovell, Bulkeley, & Owens, 2009; Rutherford, 2014). Responding research has sought to examine the material politics of
carbon governance interventions in particular cities (Bulkeley et al., 2016; Rutherford, 2014; Silver, 2017).

There are recognized barriers to local climate change action that make successful implementation far from a certain success. Scholars have described barriers such as lack of prioritization of climate change responses by political leadership, emphasis on business friendly environment, lack of technical and institutional capacity, lack of financial resources, and lack of information about how to respond including localized climate data (Robinson & Gore, 2005; Romero-Lankao, 2012; Schreurs, 2008). To try to overcome these barriers, actors are explicitly experimenting with low-carbon practices that they are not sure will work either in terms of successful implementation or in terms of actual impact on urban greenhouse gas emissions (Castán Broto & Bulkeley, 2013). Furthermore, practices that are capable of fostering systemic change co-exist with those that are limited in their potential to challenge fundamental ideas about production and consumption (Castán Broto & Bulkeley, 2013). Early attempts to implement low-carbon practices resulted in “a more piecemeal and opportunistic approach than originally envisaged” (Bulkeley & Betsill, 2013). This situation has led to calls for intensive fieldwork to engage with urban climate governance on the ground and to develop understandings of the implications of low carbon transition practices (Bulkeley & Betsill, 2013). It cannot be assumed that urban carbon governance will be effective. To address this gap, this research expands the toolkit that is available to consider effectiveness in urban carbon governance.

It is also necessary to interrogate the ‘who' of urban carbon governance, including issues of agency and justice connected to climate change response actions (Bulkeley & Betsill, 2013). Low-carbon transitions tend to lack clear conceptualizations of agency, which is complicated in urban transitions since ‘cities’ can be both actors and sites. Many actors beyond just municipal government are involved in urban carbon governance practices, however, and more research is needed to understand the dynamics shaping this joint governance. Furthermore, it is not only important who is driving, imposing, or creating the practices of low-carbon transition, it is also essential to research who, precisely, is the target of transition practices. There is no a priori reason why carbon management should be used to meet progressive social goals (Jonas et al., 2011). Therefore, the social and environmental justice implications of low-carbon transition practices are unclear (Bulkeley & Betsill, 2013). This research project fills this need by delving into the ‘who' and ‘how' of urban carbon governance.
Decarbonization is a process of political contestation against entrenched fossil fuel interests that are interwoven into societal institutions. Therefore, an interest in overcoming carbon lock-in means an interest in how change is governed. Governing is the:

“…totality of interactions, in which public as well as private actors participate, aimed at solving societal problems or creating societal opportunities; attending to the institutions as contexts for these governing interactions; and establishing a normative foundation for all those activities.” (Kooiman, 2003)

Governance and institutions are closely linked. Institutions include both formal and informal rules, from the bureaucracies of formal governments to informal societal structures, and they have been important to analyses about addressing environmental problems (Ostrom, 2011; Peters, 2005). Scholars have made distinctions between schools of institutionalisms, including rational choice and historical institutionalisms (Hall & Taylor, 1996), and later discursive institutionalism (Schmidt, 2008). In rational choice institutionalism, institutions set economic rules through both formal systems like taxes and laws and informal systems like ideologies and behaviour (North, 1990). In historical institutionalism, institutions are the building blocks of national political systems that shape political and economic action based on a process of historical path dependence (Hall & Taylor, 1996). In discursive institutionalism, institutions are contingent constructions of agents’ thoughts and practices that, on one hand, constrain agents, but, on the other, are created and changed by agents (Schmidt, 2008).

These schools of thought theorize different ways for institutions to change. In rational choice institutionalism, actors use their power to negotiate and change is related to achieving benefits based on their fixed interests. It is assumed that political institutions have incentives in place that remain relatively fixed (Campbell & Pedersen, 2001). Some historical institutionalism scholars point to exogenous shocks as reasons for institutional change. A key idea here is that historical events and processes constrain possibilities for actors to act since past choices have set up a some path dependency that can only be overcome with an external shock that removes the structural constraints that were holding the institution in place (Mahoney & Thelen, 2010; Schmidt, 2008). Other work within this school has challenged these notions of path dependency to consider how changes in the distribution of power among coalitions may result in gradual change to institutions (Mahoney & Thelen, 2010). While these approaches depend on a kind of ideational continuity, discursive institutionalism seeks to better deal with the role of ideas in driving
change. In this approach, ideas empower actors and give them the resources to create endogenous change by contesting existing institutions or building new ones (Schmidt, 2008). Exogenous change can still occur, but change can also come about endogenously as new ideas become discourses that are institutionalized. I draw on this context to consider path dependencies created by historical choices and the interaction between economic and political interests in this thesis, but I find it particularly useful to consider the ideational capabilities of actors striving to achieve decarbonization. This provides a way to think about the role of policy actors in shaping new institutions through discursive change.

Urban actors are governing carbon in many ways. In this dissertation, I specifically focus on carbon governance through buildings in the intensive research phase as an entry point into processes of urban decarbonization. This is justified since buildings are a significant target for urban carbon governance. Building-oriented initiatives focus on issues like energy efficiency, on-site renewable energy generation, and integrated energy demand reduction measures, for example (Castán Broto & Bulkeley, 2013). A large-scale overview of material practices of urban climate change response highlighted that 25% of the studied initiatives explicitly targeted buildings (Castán Broto & Bulkeley, 2013). In addition, a survey of the members of the C40 Cities Climate Leadership Group found that buildings were a central focus for city climate action since over 20% of reported actions target buildings and 47% of the city’s greenhouse gas emissions are attributed to buildings (C40 Cities & ARUP, 2014). Within the C40 Cities membership, more actions have progressed from the pilot project stage to city-wide transformative implementation in the buildings category than of any other category of urban climate change response action (C40 Cities & ARUP, 2014). Finally, actions targeting buildings are undertaken across the world, but make up a higher proportion of climate action in C40 member cities in Europe, North America, East Asia, and South and West Asia than in cities in Africa, Latin America, and Southeast Asian and Oceania (C40 Cities & ARUP, 2014). Given this prevalence, I selected buildings as my entry point into urban carbon governance practices and politics.

Most interventions in urban carbon governance relate to buildings in some way. This focus also allows me to study both private and public interventions since buildings are sites of both forms of governance. Furthermore, I think that by asking how carbon governance is congealed in physical artifacts like buildings as well as how the built environment impacts governance, I can
gain novel insights into processes of urban decarbonization. For this research project, I will follow scholars who have examined the ways that objects matter politically (Marres, 2012; Meehan, Shaw, & Marston, 2013; Shaw & Meehan, 2013). Scholars have sought to understand how objects are both “productive of reality and politically important” (Shaw & Meehan, 2013). This perspective leads to calls to understand the “investment of things and devices with normative capacities…as a performative accomplishment” (Marres, 2012). For example, objects like smart meters are equipped in ways that enable political capacities through configurations like sustainable living experiments (Marres, 2012). In this research project, I will consider buildings as objects that provide a particularly useful perspective into processes of urban decarbonization since they are a focal point for the performance of low-carbon cities.

One focus of this dissertation is the materiality of urban environments and the role that the material plays as people try to implement low carbon transformations. This approach involves considering the ways in which the physical stuff of the city is a “lively participant” in urban spatio-temporal processes (Latham, McCormack, McNamara, & McNeill, 2009). Over the last fifteen years, some geographers have responded to calls for increased attention for materiality in response to what was perceived as an emphasis on the symbolic or representational out of the cultural turn (Latham & McCormack, 2004; Latham et al., 2009; Rutherford, 2014). Critiques have cautioned scholars to approach ‘re-materialization’ cautiously and, in particular, not to simply equate materiality with the concrete as some perceive was done in the past (Anderson & Wylie, 2009; Latham et al., 2009). Although, “it needs to be remembered that at the heart of urban political economy are things whose nature is far from concrete – commodities” (Latham et al., 2009).

Geographers have drawn on elements of Marxian thought to think about relational materiality, but they have also drawn on work that thinks about the co-production of materiality through the assemblages of human and non-human elements (Latham et al., 2009). These ideas are influenced by scholars of actor network theory (Latour, 2005) and the cyborg (Haraway, 1991). In particular, these scholars disrupt the idea of a clean divide between subjects and objects and analyze the ways that materiality is assembled and disassembled. Critics have argued that actor network theory fails to address power and politics since it leaves out the explanatory power of the context in which urban processes operate (Brenner, Marcuse, & Mayer, 2012). However, scholars have used actor network theory approaches to study power and politics in urban
environmental governance (Rutland & Aylett, 2008; Rydin, 2013), while arguing that it allows scholars to study “concrete and situated practices of socio-material ordering” (Blok, 2013).

This dissertation draws on these relational approaches to materiality that consider the ways that human and non-human elements are drawn together and driven apart through the processes of urban circulation. In particular, I am interested in how low carbon transformations of infrastructure are influenced by the material make up of particular urban systems. This dissertation does not argue that the materiality of places determines both the path the city will take and the politics of decarbonization. Instead, I am interested in the interaction of human and non-human as decarbonization is assembled together and I argue that this relational work of assembling the elements of carbon governance is a political project.

Some similar themes have been important in infrastructure studies. Early work on infrastructure from science and technology studies scholars laid the groundwork for conceptualizing infrastructure as socio-technical systems (Monstadt, 2009). Research on large technical systems – inspired by Hughes (1983) – particularly expanded this work. Scholars in science and technology studies sought to break down distinctions between the social and the technological to instead examine the interconnections and complex assemblages of infrastructure. Ideas from actor network theory about considering the agency of the ‘more than human’ and examining the interactions between human and non-human actants (Latour, 2005) provided a new way of considering agency and flow within networks that influenced conceptualizations of infrastructure. More recent work on assemblage urbanism and urban political ecology draws on the relational aspects of this approach (Silver, 2013). Much of this work has been historical, but more recent research on socio-technical transitions considers how these large technical systems undergo change (Monstadt, 2009). This approach examines the links between technology and institutional arrangements to theorize how socio-technical systems change (Geels & Kemp, 2007; Smith, Voß, & Grin, 2010) and path dependency and inertia are attributed to institutional regime structures (Smith, Stirling, & Berkhout, 2005). However, critiques have noted that scale is frequently only implied in this work and that it has dealt inadequately with political and governance aspects of socio-technical transitions (Bulkeley et al., 2011; Meadowcroft, 2009).

Scholars have critiqued science and technology studies approaches to infrastructure studies, particularly related to the focus on flows:
“[T]he emphasis on the fluid characteristics of urban space risks overlooking the particular combinations of fixed capital and human expertise that enable specific nodes within the global system to play enhanced roles in the arena of cultural and economic production.” (Gandy, 2005, pg.31)

This critique links to capital and the way that infrastructures are fundamental to capitalist urbanization. For Marxist political economists like Harvey, “the materiality of urban infrastructures was one of the entry points into excavating the nature of capitalist urbanization and the role of the state therein” (Swyngedouw, 2003). Urban political ecology shares these political economic roots in literatures that have considered the socio-natural production of the city. Scholars working in this tradition “analyze the sociospatial conditions of urban metabolism and look at urbanization processes, social power, economic transactions, cultural habits etc. through the prism of human and physical interrelationships” (Monstadt, 2009). Early work examined urban water systems (Kaika, 2004), but urban infrastructures have not been an area of focus for urban political ecology and studies have so far only scrutinised the characteristics of sociotechnical systems in a limited way (Monstadt, 2009). Nonetheless, some have sought to draw on actor network theory and sociotechnical systems literatures while keeping capital as a central focus (Graham & Marvin, 2001).

This dissertation does not draw on urban political ecology, but instead draws on assemblage theory to understand urban infrastructure. There is cross pollination across these areas since they both see urban infrastructure as dynamic and socio-political as much as technical (Hodson & Marvin, 2009; Kaika & Swynegedouw, 2000; McFarlane & Rutherford, 2008; Monstadt, 2009; Rutherford & Coutard, 2014). However, an assemblage approach considers the socio-technical coproduction of urban infrastructures in a manner that does not necessarily attribute the socio-technical form of infrastructure to settled readings of power relations (Bulkeley, McGuirk, & Dowling, 2016). This approach is suitable for studying uneven power relations in urban green assemblages since “capital is hardly the only force exerting itself within city-making practices” (Blok, 2013). This dissertation is also influenced by work on imaginaries and infrastructure. Kaika and Swynegedouw, for example, analyze the ways that networked infrastructures are interwoven with imaginaries of modernity and fetishized in a Marxian sense:

“The fetishization of networks dwells exactly in the twin-condition that connection to the network implies acquiring the use value of the utility
and realizes the promise of participating in the phantasmagoric new world of technological advancement and ‘progress’; a world in which human freedom and emancipation resides in connecting to the technological networks.” (Kaika & Swyngedouw, 2000)

More recently, Jasanoff and Kim (2015) advanced the concept of sociotechnical imaginaries to consider how visions of social order are coproduced with science and technology. In essence, this dissertation draws on work that sees sociotechnical networked infrastructures as deeply intertwined with our understanding of who we are and what the future holds. These themes unfold in the following chapters, which are outlined in the next section.

1.3. Dissertation Outline

Chapter 2 explains the methodology for the research, which was split into two phases. In the extensive phase, I used a discourse analysis and textual network analysis approach to examine the policy documents of the 17 founding members of the Carbon Neutral Cities Alliance. In the intensive phase, I conducted interviews and building site visits in Stockholm, London and San Francisco. Chapter 2 also describes the three urban case studies, including the targets, regulatory context and resources/incentives that characterize carbon governance affecting each city.

Chapter 3 examines configurations of carbon neutrality in the building and energy sector as expressed in the urban governance documents of the members of the Carbon Neutral Cities Alliance (CNCA). ‘Carbon neutrality’ is a mutable idea, which makes it unclear what kinds of future urban systems are imagined. As self-identified pioneers of deep decarbonization, the CNCA members are constructing ideas about what carbon neutral means and how urban systems should be changed to reduce greenhouse gas emissions. In this chapter, climate governance policy documents provide a window to understand how these carbon neutral imaginaries are being constructed. The analysis draws on discourse analysis and textual network analysis to unpack the socio-technical configurations that are planned to be mobilized to constitute carbon neutral built environments. Concept map visualizations are used to scrutinize planned configurations of socio-technical objects (e.g. solar photovoltaics, district energy, and energy efficiency technology) and policy instruments (e.g. energy use benchmarking and urban planning tools). The analysis shows three key building and energy configurations: 1) The District Energy City, 2) The Zero Net Energy City, and 3) The Natural Gas Transition City. Furthermore, the findings demonstrate that urban imaginaries of carbon neutrality are incorporating complex
configurations of socio-technical objects while, at the same time, distinct socio-technical configurations are being favoured in individual places. These configurations inform socio-technical imaginaries that will continue to drive policy outcomes over time. This chapter has been accepted as a paper subject to acceptance of revisions:


Chapter 4 identifies visions for the built environment in carbon neutral urban futures and the storylines driving those urban imaginaries by analyzing the discourses in carbon governance texts. Local authorities have begun aiming for ‘carbon neutral’ transformations, but it is not clear what kind of city will result. Different imaginaries about the futurity of energy will send cities down divergent sociotechnical paths. Using discourse analysis, this paper identifies the storylines underlying sociotechnical imaginaries of urban carbon neutrality among the 17 founding members of the Carbon Neutral Cities Alliance. This chapter elaborates on five storylines in urban carbon governance texts: 1. The diverse meanings of carbon neutrality 2. The new economy of carbon control 3. The city as a laboratory 4. Technological fixes and the modern city and 5. Reframing what it means to be a ‘good’ urban citizen. The developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice. Trends include a focus on technological fixes and innovation as solutions where private capital is a fundamental partner, as well as reflexivity about the experimental nature of achieving carbon neutrality. This chapter has been published as a paper in *Energy Research and Social Science:*


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1 I had the idea for this paper, developed the research design, collected all of the data, completed all of the analysis, wrote 90% of the paper, and completed all revisions. We both contributed to the conceptual approach for the paper.

2 I had the idea for this paper, developed the research design, collected all of the data, completed all of the analysis, wrote 90% of the paper, and completed all revisions. We both contributed to the conceptual approach for the paper.
Chapter 5 examines patterns in what is being made to matter politically through the translation of carbon governance into building-energy infrastructure by urban decarbonization actors. This chapter interrogates how carbon governance is rendered through urban buildings and energy systems, and the types of governance used to facilitate these changes, in three urban case studies: Stockholm, London and San Francisco. To do so, I delve into the material politics of implemented decarbonization efforts in these cities. I find that emerging patterns across the temporal, spatial and agential dimensions of urban decarbonization practice carry implications for whether or not cities are on trajectories toward decarbonization. Overall, this chapter clarifies the nature of actually implemented urban decarbonization and demonstrates how a material politics approach can be used to examine the implementation of urban carbon governance in a way that encompasses the messy, materially embedded, and contested nature of infrastructure transformations.

Chapter 6 expands the toolkit available to consider progress towards decarbonization. To complement dominant approaches focused on accounting for GHG emissions, I apply a different measure for assessing the effectiveness of urban climate measures – transformative capacity. I demonstrate the use of this concept by empirically evaluating the carbon governance of buildings based on the case studies of Stockholm, London and San Francisco. Since political dynamics are a key aspect of decarbonization, I focus specifically on the politics of transformative capacity development using a political dynamics of decarbonization framework. I argue that new urban development is often low carbon and is building transformative capacity through norm change, new coalitions of support, and capacity building. However, urban actors’ efforts to change the existing built environment have faced challenges and there has been limited development of transformative capacity that would allow urban actors to change the existing buildings sector. The chapter highlights two key insights. First, a transformative capacity for urban decarbonization approach highlights the role of political mechanisms in catalyzing the scaling and entrenchment of carbon governance. In so doing, the approach refocuses attention on momentum along decarbonization trajectories, which offers a framework to evaluate the potential impact of carbon governance that speaks to its systemic outcomes. Second, transformative capacity is not just about making sure the tools are at hand (information about building energy use, loans for energy upgrades), but it is also a process of triggering political dynamics that build momentum. Future carbon governance of existing buildings should consider
the complementary roles of instrumental solutions and political dynamics to develop transformative capacity for decarbonization.

Chapter 7 summarizes key findings, highlights the contributions and implications of the research, and offers recommendations for future research.
Chapter 2
Methodology and Case Studies

2.1. Research Design

It is critical that we evaluate urban decarbonization as practices emerge since it is not yet clear which carbon governance approaches will transform urban systems in time to successfully address climate change. I tackled this task in this research and I gave particular attention to whether or not current urban carbon governance practices could build towards transformative change, as well as how other cities can learn from the experiences of the studied cities. This research focused on the seventeen members of the Carbon Neutral Cities Alliance. It included an extensive phase and an intensive phase of data collection. For the extensive phase of the research, I conducted a discourse analysis and textual network analysis of policy documents to examine what the urban low carbon future is imagined to be among the seventeen founding members of the Carbon Neutral Cities Alliance. For the intensive phase of the research, I examined three urban case studies over a five-week field season in each city. The three urban case studies were selected from the members of the Carbon Neutral Cities Alliance. In each case study, I collected data from policy documents, grey literature, interviews, and site visits to observe building retrofits. This approach allowed me to analyze how urban buildings are being changed through explicit efforts to decarbonize cities and what types of governance facilitate these changes. I used a case study approach not to cross-examine for causal factors, but instead to generate insight about various expressions of urban decarbonization by learning through comparison.

Before expanding on the methods I used for the extensive and intensive phases of the research, I will highlight two considerations related to ethics and positionality. The first relates to the narrow geographic focus to wealthy, industrialized cities in the global North. As I outlined in the previous section, I incorporate postcolonial critiques of urban studies theory by acknowledging throughout the thesis that this geographic focus introduces limitations. It is essential that the decarbonization practices and politics identified through research in the global North are not simply extended to analyze cities in the global South, but instead future research must consider
the plurality of cities and build urban decarbonization theory from the experiences of global South urban contexts. The second consideration I will highlight here relates to my focus on interviewing ‘elite’ actors in the intensive analysis. I interviewed policy makers, politicians, urban development industry representatives, and NGO representatives working to implement decarbonization, which I describe as a community of decarbonization actors. Though this is an important and powerful group of actors, a focus on elites excluded marginalized voices that may represent a different understanding of what decarbonization should look like. I address this issue further in a subsequent section. In addition, I navigated an insider/outsider relationship with interviewees since I presented at times as a member of this community because of my interest in advancing the implementation of decarbonization and, at other times, as an external researcher evaluating their city’s progress in reaching decarbonization goals. Multiple power dynamics, including insider-outsider duality, are a feature of elite interviewing that can influence research, which required my reflexive consideration as research was conducted (Parry, 1998). I offered anonymity to the individuals (with institutional or sectoral affiliations specified) to hopefully allow the elite actors to more openly reflect on progress and challenges in implementation.

2.2. Extensive Analysis

This study focuses on a sample of the climate governance policy documents produced on behalf of the 17 cities that are founding members of the Carbon Neutral Cities Alliance (CNCA). The sample was limited to policy documents of CNCA founding members. This scope is justified because CNCA founding members are among the first local governments trying to intentionally achieve carbon neutrality and the stated goal of the transnational network is to inspire similar action in other cities outside of the network. As a result, the visions of future carbon neutral cities developed by urban actors for these cities are particularly influential and may define what counts as urban decarbonization.

For each of the seventeen founding members of the CNCA, I collected climate governance policy documents produced on behalf of each city with an emphasis on the most recent documents at the time of analysis (November 2015). This sample of policy documents (see Table 2) formed the body of text that was object of study for this research.
<table>
<thead>
<tr>
<th>City</th>
<th>Documents Included in Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlin, Germany</td>
<td>Climate-Neutrality Berlin 2050: Results of a Feasibility Study</td>
</tr>
<tr>
<td>Boston MA, USA</td>
<td>Greenovate Boston: 2014 Climate Action Plan Update</td>
</tr>
<tr>
<td>Boulder CO, USA</td>
<td>Boulder’s Climate Commitment 2015</td>
</tr>
<tr>
<td>Copenhagen, Denmark</td>
<td>CPH 2025 Climate Plan; Copenhagen Energy Vision 2050</td>
</tr>
<tr>
<td>London, United Kingdom</td>
<td>Delivering London's Energy Future; The Mayor's Climate Change and Energy Strategy (2011)</td>
</tr>
<tr>
<td>Melbourne, Australia</td>
<td>Melbourne - Zero Net Emissions 2020</td>
</tr>
<tr>
<td>Minneapolis MN, USA</td>
<td>Minneapolis Climate Action Plan 2013</td>
</tr>
<tr>
<td>New York NY, USA</td>
<td>New York City’s Pathways to Deep Carbon Reductions; OneCity Built to Last</td>
</tr>
<tr>
<td>Oslo, Norway</td>
<td>Oslo Green Capital Brochure; Urban ecology programme 2011 - 2026</td>
</tr>
<tr>
<td>Portland OR, USA</td>
<td>Climate Action Plan 2015</td>
</tr>
<tr>
<td>San Francisco CA, USA</td>
<td>San Francisco Climate Action Strategy 2013 Update</td>
</tr>
<tr>
<td>Seattle WA, USA</td>
<td>Getting to Zero: A Pathway to a Carbon Neutral Seattle (2011); Climate Action Plan (June 2013)</td>
</tr>
<tr>
<td>Stockholm, Sweden</td>
<td>Roadmap for a Fossil Fuel-Free Stockholm 2050</td>
</tr>
<tr>
<td>Vancouver, Canada</td>
<td>Greenest City: 2020 Action Plan; Renewable City Strategy 2015-2050</td>
</tr>
<tr>
<td>Washington DC, USA</td>
<td>Sustainable D.C.</td>
</tr>
<tr>
<td>Yokohama, Japan</td>
<td>FutureCity Initiative; Mid Term Plan of the City of Yokohama; Master plan of YCSP</td>
</tr>
</tbody>
</table>
It is vital to focus on these documents since the policy discourses on deep decarbonization are largely textual so far. Furthermore, these documents provide insight into developing socio-technical imaginaries of urban carbon neutrality where language does political work to drive material outcomes. The policy documents included in the sample span from 2009-2015 and range from short-term climate action plans to long term ‘roadmaps’ that set out carbon neutral scenarios in the distant future. The policy documents focus on carbon governance undertaken in the name of a place, but the documents often reference transnational flows and significantly include governance beyond local government regulatory power. The sample focuses on municipal-led documents, but these documents were often developed with the involvement of stakeholders like local businesses, community groups and local citizens. All documents were available publicly on the Internet in English. Because the transnational network interaction is conducted largely in English, key climate governance documents were available in English for all seventeen cities. The limitations of this approach include restricted insight into the broader context in which these policy documents operate. Future work can build on these methods using more in-depth methods, such as interviews. One purpose of these plans is to bring together urban actors on this issue and it is likely that the documents conceal struggle and contestation within the city. Future research could seek to understand alternative discourses of carbon governance within cities, but that is beyond the scope of this dissertation.

For the extensive analysis, I conducted a discourse analysis drawing on Hajer and Versteeg (2005) and Foucault (1972). Discourse analysis aims to explore the outcomes of discourse in actions or attitudes, to identify the frameworks within which discourses are produced and circulated, and to reveal the structures that reinforce particular statements as normal (Waitt, 2005). I conducted a close and reflective reading of the sample of texts listed in Table 2 (Genus & Theobald, 2016; Waitt, 2005) that was focused on identifying the discursive elements constituted as key themes or topics and actors (Carvalho, 2008). I was also interested in the discursive strategies employed in the texts, particularly the discursive strategies of positioning (constructing actors to do certain things), legitimation (normatively justifying actions or powers) and (de)politicization (attributing (a)political nature to certain realities) (Carvalho, 2008). It is helpful to note that actors have a significant role in discourse analysis; Hajer and Versteeg (2005) take a Foucauldian approach in examining how power is created in the terms conducting a political discussion through regularity in language, but expand on this approach to also
consider that actors may have made those statements strategically (Hajer & Versteeg, 2005). Actors exercise power by trying to impose a particular frame and, through efforts like these, they “are actively ‘positioning’ themselves and others drawing on discursive categories” (Hajer & Versteeg, 2005). One way that this is accomplished is through the use of narratives or storylines (Lovell, Bulkeley, & Owens, 2009). I used this discourse analysis approach to identify how the socio-technical building blocks of carbon governance are drawn together into distinct configurations that tell a story about what a future carbon neutral city should look like (Chapter 3) and to create heuristic constructs in the form of storylines that I use to consider what kinds of narratives about urban carbon neutrality are considered ‘true’, ‘normal’ or even ‘inevitable’ (Chapter 4). I expand on my use of this method and provide greater methodological detail in Chapter 3 and 4.

I also conducted a textual network analysis. This method allowed me to systematically analyze the links between socio-technical objects that I identified in the body of texts and draw a concept map of how carbon neutrality is conceived. I identified which socio-technical objects and policy instruments are being privileged in the sample of texts and systematically extracted and analyzed the links between these elements using textual network analysis. Textual network analysis allows analysts to gain a better understanding of how ideas are connected across a sample of texts by considering the centrality or marginality of the connection between ideas, objects or arguments (Carley, 1993; Palmquist, Carley, & Dale, 1997). I then produced collective concept maps of how carbon neutrality is conceived among the members of the CNCA. I expand on my use of this method and provide greater methodological detail in Chapter 3.

2.3. Intensive Analysis

For the intensive analysis, I focused on carbon governance of buildings related to three urban case studies: Stockholm, London and San Francisco. My methods included semi-structured interviews, documentary analysis of relevant policy document and reports, and site visits to low carbon building and energy infrastructure. I used a case study approach to understand the practical and concrete aspects of urban carbon governance through buildings, but also to better understand the broader phenomenon of urban decarbonization. A case study approach is helpful given these purposes since it can both verify existing explanatory concepts and develop new explanatory concepts (Baxter, 2010). This approach can produce “deep, concrete explanations of
social phenomenon that are attentive to a variety of contextual influences at various scales” (Baxter, 2010), which is a valuable contribution given the current gaps in our understanding of both urban carbon governance and urban decarbonization more broadly.

I draw on data from three urban case studies in order to conduct a robust theorization of urban decarbonization. The small number of cases allows for in-depth qualitative research, which is a method that allows for a holistic understanding of social phenomenon (Creswell, 2003; Yin, 1985). Furthermore, spatial (place-oriented) cross comparisons are a common design in geography and can allow for a more robust understanding of the phenomenon in question as well as an understanding of the transferability of the findings (Baxter, 2010). The case study approach to the study of urban carbon governance of buildings allowed me to understand each case holistically and intensively (Baxter, 2010). This was aided by my physical presence in the city, since it provides a contextual understanding of the cities and opportunities for in-depth interpretation (Kearns, 2010). Embedding myself in each city for five weeks allowed me to draw first hand observations beyond interviews and site visits (Kearns, 2010). My use of the case study approach is not intended to be a comparison between the cities to find causal factors. Instead, it is an interpretive approach to theorization of urban decarbonization drawing on data from three urban contexts. This approach draws on a key advantage of comparative studies, which is the opportunity to “generate and modify concepts and theory so that they explain commonalities across cases despite contingencies or context” (Baxter, 2010, emphasis in original). Since we do not know what urban decarbonization may look like, I have focused on a group of cities where actors are apparently purposively pursuing decarbonization. I sought to understand the material and political expression of those efforts and analyze whether or not urban decarbonization appears to be taking place. It is likely that subsequent additional research in more urban contexts will further add to the theorization of urban low carbon transitions.

The three case study cities were chosen based on three criteria: international leadership in carbon governance, heterogeneity within that leadership group, and evidence of leadership in building decarbonization. The first criterion was membership in the Carbon Neutral Cities Alliance (CNCA), a transnational municipal climate governance network founded in 2014 by local governments in wealthy, industrialized countries. The network is made up of local governments that are, in their own words, adopting “the most aggressive GHG reduction targets undertaken by any cities across the globe” (Carbon Neutral Cities Alliance, 2015:p.ii). The CNCA has a clear
geographic bias in membership towards North America and Europe (see table 1), but this limited geographic scope is important to study because, as self-identified pioneers of urban “deep decarbonization” (Carbon Neutral Cities Alliance, 2015), the founding members of the CNCA are defining what it means for a city to become carbon neutral. Second, within the restricted scope of the CNCA, I selected cities that are as different from each other as possible in terms of demographics, climate, urban form and institutional setting (e.g. regulatory strength of municipal government, alignment with national climate policies). The third criterion for case study selection was the presence of urban carbon governance of buildings. Strategies aimed at buildings to both improve energy efficiency and decarbonize energy sources are prevalent, but there are also a number of other situation-specific strategies used by urban actors (Castán Broto & Bulkeley, 2013; Kennedy, Ibrahim, & Hoornweg, 2014). Since the study uses urban carbon governance of buildings as an entry point into urban processes of decarbonization, I looked for the presence of carbon governance of buildings over at least a 5 year time period during documentary analysis, which I assumed was a long enough time period for some implementation to have unfolded. Based on these criteria, I selected Stockholm, San Francisco and London. The approach for this research is not a comparison between the cities to find causal factors or best practices. Instead, it is an interpretive approach to theorization of urban decarbonization drawing on data from three urban contexts.

I conducted interviews with 40 industry, government and not-for-profit organization representatives who were involved in building and energy decarbonization over five week field visits to each case study in 2016-2017. This included 11 interviews in Stockholm, 17 interviews in London, and 12 interviews in San Francisco. The semi-structured interviews were conducted using an interview guide (see Appendix A) that listed key concepts and fully worded questions. I interviewed individuals participating in urban carbon governance at an elite level using purposive sampling, while ensuring a range of affiliations across municipal government, non-governmental and private sector, and I expanded the participants using a snowball sampling method (Lynch, 2013). The interviews were transcribed and thematically coded. I interviewed individuals performing, and making practically effective, urban carbon governance projects, including:
- Employees of municipal government climate/sustainability departments
- Other relevant municipal employees (planning, built environment, energy etc.)
- Private sector participants in carbon governance
- Energy utility employees
- Employees for ENGOs
- Larger jurisdiction organization employees working on urban carbon governance

In these interviews, I was interested in the ways in which these individuals are constructing and reinforcing everyday practices of urban carbon governance. In particular, I was concerned with which ways of doing things are gaining dominance in carbon governance and how these rationalities are becoming internalized in low/zero carbon built environments through the actions of urban actors. Drawing on governmentality, I conceptualized power as circulating through the socionatural fabric of the urban and seek to understand the relational power of actors and institutions (Foucault, 1991; McGuirk et al., 2014).

I interviewed practitioners and policymakers who are working to implement decarbonization in their cities at an elite level. In this research, I was interested in convergence and contestation within the group of actors striving to achieve decarbonization. This community’s decarbonization efforts are a political struggle against the entrenched interests of carbon lock-in across social, institutional, technical and economic systems (Bernstein & Hoffmann, 2016; Unruh, 2000). The limitation of this approach, however, is that it does not examine contestation of decarbonization from external groups, such as fossil fuel interests and grassroots organizations who push back on discourses of de-politicization and technocratic solutions. In addition, by viewing my key informants as a community of decarbonization actors, my analysis weighs their voices relatively evenly across affiliations. This approach serves to recognize the broader agencies that are involved in urban climate governance and to push back on the overemphasis on municipal government actors in climate governance literature (Bulkeley et al., 2016; Castán Broto & Bulkeley, 2013). The limitation of this approach is that comparisons are not often made across affiliations (e.g. municipal government vs. industry), which somewhat untethers participants’ voices from their institutional affiliations.

I further developed my understanding of carbon governance through buildings by conducting site visits to observe building retrofits and energy infrastructure. This object orientation to data collection provided different insights into urban carbon governance and a different perspective from which I can seek to understand alignments of actors, interests, subjects, objects, and
mechanisms. I conducted 19 building tours and site visits, including in-depth and self-directed tours of buildings ranging from single-family homes to commercial buildings, as well as tours of urban energy infrastructure and site visits to eco-districts and neighbourhoods.

In the following sections, I introduce the three urban case studies in more detail with a specific focus on targets and policies affecting carbon governance of buildings in each place. Urban carbon governance is multi-level and involves action taken by a range of different stakeholders across local, national and global spheres (Bulkeley & Betsill, 2013). Actors and institutions are setting decarbonization targets at multiple policy scales – from municipal (e.g. the City of Stockholm’s goal to be fossil fuel free by 2040) to international (EU directives on zero net energy buildings) – and these targets all intersect at the urban scale when they are implemented in buildings and energy. Therefore, this dissertation examines carbon governance affecting Stockholm, San Francisco, and London’s urban systems whether it is driven by a neighbourhood group, local government, state agency, national government, transnational network etc.

2.3.1. Stockholm

Previous research has examined various aspects of energy and carbon governance in Stockholm. Eco-districts in Stockholm have been analyzed, including building energy efficiency policies (Mahzouni, 2015), effectiveness in reducing metabolic flows (Iveroth, Johansson, & Brandt, 2013) and whether an eco-district triggers broader transformation processes (Williams, 2016). Stockholm has been a leader in urban sustainability (Metzger & Olsson, 2013), although climate governance has not proceeded without contestation and struggle (Rutherford, 2014). Local climate change governance more broadly in Sweden has also been studied (Granberg & Elander, 2007). Research has mostly focused on interventions within Stockholm (e.g. eco-districts), while this research instead considers carbon governance of buildings broadly across the urban area.

2.3.1.1. Key Targets

The population of Stockholm is approximately 901,000. The City of Stockholm plans for the city to be fossil fuel free by 2040 and for the City’s own operations to be independent of fossil fuels by 2030. Per capita emissions are intended to be reduced to 2.3 tons CO$_2$eq/capita by 2020 (City of Stockholm, 2016). City-wide greenhouse gas emissions have been reduced approximately 56% between 1990 and 2016 (C40 Cities, 2017). The City of Stockholm is aiming to halve the
energy use of the existing building stock by 2050 (from 1995 levels) and has achieved about a 30% reduction so far. The City committed to reducing energy use by 10% in its own operations between 2016-2019, including the significant number of residential properties owned through the City’s three property companies (City of Stockholm, 2016).

The target for a fossil fuel free Stockholm by 2040 also requires changes to energy supply. District heating meets 80% of Stockholm’s heating needs, which has been historically facilitated by the proliferation of communal residential buildings where owners have a share in the whole building (Dzebo & Nykvist, 2017). One key task of carbon governance is fuel switching to non-fossil fuels for district heating, such as biofuels and waste incineration. These new fuel sources are not necessarily benign and may represent new pathways of infrastructure lock-in that do not support sustainability (Corvellec, Campos, & Zapata, 2013; Dzebo & Nykvist, 2017). In fact, reliance on incineration places a cap on progress towards decarbonization since about a third of the carbon in Swedish waste is from fossil-fuel sources (e.g. plastics) (Jones, Blomqvist, Bisaillon, Lindberg, & Hupa, 2013). Nonetheless, most city-wide GHG emission reductions to date have been achieved due to this fuel switching. Energy and heat production for Stockholm comes almost entirely from cogeneration plants owned by the corporation Fortum Värme. The City of Stockholm sits on the board, but is not the majority stakeholder. There is one coal-fired combined heat and power plant in operation in Värtan, which is the single largest source of greenhouse gas emissions for the city (City of Stockholm, 2010). Negotiations have suggested this plant may be closed in late 2020 or 2030 (City of Stockholm environment administration employee, interview, Nov 10 2015). Renewable energy development is also taking place, particularly solar PV installation owned by the City of Stockholm.

2.3.1.2. Standards, codes and regulations

The City of Stockholm directly owns about 20% of the buildings in Stockholm and most of these holdings are residential units (City of Stockholm, 2012). Furthermore, the City of Stockholm owns 70% of the land area of Stockholm. The municipal government therefore has a significant amount of control over energy and building standards. Municipal housing companies have been directed to meet efficiency standards and retrofit existing building stock to achieve energy efficiency goals. The City of Stockholm requires that new buildings on city-owned land demand a maximum of 55kWh/m², excluding plug load (e.g. HVAC, lighting, water heating etc.). After
2020, this standard is planned to be lowered to 45kWh/m². The Swedish Building Code already requires a high degree of efficiency, which is influenced by EU directives for all new buildings to be nearly zero energy by 2020 (Hermelink et al., 2013). Note that the Swedish building code requires follow-up monitoring to ensure that these standards are met, and developers frequently plan to build extra efficient buildings to ensure that they meet the standard in performance testing (Stockholm development industry representative, interview, Nov 23 2015).

The City of Stockholm also leverages its ownership of prime urban land to require developers to achieve high environmental standards in special eco-districts, which are particular urban neighbourhoods where new developments are required to meet higher environmental standards than the city as a whole. Stockholm’s Hammarby Sjöstad eco-district was developed on a former industrial site between 1996 and 2012 using a closed-loop urban metabolism approach for energy, water and waste. Development of the Stockholm Royal Seaport follows this experience and has set goals to be fossil fuel free by 2030 (ten years earlier than the rest of the city) and achieve a carbon footprint of 1.5 tonnes per capita (City of Stockholm, 2015a).

2.3.1.3. Incentives, Funding and Capacity Building

While the municipal government also targets privately owned buildings, this sector has been difficult to reach through municipal policies or programs. Demonstration projects have been undertaken to build capacity and show that it is possible to accomplish energy retrofits in particularly common or difficult to retrofit housing. Demonstration projects pursued in partnership with public housing agencies and universities have demonstrated energy efficiency solutions, including 7 apartment buildings in the suburbs. This energy efficiency demonstration project, called Vision for Järva, reduced energy use by 50% (City of Stockholm, 2015b).

2.3.2. London

Previous research has examined some relevant aspects of carbon governance in London. Various climate experiments within London have been studied, including the ways in which infrastructure development can experiment with new low carbon logics (Bulkeley, Castan Broto, & Maassen, 2013) and the role of London as a national exemplar for energy experiments (Hodson & Marvin, 2007). The Greater London Authority’s use of planning tools (particularly related to the expansion of combined heat and power) has been found to reduce GHG emissions
(Day, Ogumka, Jones, & Dunsdon, 2009). Scholars have also examined cases attempting to plan energy efficient redevelopments in London (Deakin, Campbell, & Reid, 2012). Finally, the role of intermediary organizations in coordinating low carbon transition activities has also been examined in London (Hodson, Marvin, & Bulkeley, 2013). This research takes a broader approach by examining carbon governance of buildings across the urban area instead of specific interventions and by considering the ways that overlapping levels of authority are involved in urban carbon governance for London.

2.3.2.1. Key Targets

The Greater London Authority (GLA) has a population of about 8.6 million. In 2014, greenhouse gas emissions were 16% lower than 1990 levels with a 26% population increase since 1990. Per capita GHG emissions in 2014 were estimated at 4.4 tonnes (Mayor of London, 2017). While GHG reductions in London over this time period can be partly attributed to building retrofits and changes in the transportation sector, much of these reductions are due to changes in energy supply, particularly reduced coal combustion nationally (Mayor of London, 2015). The GLA has committed to greenhouse gas emission reduction targets of 60% (below 1990 levels) by 2025 and to become a zero carbon city by 2050 (Mayor of London, 2016). The Mayor of London is aiming for 25% of the heat and power used in London to come from local decentralized systems by 2025 (City of London, 2015). To meet this goal, “the Mayor prioritises the development of decentralized heating and cooling networks at the development and area wide levels, including larger scale heat transmission networks” (City of London, 2015; p.194). The GLA acts as a regional government above the 33 boroughs of London, which are local authority districts. Some boroughs also have energy and greenhouse gas emission goals.

2.3.2.2. Standards, codes and regulations

In 2006, the UK government announced that by 2016 all new homes in the UK would be carbon neutral. Over the next decade, developers engaged in discussions about what implementation would look like in practice (e.g. how much renewable energy generation would be allowed to offset energy use by the building). This policy trajectory shaped new development in London, although in 2015 the goal was scrapped to significant outcry from environmentalists and homebuilders. However, in 2016, energy planning by the GLA was still set to ensure progression towards zero carbon standards but with a more nebulous timeline. Large new developments in
London are subject to planning controls through the GLA’s London Plan. The London Plan allows the GLA to set both energy supply and efficiency requirements for large developments in London. Since 2007, large developments have reportedly achieved average energy efficiency savings 30-40% above national building code requirements (City of London, 2015).

The London Plan also requires that new major developments connect to lower carbon district energy systems and produce renewable energy using solar PV and heat pumps (Mayor of London, 2015). A capacity study was carried out in 2011 that looked at lower carbon energy supply opportunities in London with a timeframe out to 2025 or 2030 (City of London, 2015). The greatest opportunity was found to be district heating supplied by natural gas fuelled combined heat and power. In 2015 alone, the GLA secured commitments to the provision of gas-fired combined heat and power plants and renewable energy infrastructure including: “Combined Heat and Power (CHP) plant able to produce over 26MW of electricity…and a similar amount of heat, more than 74,000m² of solar photovoltaic (PV) panels…and a substantial number of heat pump installations” (Mayor of London, 2015). More recently, the Greater London Authority has become interested in renewable heat (sourced from the air, ground, industrial processes etc.), which research shows is sufficiently available to meet all of London’s heating needs (Mayor of London, 2013). Decentralized and renewable energy development is also pursued by the boroughs. For example, the borough of Merton requires new developments to provide 10% of its energy use from on-site renewable energy generation (Merton Council, 2016).

2.3.2.3. Incentives, Funding and Capacity Building

RE:FIT and RE:NEW are two key GLA programs that seek to improve the energy efficiency of existing buildings. RE:FIT has targeted public buildings since its launch in 2009. 90% of the funding for the program has come from the EU. RE:FIT provides expert support and tools to help public agencies secure energy performance contracts with the private sector to upgrade the energy efficiency of various kinds of public buildings. Through energy performance contracts, there are no upfront costs for upgrades and, instead, the costs are paid over time through the cost savings generated by the efficiency upgrades. RE:FIT has been expanded within and beyond the GLA. Similarly, RE:NEW is a GLA program seeking to leverage various sources of funding to enable energy efficiency retrofits of private residential buildings. After the program launch in 2009, RE:NEW sought to increase the uptake in London of efficiency subsidies offered through
obligations imposed by the national government on energy companies. Originally a grant program to boroughs to support door-to-door assessment of residential energy use, the RE:NEW program was retooled in the image of RE:FIT to work strategically with boroughs and housing associations to focus on retrofitting social housing. Other energy efficiency programs are also delivered by local boroughs and by energy companies. By the end of the 2013-2014 fiscal year, broad market activity including these programs had led to retrofits of 500,000 homes in London and 400 public sector buildings (Mayor of London, 2015).

Several subsidies, loans and other financing sources have been available in London, including through the Green Deal, the London Green Fund and energy company obligations. The Green Deal was a UK program intended to encourage energy efficiency retrofits of homes by offering low interest loans, but is widely acknowledged to have failed as a program since uptake was minimal due to problems with program design and implementation. The UK government has also required energy suppliers to deliver certain amounts of efficiency gains in homes and companies have met these obligations by offering various kinds of grants. The specific targets of the grants have varied over time, from focuses on physical characteristics (e.g. targeting homes with solid walls where insulation is more difficult and expensive) or socio-economic characteristics (e.g. reducing energy costs for low-income households). The London Green Fund is a £120 million fund with a revolving loan design that offers funding for waste, energy efficiency, decentralized energy and social housing projects. Renewable energy development is also being funded through community initiatives. Brixton Energy is a not-for-profit co-operative in south London that has developed multiple renewable energy projects in the area.

2.3.3. San Francisco

Previous research has considered climate policy at the local level in California (Bedsworth & Hanak, 2013). Energy and carbon policies adopted in San Francisco have also been studied, including energy use benchmarking and auditing (Palmer & Walls, 2017) and the social consequences of San Francisco’s green building code (Mehdizadeh & Fischer, 2013). In addition, scholars have also studied the urban political economy of green buildings in San Francisco (Knuth, 2015) and, more broadly, the clustering of LEED certified buildings in metropolitan areas in the US (Kaza, Lester, & Rodriguez, 2013). This research looks beyond just the local government policies to examine the material and political accomplishment of carbon
governance through buildings, which complements existing research on municipal policies, LEED certification, and the economic geography of green buildings in San Francisco.

2.3.3.1. Key Targets

The population of San Francisco is approximately 860,000. Carbon governance in San Francisco is pursued in the context of the local government’s 100% renewables goal, which means, by 2030, residential electricity should come entirely from renewable sources and 80% of commercial electricity use (for industrial and business purposes) should come from renewable sources (City of San Francisco, 2013). In 2010, GHG emissions were 14.5% lower city-wide than 1990 levels. This decrease is mostly due to the decreasing emissions intensity of electricity because of the California’s Renewables Portfolio Standard and the closure of two fossil fuel plants in San Francisco (City of San Francisco, 2013).

2.3.3.2. Standards, codes and regulations

San Francisco adopted a Green Building Code in 2008 that required new and majorly retrofitted residential and commercial buildings to, among other things, reduce energy use beyond the requirements of the California Green Building Code. Revised three times, the San Francisco Green Building Code now requires that new construction meets California code, installs solar PV, thermal or green roof for buildings 10 floors or less, and meet city-specified requirements linked to the LEED and GreenPoint Rated green building rating systems. The latest San Francisco code only requires that the California code be met since the California code has essentially caught up to the energy efficiency requirements of San Francisco’s Green Building Code. Building codes essentially just regulate the building envelope and higher levels of building envelope efficiency are difficult to justify as ‘cost-effective’, which is a requirement in the current regulatory environment. In 2007-2008, the California Energy Commission and the California Public Utility Commission, which are respectively the state’s energy policy and planning agency and the utilities regulator, announced the goal that by 2020 all new residential construction will be Zero Net Energy, with new commercial buildings following by 2030. The application and interpretation of this goal has played a major role in California Green Building Code updates since then. California also passed AB 32, the California Global Warming Solutions Act, in 2006, which requires California to reduce its GHG emissions to 1990 levels by 2020.
Since 2011, the San Francisco municipal government has required private owners of buildings over 10,000 sq ft to benchmark building energy performance and conduct an energy audit. Key benchmarking results must be shared with the San Francisco Department of Environment and building tenants. Building owners are not required to implement the energy efficiency upgrades that are suggested through the energy audit, but benchmarking and auditing has identified opportunities for $60.6 million USD in cost-effective energy upgrades (SF Environment, 2015). The combined impact of the San Francisco and California’s energy efficiency policies is leading to some energy efficiency retrofits in private buildings. For example, a report published by the City of San Francisco found that “energy use has decreased by 7.9 percent and source emissions have decreased by 17 percent among properties that consistently comply [with the energy benchmarking ordinance]” (SF Environment, 2015).

The City of San Francisco is also “de-carbonizing the energy supply by replacing fossil fuels sources with renewable energy sources—micro-hydro, wind, geothermal, solar, wave, and biomass” (City of San Francisco, 2013:p.12). The municipally-owned utility, San Francisco Public Utility Commission (SFPUC) launched a program called CleanPowerSF in 2016, which sells residential customers in San Francisco electricity incorporating a higher percentage of renewable energy at the same cost as the electricity that they were previously sold from the investor-owned utility. In 2013, 73% of city-wide electricity came from an investor-owned utility and 16% from SFPUC, with the remaining from other energy service providers (City of San Francisco, 2013). This proportion is changing, however, since SFPUC’s CleanPowerSF is the new default electricity offering for San Francisco electricity customers. All San Francisco customers are being transitioned to CleanPowerSF, unless they choose to opt out. The program was enabled through California’s Community Choice Aggregation legislation, which allows local governments to aggregate the buying power of residents to secure renewable energy supply contracts.

2.3.3.3. Incentives, Funding and Capacity Building

California incentivizes energy efficiency with a number of programs delivered through electricity utilities, for example Energy Upgrade, which connects homeowners with energy efficiency incentives offered by their local government and utilities. San Francisco also offers capacity building programs to support energy efficiency, including Energy Watch which offers
energy efficiency services and financial incentives to businesses, contractors, and apartment building owners and the Property Assessed Clean Energy (PACE) financing program, which offers loans for energy efficiency and renewable energy upgrades for homes and businesses.

Renewable energy generation, particularly solar photovoltaics, is also to be supported by a number of other local government policies (City of San Francisco, 2013). For example, incentive programs from the City of San Francisco support solar PV installation. Up to 2013, $15.5 million USD had been provided to reduce the installation costs of PV systems for residents, businesses and community organizations, including additional incentives for identified ‘environmental justice’ neighbourhoods that have experience higher historical levels of pollution (City of San Francisco, 2013:p.22).
3.1. Introduction

Addressing the climate change crisis requires transformative change. In light of this, some local governments have started to take what they describe as a transformative rather than incremental approach to greenhouse gas emission reduction (Carbon Neutral Cities Alliance, 2015). They are trying to chart the waters of urban “deep decarbonization” (Carbon Neutral Cities Alliance, 2015). However, there are no models for urban systems that have overcome fundamental fossil fuel dependence and become carbon neutral. In fact, there is no single fix that can overcome widespread carbon lock-in across society (Unruh, 2000). The governance of transformation instead requires normative steering and negotiation about what the future ought to be (Meadowcroft, 2009). So what is the future carbon neutral city actually imagined to be?

The urban is an increasingly important wedge of climate governance (Bulkeley & Betsill, 2013; Castán Broto & Bulkeley, 2013; Reckien et al., 2014; Romero-Lankao, 2012). We know that actors from across government, private, and community spheres are intervening in social and technical urban systems to try to address climate change (Bulkeley & Castan Broto, 2013). However, we also know that these efforts have encountered barriers and have often failed to address key drivers of climate change (Bulkeley & Betsill, 2013; Burch, 2010; Romero-Lankao, 2012). Thorny barriers are no surprise since carbon lock-in creates a policy inertia that makes it difficult to make systemic change (Unruh, 2000). Despite these setbacks, urban policy makers have started to explicitly target wide-reaching transformations, which is beyond the scope of action previously studied by scholars. This paper focuses on this unique slice of urban carbon governance where actors are deliberately reaching for decarbonization. To understand how the decarbonized future of cities is being imagined, we unpack the low carbon futures discursively constructed by urban actors in the cities that are members of a transnational network called the Carbon Neutral Cities Alliance.
Transnational climate governance networks, such as the Carbon Neutral Cities Alliance, are intertwined with visions of scientific and technological progress (socio-technical imaginaries), which carry with them implicit ideas about public purposes, collective futures, and the common good. Yet, because policies are determined by local socio-technical conditions, socio-technical imaginaries vary across sites. In principle, imagined futures—or the balance between their socio-technical configurations—could be different. We use this understanding of imaginaries in our examination of policy documents aimed at achieving carbon neutrality. The imaginary of urban carbon neutrality is transnationally linked through the network, but this study focuses on the climate governance documents of the member cities rather than the transnational network. More specifically, we unpack the underlying discourses in member cities’ climate governance documents in order to delve deeper into imaginaries of urban carbon neutrality. We argue that science and technology studies scholars’ work on socio-technical configurations is helpful to structure this unpacking. It is important to note that, although low carbon transitions must take place across urban systems and must be integrated with adaptation to climate change, this study focuses specifically on efforts to reduce greenhouse gas emissions in the buildings and energy sector in order to maintain a manageable scope. This focus is justified since building oriented initiatives make up a substantial proportion of urban carbon governance (C40 Cities & ARUP, 2014; Castán Broto & Bulkeley, 2013).

Based on our analysis, we interpret three key building and energy configurations: 1) The District Energy City, 2) The Zero Net Energy City, and 3) The Natural Gas Transition City. Furthermore, we find that, despite the importance of a few socio-technical policy mechanisms and objects, urban imaginaries of carbon neutrality are incorporating complex configurations of socio-technical components. At the same time, distinct socio-technical configurations are being favoured in individual places. These configurations are important because they feed into socio-technical imaginaries that drive policy outcomes and influence the shape of urban space.

We begin by explaining how literature on imaginaries helps us to consider the construction of the future and by elaborating on our use of configurations literature to unpack imaginaries. In the findings section, we first present textual network analysis visualizations and explain how we used this approach to unpack socio-technical patterns. We then analytically distinguish three descriptive configurations of future carbon neutral cities based on patterns in the studied documents. In doing so, this paper contributes to literature on the production of meaning and
power in the negotiation of environmental governance while expanding the urban carbon governance literature to include the ontological politics of carbon neutrality.

3.2. Governing the Future with Imaginaries

There are many different ways to construct the future. In planning literature, scholars write about scenarios, roadmaps, benchmarking, or visioning exercises, which are all tools used in various ways to imagine the future of urban areas (Boyko et al., 2012; A. Shaw et al., 2009). Political scientists have written extensively about utopian thinking (Goodwin & Taylor, 2009) and scenario analysis (Garb, Pulver, & Vandeveer, 2008). Others scholars have used the idea of imaginaries to discuss the ways that ideas about desirable and attainable futures are constructed through the lens of our understanding of who we are and the constitution of state-citizen relations (Jasanoff & Kim, 2015). These literatures all recognize the different ways that we talk about what the future \textit{ought} to be. However, we find imaginaries particularly helpful for our purposes because it provides a conceptual framework to understand feedback between talk and practice while also allowing for a dynamic and fluid consideration of the urban.

Particularly influential applications of the concept of imaginaries include Anderson’s definition of a nation as “an imagined political community” (Anderson, 2006) where people maintain and reproduce the collective community through shared practices. Expanding on this, Taylor used social imaginary to refer to how people broadly understand their social existence and he explored how changing imaginaries contribute to patterns of historical change (Taylor, 2004). Imaginaries have also been conceptualized in the context of the urban. The concept of urban imaginaries recognizes that a collective imagination is developed and reinforced through the urban dwellers’ daily practices, which builds the city as, at the same time, both an indefinite and a singular place (Çinar & Bender, 2007). Considering urban imaginaries can help us to understand the imagined political community of city, but it can also help us to examine how urban imaginaries from different places might transnationally influence one another (Hult, 2013). Imaginaries ontologically allow for a flexible and fluid understandings of the urban.

However, Jasanoff and Kim (2015) point out the lack of attention paid to science and technology in much of the work on imaginaries. To fill this lacuna, they propose the concept socio-technical imaginaries. Socio-technical 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 & Kim, 2015). They argue that imaginaries “at once describe attainable futures and prescribe futures that states believe ought to be attained” (Jasanoff & Kim, 2009). Though much of the application of the socio-technical imaginaries concept to-date has focused on nation-states, it can be applied to any organized groups and therefore is applicable to the urban (Jasanoff & Kim, 2015).

As the work of these scholars has shown, imaginaries are important because they influence possible future trajectories of the city through their repeated performance. The performative nature of imaginaries echoes the assertion of discourse scholars that language does political work that paves the way for different kinds of policy outcomes (Hajer & Versteeg, 2005). ‘Talk’ is institutionally stabilized and publically performed to become a collectively held lens through which we see the world and make decisions (Jasanoff & Kim, 2015). However, the notion of socio-technical imaginaries reaches beyond language, to the materiality of political action. ‘Talk’ is intrinsically connected to the organization of socio-technical governance arrangements. Hence, political experiments in achieving carbon neutrality proceed by attempting to secure the necessary involvement of human and non-human actors in the process of performing imaginaries. In this way, talk about carbon neutral governance and the objects that are enlisted in carbon transitions constrain some futures while enabling others.

Furthermore, the concept of urban imaginaries is used in this paper to engage with the spatially nebulous concept of ‘the city’. Urban scholars have called for attention to the ways that urban systems can be understood as processes of metabolism and flow rather than a fixed, bounded space (Gandy, 2004). Recently, these calls have focused on the importance of considering the relationship between the ‘city’ and the ‘hinterland’ when studying the urban (Huber, 2015) and the global reach of urbanization as a process (Angelo & Wachsmuth, 2014). In other words, we should not cut off the far-reaching tendrils of urban systems in misguided efforts for analytical simplicity. Embracing fluidity is similarly key to recent understandings of climate governance. Here, the idea of discrete levels of the international, national and local has given way to consideration of “the emergence of new political spaces” (Bulkeley & Betsill, 2013) that tackle climate governance across these boundaries. Imaginaries ontologically accommodate these calls for dynamic understandings of the urban and of climate governance. As a concept, imaginaries focus on the ways that social reality is understood and performed and how that understanding
influences the future. The scope and the participants in the collective construction are not prescribed. These features make imaginaries suited for the consideration of the wide range of authority and broad breadth of spatial scope of urban climate governance policy documents. The concept of imaginaries can encompass this broad scope while still connecting with the idea of a particular urban place. By examining the content of imaginaries, the ontological politics of carbon transition come into greater focus.

Our purpose is to understand and compare imaginaries of urban carbon neutrality. To do so, we unpacked the underlying discourses represented in climate governance documents using configurations literature, which draws from science and technology studies. Science and technology studies sees technologies as embedded elements in socio-technical systems so that the social and the technical are co-constitutive (Bijker & Law, 1992; Coutard, 1999). Central concerns in this body of literature are often the relationships between objects and actors (Marres, 2012) and the configurations of technological objects and social organization structures into socio-technical orders (Walker & Cass, 2007). This body of work is relevant for this paper since it has tackled the materiality of networks and has wrestled with similar questions on the radical transformation of infrastructure. This approach also fosters an emphasis on objects, which is usually underemphasized in work on imaginaries. In one study with an aim similar to ours, Walker and Cass (2007) analyze the relationships between technological objects and forms of social organization related to renewable energy policy in the UK. They identify five different configurations of renewable energy implementation by parsing out underlying discourses, participating technologies, size of projects, and characteristics of social and infrastructural organization (Walker & Cass, 2007). As a concept, configuration is focused on the organizing or ordering of socio-technical objects – the ways they are brought together, sorted, held together, and/or drawn apart. Socio-technical imaginaries, on the other hand, are broader visions of desirable futures that are collectively held and publically performed. The concept “pulls together the normativity of the imagination with the materiality of networks” (Jasanoff & Kim, 2015) to describe a vision of how life ought to be lived. A configurations approach offers a thorough framework to unpack imaginaries by breaking them down into constitutive socio-technical configurations.
3.3. Methods

This study focuses on a sample of the climate governance policy documents produced on behalf of the 17 cities that are founding members of the Carbon Neutral Cities Alliance (CNCA). We used textual network analysis as an interpretive tool to examine the building blocks of carbon neutral governance. By systematically extracting and analyzing the links between these building blocks within a body of texts (the sample listed in Table 2), we can draw a collective concept map of how carbon neutrality is conceived among the members of the CNCA. Textual network analysis enables us to gain a better understanding of how ideas are connected across our sample of texts, augmenting our configurations analysis by highlighting the centrality, marginality and similarity of the connection between ideas, arguments or objects across a body of texts (Carley, 1993; Palmquist et al., 1997). The measure of centrality is the number of links directed toward and going out from a particular concept. If a particular concept has a large number of links to other concepts, that is, greater centrality, it will have a greater importance within the concept map than a concept that is poorly linked. Here it is used as a tool to help interpret relationships between objects of carbon neutral governance and between policy instruments in the sample of climate governance documents. ‘Objects of governance’ means the urban elements that will be increased to achieve carbon neutrality (e.g. energy efficient technology). ‘Policy instruments’ refers to the means through which urban actors plan to bring about those increases (e.g. financial incentives).

It is important to note that although one might assume that some objects of governance and policy instruments are predominately material technologies (e.g. geothermal power) and others one might consider social (e.g. urban planning tools), they are better considered as socio-technical. The mobilization of ‘solar’, for example, could require solar photovoltaic panels, wires, inverters, electricity, installation labour, financial inventive mechanisms, local government policies, a household rooftop etc. The labels that we have chosen in the analysis represent both the social and the technical aspects. Taking this into account, our textual network analysis unpacks urban imaginaries of carbon neutrality to show which socio-technical objects and instruments will be mobilized and what kinds of connections exist between them.

Relevant objects of governance and policy instruments were identified using a grounded theory approach during qualitative analysis of the sample of climate governance texts. These objects
appear as nodes in the network graphs. We built a two-mode matrix where the rows represented each city \( (n = 17) \) and the columns represented each identified object of governance \( (n = 16) \) and another two-mode matrix where the rows represented each city and the columns represented each identified policy instrument \( (n = 11) \). For each city, we coded for the presence or absence of each object and policy instrument (see Appendix 1). Presence was judged using a close reading of the documents by one of the authors rather than quantitative content analysis for the exact terms used here, and one small passing reference to an object or policy instrument was not counted as presence.

We then transformed these matrices into adjacency matrices, which are used to represent the co-occurrence of bits of text across a larger sample of text (Palmquist et al., 1997). The adjacency matrices represented the number of times that objects (or instruments) co-occur within climate governance texts referring to one city. We entered the results into the network analysis software UCInet and used Netdraw to create visualizations (Borgatti, Everett, & Freeman, 2002). By focusing on co-occurrences, the resulting visualizations show the strength of connection (ties) between objects or instruments. This is a measure that allowed us to examine which strings of objects are dominant among the members of the CNCA and how the strength of ties between objects of governance reflect divisions or clusters across this body of texts. The centrality of different objects of governance can also be visualized by how often each object is connected to all other objects across our sample of texts, reflected by the size of nodes. The complexity and density of the concept map is indicated by the number of objects present and the extent to which each object is connected to all other themes. While there are many more network measures available to analysts (Scott, 1991), these were the most useful to address our research questions.

We also conducted a qualitative discourse analysis of the sample of texts. The discourse analysis had two purposes: 1) informing the identification of relevant objects of governance and policy instruments to feed into the textual network analysis, and 2) interpreting key socio-technical configurations of urban carbon neutrality. The discourse analysis drew on the approaches of Hajer and Versteeg (Hajer & Versteeg, 2005) and Foucault (Foucault, 1972). One of the authors (Tozer) performed a close and reflective reading of the sample of texts listed in Table 2 (Genus & Theobald, 2016; Waitt, 2005) that was focused on identifying the discursive elements constituted as key themes or topics and actors, as well as the discursive strategies employed in the text (Carvalho, 2008). We were especially interested in looking for the discursive strategies
of positioning, legitimation and (de)politicization. Positioning focuses on how actors are constructed to do certain things by the texts, legitimation normatively justifies the deployment of specific powers or actions, and (de)politicization is the attribution of (a)political natures to certain realities (Carvalho, 2008). These strategies are discursive manipulations of reality (both conscious and unconscious) produced by the authors of texts as they take a certain perspective and try to produce particular effects or meanings (Carvalho, 2008). Our approach employed the strategies distilled by Waitt, who recommends identifying key themes through absorption in the texts and the investigation of the ways in which ‘truth’ is constructed, inconsistencies are developed, and silencing mechanisms are included (Waitt, 2005). In addition to feeding into the textual network analysis, the discourse analysis allowed us to iteratively distill key socio-technical configurations of urban carbon neutrality. These configurations are not explicitly given within the texts but, instead, are heuristic constructs we use to interpret how socio-technical elements are being drawn together to tell stories about what future urban decarbonization might look like in particular places.

These methods allow us to examine the socio-technical configurations that make up imaginaries of future carbon neutral cities in two ways. The textual network analysis acts as an interpretive tool that allows us to analyze what kinds of objects are imagined to be important components of future carbon neutral cities and what kinds of policy instruments will be used to achieve those futures. In this way, we unpack the socio-technical building blocks of planned carbon neutral governance. The discourse analysis allows us to also interpret patterns in the ways that socio-technical objects are assembled in policy documents to consider emphases on particular kinds of socio-technical configurations. Therefore, the analysis broadly identifies the socio-technical objects that urban actors imagine will make up future carbon neutral cities on one hand, while, on the other, interpreting patterns in the imagined assemblage of those socio-technical objects for particular places.

3.4. Unpacking Configurations of Urban Carbon Neutral Imaginaries

3.4.1. Which objects are targeted by urban carbon neutral governance?

Our purpose with the visualization in Figure 1 is to analyze which objects are dominant targets of carbon neutral governance across the Carbon Neutral Cities Alliance. You will recall that we
derived the nodes by allowing them to arise through the discourse analysis, which means they reflect important patterns and silences within the texts. Ties between objects mean that they co-occur in the governance texts for a particular city. A heavier line weight means that the objects co-occur more frequently across the sample of texts. As a result, the most dominant (or frequently occurring) objects are shown at the confluence of the heaviest concentrations of line weights.

Figure 1 Visualization of the objects targeted in climate governance policy documents of the founding Carbon Neutral Cities Alliance members

Several interesting features can be interpreted from this visualization. The visualization shows that district energy, energy efficient technology, and solar power have particularly key roles in urban imaginaries about carbon neutral futures. Heat pumps (air and geothermal), combined heat and power (CHP), biofuels, wind power, and reduced energy demand behaviour also seem to play moderately important roles. Reduced energy demand behaviour has strong connections to

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3 The nodes represent the urban objects that will be increased to achieve carbon neutrality, where ties show that they co-occur in our sample of texts and the line weights show the relative frequency of co-occurrence.
energy efficient technology and solar, but otherwise is not a very dominant object of governance. Overall, the sample of policy documents emphasizes the technological aspects of objects. In addition, it would not be unreasonable for one to assume that fossil fuels would be replaced in urban futures that have achieved carbon neutrality. Nonetheless, natural gas is included in some futures. Natural gas has moderately strong connections to district energy and combined heat and power (CHP). We can see that there is high degree of interconnectivity across the objects, which shows that the seventeen cities are drawing on a fairly consistent suite of options—no object appears dominant in this concept map. This is as opposed to, for instance, divergent ‘camps’ favoring completely discrete options. The implication of this interconnectivity is that carbon neutral governance is not planning a silver bullet, but instead reflects anticipated use of a complicated suite of socio-technical tools. While configurations in particular places favour some socio-technical objects over others, they still plan to draw on a broad suite of technologies and behaviours in some way. This suggests that urban imaginaries of carbon neutrality are incorporating complex configurations of socio-technical objects. Again, the content of imaginaries is important because socio-technical imaginaries are powerful drivers of policy outcomes that shape urban space (Jasanoff & Kim, 2015).

3.4.2. What kinds of policy instruments will be used to achieve carbon neutral futures?

Urban carbon neutral imaginaries enlist various policy tools as planned mechanisms to achieve low carbon urbanism. Figure 2 compares patterns of emphasis on particular policy instruments in the studied climate governance documents. We created labels for the policy instrument categories through the discourse analysis and these labels are explained in more detail in Table 3.

Table 3 Explanation of policy instrument categories

<table>
<thead>
<tr>
<th>Policy Instrument Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmarking and Reporting</td>
<td>Mandatory energy use benchmarking and reporting of results for at least a portion of urban buildings</td>
</tr>
<tr>
<td>Building Standards</td>
<td>Requirements to meet a building standard with an energy or carbon element</td>
</tr>
<tr>
<td>Capacity Building</td>
<td>Provide information, increase skills, provide technical analysis</td>
</tr>
<tr>
<td>Financial Incentives</td>
<td>Provision of grants, loans and other financial rewards</td>
</tr>
<tr>
<td><strong>Financial Penalties</strong></td>
<td>Application of fees or taxes</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td><strong>Lead by Example</strong></td>
<td>Activity targeting municipal operations or assets that demonstrates behaviour/technology to be imitated</td>
</tr>
<tr>
<td><strong>Lobby Authorities</strong></td>
<td>Target change in the policy of another level of government, business, or other agency beyond the direct control of the municipality</td>
</tr>
<tr>
<td><strong>Municipal Energy Supplier</strong></td>
<td>Deliver carbon and energy changes through a municipally controlled utility company</td>
</tr>
<tr>
<td><strong>Private Sector Engagement</strong></td>
<td>Engagement of the business sector through activities like awards for top ‘green’ businesses</td>
</tr>
<tr>
<td><strong>Public Sector Engagement</strong></td>
<td>Public displays related to energy and carbon, as well as continued engagement with citizens through committees and other groups</td>
</tr>
<tr>
<td><strong>Urban Planning Tools</strong></td>
<td>Use of planning tools like zoning and fee structures</td>
</tr>
</tbody>
</table>

Similar to Figure 1, ties between policy instruments mean that they co-occur in the governance texts for a particular city. A heavier line weight means that the instruments co-occur more frequently across the sample of texts. The most dominant (or frequently occurring) instruments are shown with the confluence of the heaviest concentrations of line weights. The visualization (see Figure 2) shows that capacity building, financial incentives, leading by example, building standards, and benchmarking and reporting are important policy instruments in carbon neutral governance. Interestingly, this represents a mix of enabling and regulatory tools. Financial penalties, on the other hand, are only weakly connected to other mechanisms. There is an emphasis on demonstration, information provision, and incentives, as visualized through the high degree of interconnection between them. The policy instruments described often depend on the extension of municipal authority to influence other actors where regulatory control is not possible. Socio-technical imaginaries delimit attainable and desirable futures (Jasanoff & Kim, 2015), but they also delineate the means through which that future will be achieved. This analysis suggests that urban carbon neutral imaginaries will be enacted through the conscription of diverse public, private and individual authorities into a shared vision. Research on policy choice has offered a tripartite categorization of policy instruments: regulation (the stick), economic means (the carrot), and information (the sermon) (Bemelmans-Videc et al., 2011). Decision makers are thought to move over time from the least coercive to the most coercive
means for a given policy area, but policy instrument choice is also thought to be impacted by other factors, such as political culture (Bemelmans-Videc et al., 2011). Though the analysis in this section shows that regulatory governance is included, the policy tools largely emphasize the ‘carrot’ and ‘sermon’ approaches over the ‘stick’ approaches to policy design. This may reflect the types of municipal power available and/or a partnership approach to private capital.

Figure 2 Visualization of the policy instruments emphasized in climate governance documents of the founding Carbon Neutral Cities Alliance members

3.5. Socio-technical Configurations

The preceding analysis took a deep dive into the building blocks of urban carbon neutral imaginaries by examining the socio-technical objects and instruments featured in climate governance policy documents. We identified which building blocks to include in the concept maps through the discourse analysis. In each city’s policy documents, however, socio-technical

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4 The nodes represent the means through which urban actors plan to bring about increases in particular urban objects to achieve carbon neutrality, where ties show that they co-occur in our sample of texts and the line weights show the relative frequency of co-occurrence.
objects are assembled together in particular configurations. In addition to feeding into the textual network analysis, the discourse analysis allowed us to interpret three key socio-technical configurations of urban carbon neutrality (see Table 4). Recall that these configurations are not explicitly given within the texts. Instead, they are heuristic constructs that allow us to interpret the ways that socio-technical building blocks are being drawn together in the texts to tell a story about what a future carbon neutral city might look like in a particular place. In practice, these imagined configurations exist in overlapping fashions in the policy documents for particular cities. Here, they are distinguished for analytical purposes in order to highlight which socio-technical configurations are being normatively privileged. When considering these heuristic configurations, recall that this study focused on buildings and energy and excluded transportation to maintain a manageable scope.

**Table 4 Heuristic types of urban building and energy configurations interpreted from the climate governance document sample**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The District Energy City: An efficient and compact built environment powered by biomass CHP</strong></td>
<td>This carbon neutral city of the future is characterized by a dense built environment and compact urban development as the city continues to expand. The use of resources is highly efficient due to modern technology upgrades to buildings, with a particular focus on energy efficiency. Heat is provided to buildings through a district energy system that is highly interconnected. Extensive heat network infrastructure is embedded into the fabric of the city. Energy production focuses on combined heat and power systems fuelled largely by biomass.</td>
</tr>
<tr>
<td><strong>The Zero Net Energy City: Efficient buildings powered by building integrated PV and distant wind power</strong></td>
<td>This carbon neutral city of the future is typified by technologically advanced buildings that produce as much energy as they use. Buildings are energy efficient and solar photovoltaics are integrated into the built form of the city. The behaviour of individuals is one focus of governance. Further renewable energy is supplied by wind turbines located physically distant from the core urban area.</td>
</tr>
<tr>
<td><strong>The Natural Gas Transition City: District energy powered by natural gas with a renewable gas future</strong></td>
<td>This carbon neutral city of the future passes through a phase of development focused on natural gas expansion in order to transition the energy system from coal. Extensive district energy infrastructure connects and supplies heat to many buildings in the city. CHP plants fuel the district energy system in the near term. At an indeterminate point in the future, natural gas will be replaced as a fuel, perhaps through the incorporation of renewable gas.</td>
</tr>
</tbody>
</table>
We have not categorized the studied cities because, in practice, urban actors are taking multifaceted approaches to achieve carbon neutrality and we wish to avoid essentializing the approach taken in each city. However, we include the following examples to offer deeper insight and bring alive the narratives of carbon neutrality taking shape among the members of the Carbon Neutral Cities Alliance. In Stockholm, one expression of the carbon neutral imaginary is similar to the District Energy City configuration. District energy has been a central urban infrastructure for many years. Continued fuel switching to biomass and waste-to-energy technology as well as district energy infrastructure expansion will continue this pattern to achieve decarbonization. This configuration is pursued in combination with a compact and very energy efficient built environment (City of Stockholm, 2014). In San Francisco, low carbon urbanism will continue to emphasize solar PV generation. Zero net energy approaches to building development and retrofit are key to low carbon plans in San Francisco, which combines energy efficiency and on-site renewable generation (City of San Francisco, 2013). In London, the planned carbon neutral future includes a role for natural gas expansion to power district energy generation. This natural gas expansion is positioned as a bridge between existing coal-fired power plants and future lower or zero carbon energy sources that would be substituted into the district energy generation system. Potential fuel sources for future substitution are waste heat or biogases that not yet considered commercially viable options (Mayor of London, 2011). Of course, other options are being pursued in all three places and the complicated work of decarbonization cannot be adequately summed up in three standard configurations. Nonetheless, the application of our three heuristic configurations makes it clear that an emphasis on different sociotechnical configurations drives different material interpretations of carbon neutrality.

3.6. Discussion

There are two key findings that can be drawn from this analysis. The first is that efforts to achieve urban carbon neutrality will be manifold; instead of a silver bullet, cities plan to use a multi-pronged approach. The textual network analysis findings illustrate an extensive articulation of policy, behaviour and technology options in climate governance documents. While there is an emphasis on district energy, energy efficient technology, and solar power and there are sociotechnical objects and policies left out, the high degree of interconnectivity visualized in Figure 1 and 2 still makes it clear that urban deep decarbonization pioneers are planning to use a complicated suite of objects and tools to reach their goals.
The second key finding of this paper is that, at the same time, distinct socio-technical configurations are being favoured in individual places. Our analytical interpretation of three key configurations demonstrates that particular places are normatively highlighting specific combinations of socio-technical objects and policies. As a result, there is some diversity among cities in the material interpretation of carbon neutrality. Our analysis identified three key heuristic configurations: 1) The District Energy City 2) The Zero Net Energy City 3) The Natural Gas Transition City. It matters that different socio-technical configurations are envisioned for future carbon neutral cities; Different kinds of city will result. The power of imaginaries is that particular socio-technical configurations are institutionalized and embedded into material systems and norms (Jasanoff & Kim, 2015). As the governance documents are implemented, these configurations may strongly inform socio-technical imaginaries that will continue to drive policy outcomes over time.

This study focuses on imaginaries of the future, but these imaginaries are, of course, influenced by existing configurations and conditions. Historical development patterns have created cities that already have extensive district heating infrastructure – for example, Stockholm and some other European cities – or created cities connected to coal dependent regional electricity grids – for example, London. Social, economic, technical and political conditions shape the possibilities imagined for the future; different kinds of cities generate different imaginaries. Furthermore, this study is based on climate governance documents that describe the future, but they are not passive policy documents outlining a potential path. Instead, the imaginaries represented through these documents are shaping attainable and desirable futures and delimiting the nature of carbon neutrality. This has real impact on policy outcomes. Imaginaries are repeatedly embedded into infrastructure and institutions as policies are enacted, thereby guiding urban futures through their repeated performance. This feedback between talk and practice makes it clear how the language studied in this paper does political work to pave the way for different kinds of cities.

3.7. Conclusion

The urban carbon governance efforts of the members of the Carbon Neutral Cities Alliance (CNCA) are shaping what it means to be a carbon neutral city. Transnational governance networks such as the CNCA are entangled with visions of scientific and technological progress that influence understandings of collective futures and public good, but these socio-technical
imaginaries vary across localities. ‘Carbon neutrality’ is a mutable idea, which makes it unclear what kinds of future urban systems are imagined. In this paper, we have unpacked urban imaginaries of carbon neutrality represented in the policy documents of the founding members of the Carbon Neutral Cities Alliance to examine the constitutive socio-technical configurations.

Our focus on configurations showed that efforts to achieve urban carbon neutrality will be manifold as urban actors assemble a range of socio-technical objects in the pursuit of decarbonization. Although the emphasis within the studied policy documents rests particularly on district energy, energy efficient technology, and solar power, future carbon neutral cities are broadly imagined to incorporate complex configurations of socio-technical objects. There are some patterns within the complexity. Overall, the sample of policy documents emphasizes the technological aspects of socio-technical objects (e.g. various fuel sources for energy generation). In addition, the policies that will be used to achieve carbon neutrality include both regulatory and voluntary policy instruments, although the emphasis on the latter may reflect limited regulatory power over relevant sectors as well as a desire to enlist private capital as a partner.

Furthermore, our findings show that different socio-technical configurations are favoured in climate governance policy documents for different places. From our analysis, we interpreted three heuristic configurations that highlight specific combinations of socio-technical objects: 1) The District Energy City: An efficient and compact built environment powered by biomass CHP, 2) The Zero Net Energy City: Efficient buildings powered by building integrated PV and distant wind power, 3) The Natural Gas Transition City: District energy powered by natural gas with a renewable gas future. These three heuristic configurations show how the emphasis on different sociotechnical configurations drives different material interpretations of carbon neutrality. Sociotechnical imaginaries constituted from these divergent configurations will embed into society different understandings of how a carbon neutral urban life ought to be lived.

There are several implications for these findings. While divergence between favoured socio-technical configurations could be an effective way of respecting different local circumstances (e.g. no accessible biomass source or good conditions for solar photovoltaics), the dominance of particular socio-technical configurations could also potentially limit the scope of urban carbon neutral imaginaries. Widespread integration of the Natural Gas Transition City configuration into imaginaries, for instance, will create new interests in fossil fuels that will be difficult to
overcome. While it is often represented as a simple technological substitute to make the switch to renewable gas fuel, the entrenchment of fossil fuels is actually perniciously political (Bernstein & Hoffmann, 2016). Clearly, given the complexity of governance objects and policy instruments mobilized among the CNCA members, these paths offer a means to steer governance towards achieving decarbonization. Yet, as our textual analysis suggests, while the dominant configurations offer pathways, other urban actors pursuing carbon neutrality will necessarily have to meander through a diverse landscape of objects and policy instruments to attain their goal. It also important to note, however, that the group of cities studied here is not even close to a comprehensive representation of global diversity. Care should be taken to avoid inappropriate prescription based on these findings that eschews demands for North-South redistributive justice in climate change mitigation governance.

It is essential that future research examines the material implementation of urban carbon neutral governance beyond the textual approach taken for this paper. The negotiation of decarbonization is ongoing and experimental, but the development of powerful socio-technical imaginaries, as well as their investment in institutions and infrastructure, already shapes nascent decarbonization pathways.
Chapter 4
Discourses of Carbon Neutrality and Imaginaries of Urban Futures

4.1. Introduction

We do not yet know what a completely carbon neutral city looks like. Nevertheless, imaginaries have begun to shape these urban futures through policy documents around the world. Local authorities have begun aiming for ‘carbon neutral’ transformations (Carbon Neutral Cities Alliance, 2015). These transformations will not culminate in one kind of city; different imaginaries about the futurity of energy will send cities down divergent sociotechnical paths. It is not yet clear what these paths will look like and whether they all might lead to significant greenhouse gas emission reductions.

Imaginaries about a place influence policy outcomes through their repeated performance (Çinar & Bender, 2007; Jasanoff & Kim, 2015). Rather than ‘just talk’ then, the discourses underlying imaginaries do political work and become a lens through which we see the world and make decisions (Hajer & Versteeg, 2005; Jasanoff & Kim, 2015). The power of these visions for the future, or ‘sociotechnical imaginaries’ (Jasanoff & Kim, 2009), is reinforced and amplified as they are embedded into material networks and societal norms. In this way, sociotechnical imaginaries define what kind of future is both desirable and possible. The processes of imagining and producing energy futures are understudied despite the importance of these dynamics in ordering society (Delina & Janetos, 2018). Here we undertake an analysis of sociotechnical imaginaries, which is a type of analysis that is “a form of intensely political narration, reminding both observers and observed that the seen reality is not the only one about which we can dream” (Jasanoff & Kim, 2015).

The aim of this paper is to examine the meaning of ‘carbon neutral’ in policy discourses to illuminate the sociotechnical paths to low carbon futures that are imagined by urban decarbonization pioneers. In order to unpack carbon neutrality, we analyze the discourses represented in urban carbon governance texts of the 17 founding members of the Carbon Neutral Cities Alliance, which is a network of local authorities mainly from Europe and North America.
that are pioneering deep decarbonization. We identify the storylines underlying urban imaginaries of carbon neutrality among these pioneers. By unpacking the storylines driving urban imaginaries, this paper provides insight into hegemony among ideas about urban carbon neutrality. Before tackling this aim, we first provide a discussion of the literature on sociotechnical imaginaries and storyline analysis of policy discourses, which inform this study.

4.2. Imaginaries of Urban Futures

Ideas about what the future can be powerful drivers of action in the present since these visions are embedded into decisions affecting the social and technical fabric of our society. Our understanding of who we are and where the future is headed are created and maintained through socio-technical networks spanning across society (Jasanoff & Kim, 2009). These ideas about the future, or “sociotechnical imaginaries” (Jasanoff & Kim, 2009), do not just describe desirable futures, but also delimit attainable ones. 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 & Kim, 2015). This concept considers how visions of social order are coproduced with science and technology. Sociotechnical imaginaries are performed through exercises of power like target and policy setting, which shape infrastructures, objects and institutions. It is this performative dimension that links sociotechnical imaginaries to policy as well as politics (Jasanoff & Kim, 2015). Particular visions of the future gain traction through acts of power, ongoing coalition building and the fostering of innovation (Engels & Münch, 2015; Jasanoff & Kim, 2015). Using this concept, scholars have explored where transformative ideas come from as well as how imaginations become solidified in practice through the adoption of social norms and the performance of objects (Jasanoff & Kim, 2015).

While Jasanoff and Kim (2015) orient sociotechnical imaginaries particularly to the national level and tackle topics like nuclear power in the US and South Korea, they suggest there is no reason to limit the concept to this scale. In this paper, we consider a transnational sociotechnical imaginary. Other researchers have applied the concept to a variety of scales as well as multi-scalar interactions (Ballo, 2015; Eaton, Gasteyer, & Busch, 2013; Engels & Münch, 2015; Smith & Tidwell, 2016). Indeed, national sociotechnical imaginaries may be contested locally (Eaton et al., 2013) or new imaginaries may emerge from local, everyday experience (Smith & Tidwell,
However, it can be difficult to actually attain the future described in one group’s sociotechnical imaginary if there is contention or a lack of power to change material infrastructures (Eaton et al., 2013; Smith & Tidwell, 2016). Schelhas et al. highlight local counter-narratives in the development of sociotechnical imaginaries of biofuel in the US (Schelhas, Hitchner, & Brosius, 2018) and Delina uses the concept of sociotechnical imaginaries to examine contestation among powerful and powerless actors seeking to shape the desired future of energy in Thailand (Delina, 2018). Urban carbon neutrality is a sociotechnical imaginary that is under development, but we can examine nascent imaginaries to consider what the implications will be as these visions are embedded into society. In the case of developing visions for low carbon housing in the UK, for example, experts have two competing visions for possible futures: Passivhaus and Smart Homes (Cherry, Hopfe, MacGillivray, & Pidgeon, 2017). Passivhaus uses mainly passive and low-tech design to make homes so efficient there is no need for traditional heating and cooling systems. Smart Homes, in contrast, are high-tech buildings that make extensive use of information and communication technologies to automate control of the domestic environment (Cherry et al., 2017). As this example demonstrates, choices exist about potential sociotechnical pathways when sociotechnical imaginaries are under development, but one or more may be shut down as one imaginary gains traction.

Policy discourses are recommended as useful place to start for analyses of sociotechnical imaginaries (Jasanoff & Kim, 2015). In this paper, we unpack the discourses represented in carbon governance documents using discourse analysis and literature on storylines. Scholars have used discourse analysis to consider the role of storylines in policy making. Discourse analysis derives from an intellectual tradition concerned with power dynamics, which means that it is well suited to our examination of the production of meaning and power in the negotiation of carbon governance. Discourse analysis aims to explore the outcomes of discourse in actions or attitudes, to identify the frameworks within which discourses are produced and circulated, and to reveal the structures that reinforce particular statements as normal or ‘true’ (Foucault, 1972; Hajer & Versteeg, 2005; Waitt, 2005). Instead of seeing statements as just a method of expression, it examines discourses as practices within regulating structures and analyzes the effects of texts (Waitt, 2005). Hajer uses the concept of a discourse coalition to explain how people can develop shared terms, or ‘storylines’, that construct environmental problems and delimit potential responses (Hajer, 1995). He sees a storyline as “a generative sort of narrative
that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomena" (Hajer, 1995). However, members of the discourse coalition might interpret these storylines differently. In fact, he argues that this might be a key way that a coalition is formed and maintained.

In a useful application for this study, Lovell et al. employed discourse analysis to examine what kinds of storylines are dominant in the climate and energy policy field in the UK (Lovell et al., 2009). They identify four principal storylines: (1) climate change as a problem of energy supply, (2) climate change as a problem of energy demand, (3) climate change as a market efficiency problem, and (4) climate change as an international problem (Lovell et al., 2009). Applied similarly here, a storyline analysis approach allows us to examine what kinds of ideas about carbon neutrality are powerful among the Carbon Neutral Cities Alliance members. The Carbon Neutral Cities Alliance is a transnational climate governance network of local governments that have adopted a target of at least an 80% reduction of greenhouse gas emissions by 2050 (Carbon Neutral Cities Alliance, 2015). A storylines approach is particularly helpful in adding structure to sociotechnical imaginaries analysis, in which researchers tend to use a wide range of methods and theoretical approaches. Here, we use a storylines approach as a way to analyze sociotechnical imaginaries about carbon neutral urban futures.

4.3. Methods

We used qualitative discourse analysis methods to understand dominant storylines employed by discourse coalitions in policy documents of the 17 founding members of the Carbon Neutral Cities Alliance. We drew on the Hajer and Versteeg (Hajer & Versteeg, 2005) as well as Foucault (Foucault, 1972) to guide our approach. The storylines were identified using a grounded approach in the analysis. One author conducted close and reflective readings of the texts listed in Table 2 (Genus & Theobald, 2016; Waitt, 2005) with an interest in the discursive elements constituted as objects or actors, as well as an interest in the discursive strategies employed in the text. In this context, ‘objects’ means themes or the topics constituted in the texts (Carvalho, 2008). To consider actors, we asked who is identified in the texts and how are they represented. For discursive strategies, we were particularly interested in positioning, legitimation and (de)politicization. Positioning focuses on how the texts construct actors to do certain things, legitimation is a discursive strategy that normatively justifies the deployment of particular
powers or actions, and (de)politicization is the attribution of (a)political natures to certain realities (Carvalho, 2008). These strategies are discursive manipulations of reality that are made (consciously or not) as the authors of texts take a certain perspective and try to produce particular effects or meanings (Carvalho, 2008). Our approach identified regularities/inconsistencies and for the inclusion/omission of discursive elements and strategies both within texts and across the sample of texts (Waitt, 2005). We employed tactics that call for extensive absorption in the texts to identify key themes and to investigate the development of claims highlighted as unquestionable ‘truth’, inconsistencies between claims within the texts, as well as instances where possible claims are absent or glossed over (silences in the texts). These storylines were iteratively distilled from our sample of texts, they are not explicitly given within these texts as one would expect from extracting plots from novels. These storylines are thus heuristic constructs we use to consider what kinds of narratives about urban carbon neutrality are considered ‘true’, ‘normal’ or even ‘inevitable’ and gave rise to the five storylines summarized in this paper.

4.4. Findings: Storylines Driving Urban Imaginaries

Storylines act as a kind of shorthand for actors involved in governance (Lovell et al., 2009). They are “a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomena” (Hajer, 1995). Storylines can act as a rallying point on which actors can build coalitions, despite the fact that actors may interpret narratives differently in practice (Hajer, 1995). We used a discourse analysis approach to interpret which storylines could be considered the most dominant among the carbon governance documents of the 17 members of the Carbon Neutral Cities Alliance. It is important to note that each of these storylines was not consistently emphasized across all of the cities. Storylines in our sample of carbon governance texts were detailed, nuanced and woven together, but this section highlights five storylines that provide the most analytical purchase. In addition, recall that this study focuses specifically on the built environment.

4.4.1. The carbon neutral storyline

All of the documents reflect on the definition and meaning of their goals to some degree since they are working with mutable terms like ‘carbon neutral’, ‘clean’, ‘renewable’, ‘climate neutral’ and ‘fossil fuel free’. The terminology used is deceptively similar, but actually represents very
different rationalities. The City of Berlin’s Carbon Neutral Feasibility Study, for example, focuses on a climate neutral goal (City of Berlin, 2014). The policy document calculates a per capita budget for the projected 9 billion inhabitants of Earth in 2050 based on a greenhouse gas emission level that would keep global warming below two degrees Celsius. Every person on Earth gets 2 metric tons of CO$_2$e, which means that Berlin’s target should be 85% below 1990 levels by 2050 (City of Berlin, 2014). This climate neutral storyline allows for continued use of some fossil fuels, unlike the rationalities oriented around 100% renewable energy. Vancouver declares the commonly adopted target of an 80% GHG reduction by 2050 to be inadequate and develops an imaginary of future carbon neutrality that depends on 100% renewable energy. In other places, like Melbourne, carbon neutral is imagined to include carbon offsets (City of Melbourne, 2014), which extends the spatial boundaries of the sociotechnical networks that will be used to achieve neutrality. The configuration of urban energy systems will be different as these imaginaries are invested in the sociotechnical fabric of the city and beyond.

Variations exist in urban carbon governance that affect the interpretation of ‘carbon neutral’. The historical context, existing built environment, and overlapping jurisdictional authorities influence the ways that carbon neutrality is interpreted and applied. ‘100% Renewable’ makes sense in Vancouver since the legacy development of large-scale hydropower has created an energy system that is already approaching that goal. ‘Clean energy’ is the target for New York City, where there is planned expansion of natural gas combined heat and power to replace the heavy presence of coal in the regional electrical grid. As this demonstrates, macro flows of energy are important aspects influencing this storyline. These variations can customize carbon neutral imaginaries to particular contexts, but it is important to remain aware of the differences. Imaginaries represent divergent sociotechnical paths despite using the same storyline of carbon neutrality. In other words, carbon neutrality is materialized differently due to previous and current energy entanglements involving the built environment, the accessibility of ‘clean’ energy, and regional environmental conditions.

Nonetheless, the shared overarching storyline of ‘carbon neutrality’ creates a basis for the Carbon Neutral Cities Alliance discourse coalition. Even though the storyline of carbon neutrality has different specific meanings in particular places, the shared discourse across coalition members creates common ground for collaboration. Policy documents for Boulder explain how “in 2014 Boulder was invited to join 16 other vanguard cities committed to deep
carbon reductions [in The Carbon Neutral Cities Alliance]” (City of Boulder, 2015). The storyline of carbon neutrality reduces the discursive complexity of greenhouse gas emission reduction and lets people and knowledge cluster around the shared trope of urban transformation (Hajer, 1995). The link to transformation is particularly important since it positions the discourse coalition as a place apart from other local carbon governance efforts. While many cities are seeking to reduce greenhouse gas emissions, this discourse coalition is carving out new space to seek deeper carbon reductions. The significance is demonstrated in one example from Boston’s carbon governance documents:

“Among U.S. cities, Boston has one of the lowest emissions per capita…However, European cities such as Copenhagen and Stockholm have achieved much lower emissions per capita - 4.7 and 3.3, respectively, due to both high energy efficiency, clean electricity generation, and low rates of driving. This proves that low-carbon cities with an exceptionally high standard of living are possible.” (City of Boston, 2014)

In this excerpt, Boston’s deep carbon reduction ambitions are outlined in reference to other members of the Carbon Neutral Cities Alliance even further down the decarbonization pathway. The shared space of the transnational network makes it easier for actors involved in this discourse coalition to share ideas and resources particularly helpful for deep carbon reduction planning, which could stimulate innovation in this area. Yet, the concept of ‘carbon neutrality’ is steeped in a vision of the future that is deterministic in terms of how climate variability will unfold and how ‘neutrality’ itself may be contested within the broader political economy of climate governance across the Global North and South. ‘Neutrality’ aims not only towards materializing deep decarbonization, but also to the depolitization of climate governance in its assumptions about shared and even distribution of climate response-ability.

4.4.2. The new economy of carbon control

The ‘new economy of carbon control’ storyline focuses on neoliberal economic competition. In particular, this storyline describes carbon control as a business opportunity. Consistent with ecological modernization (Hajer, 1995), actors describe ‘new’ or ‘green’ economic development goals not only as compatible with carbon neutrality, but in fact the essential means through which carbon neutrality will be achieved. Vancouver will be a "mecca of green enterprise" (City of Vancouver, 2012), for example, and Yokohama “shall achieve its economic revitalization
toward a low-carbon society by providing business opportunities through demand creation and promoting technological innovation of corporations within the city” (City of Yokohama, 2010). This storyline supports a focus on technological innovation as a key governable object since new technologies and expertise can be marketed to other cities. At times, this storyline is expressed in terms of cost savings benefits for businesses, such as in Sydney where “improving the energy efficiency of our buildings not only contributes to efforts to address climate change, it makes sound business sense. In fact, it is vital to future economic competitiveness” (City of Sydney, 2015). Carbon neutral imaginaries strongly incorporate eco-modernization ideas about the future urban economy.

Citizens of cities are mobilized as potential workers in this future economy. In the imagined low-carbon London of the future, “Londoners have the skills and knowledge to access the significantly expanded number of jobs in low carbon sectors” (Mayor of London, 2011). Jobs and carbon control are inextricably linked in the imagined future. In Minneapolis, a key task of climate action is to “continue and expand efforts to promote green jobs that support greenhouse gas emissions reduction goals” (City of Minneapolis, 2013). In 2050, “green living-wage jobs are a key component throughout the regional economy” in Portland (City of Portland, 2015).

Furthermore, rather than a local scope, the new economy of carbon control is expected to be global; It is a multi-level, interconnected imaginary. Londoners are to have access to “jobs in value chains supporting the global low carbon economy” (Mayor of London, 2011).

Finally, this storyline is sometimes connected with equity considerations. In Boston, for example, “climate action could be a major driver of growth in the Massachusetts economy, and Boston has a key role to play in shaping this growth to be equitable and sustainable” (City of Boston, 2014). While reducing greenhouse gas emissions out to the year 2025, Minneapolis will “continue to grow sustainably and equitably with more residents, jobs, and opportunity across all of Minneapolis” (City of Minneapolis, 2013). In these applications, equitable access to jobs in the new economy of carbon control is a central concern.

This storyline supports a view of the future as predicted from the aggregation of individual choices through market mechanisms. Such an imaginary of the future reproduces the status quo in terms of the global circulation of capital and entrenches an atomistic view of individual action as detached from distinct social, political, cultural and economic trajectories.
4.4.3. The city as a laboratory

The ‘city as a laboratory’ storyline describes urban areas as “innovation labs where the world’s climate solutions will be pioneered” (City of Boulder, 2015). This storyline emphasizes piloting, learning, and adaptability. In fact, the physical space and urban processes of the city are offered to public and private actors for climate governance experimentation: “Copenhagen is ready to make the city available as a green laboratory” (City of Copenhagen, 2012). The imaginary that emerges is imbued with a sense of experimentation and flexibility. The sociotechnical specifics of the carbon neutral future need not necessarily be fixed since the imaginary incorporates learning. Various tools will be used in order to enable innovation, whether it is innovation labs in Boulder, or demonstration projects like Empowerhouse in DC:

“Empowerhouse is the first passive house in DC, thanks to its air-tight building envelope, super-insulated walls, accessible green roof, and water and energy efficient technologies. While Empowerhouse started as a demonstration project for innovative green building techniques, it was recently converted into a duplex for two families in Deanwood.” (Washington D.C., 2012)

After these processes of experimentation, urban leaders will then be able to highlight successful innovations. For example, a brochure produced by the City of Oslo explains how the city uses a “series of innovative solutions for reducing its greenhouse gas emissions” (City of Oslo, 2011). The concept of an urban laboratory where experimental governance takes place is not new (Governance of Urban Sustainability Transitions & Urban Europe, 2017; Voytenko, McCormick, Evans, & Schliwa, 2016), but in this case it is the entire city that is offered up for experimentation rather than limited geographic space within a city (Evans & Karvonen, 2013).

The transnational network itself is also explained as a community of innovators. Boulder’s Climate Commitment policy document describes how “The Carbon Neutral Cities Alliance…is a learning and innovation network that seeks to develop and test new approaches to accelerated climate action” (City of Boulder, 2015). In this way, it is clear how storylines can act as rallying points for members of a discourse coalition. The local experimental experience is aggregated into a transnational experimental experience.

Bulkeley & Castan Broto (2013) used a theoretical framework focused on experimentation to conceptualize urban climate action because this approach recognized that climate governance is
happening beyond just the traditional channels of authority while also incorporating innovation and learning (Bulkeley et al., 2013). The ‘city as a laboratory’ finding here shows that experimentation is also an explicit storyline used in municipal policy documents to describe carbon governance within the city, as well as a rallying point underpinning the discourse coalition of the transnational network. This experimentalist storyline focuses our attention on the dynamics, uncertainties and ambiguities of climate mitigation action and their embeddedness in complex social, political and economic networks.

4.4.4. Technological fixes and the modern city

Another important storyline revolves around concepts of technology and modernity. In ‘technological fixes and the modern city’, a normative frame is developed to construct energy efficient and renewable energy powered cities as modern. Cities will lose stature internationally if they fail to technologically upgrade the urban built environment in terms of energy efficiency, smart technology and/or renewable energy generation. For example, “the transformation process presents an opportunity for Berlin to become a highly modern city with a power supply based on renewable energy sources” (City of Berlin, 2014). This storyline is often expressed as “world-class” city ambitions (City of Stockholm, 2014) or through competitive targets like Copenhagen’s goal to become “the world’s first carbon neutral city” (City of Copenhagen, 2012). International recognition is key. For instance, carbon governance documents describe the plan to “[develop] and [promote] Oslo as an internationally recognised sustainable city” (City of Oslo, 2011). In a way, this storyline attempts to amend the meaning of urban success. Imaginaries of carbon neutral futures link together energy, carbon, and reputation to paint achievement of carbon neutrality as a compulsory task for urbanity. In the future, global urban leaders will be carbon neutral. Such technological determinism makes the use of and benefit of technology appear as inevitable—curtailing questions about how problem formulation and solutions are co-constituted in such discourses.

The sociotechnical urban fabric is clearly targeted in this storyline. Buildings especially must change to become highly tuned machines. The governance documents of New York’s municipal government state that “By 2050, our buildings will need to become high-performance structures powered by low-carbon energy sources” (New York City, 2014). Carbon governance typically point out the high GHG contribution of buildings before describing the ways that the built
environment will be upgraded. 52% of GHG emissions in San Francisco come from buildings and the city is “working to make all new buildings green and highly efficient” (City of San Francisco, 2013) as well as reducing the amount of energy used in existing buildings. One imaginary for the future that is highlighted in Stockholm’s Roadmap to Fossil Fuel Free by 2050 is described as follows:

“The energy efficiency of the existing built environment in the city is improved with regard to heating and hot water by an average of 50 percent. Together with measures to make new buildings highly energy-efficient, this reduces energy use per square metre by almost 70 percent.”

(City of Stockholm, 2014)

This storyline is frequently focused on technology and incorporates precise calculations for percentage changes in energy efficiency or tonnes of greenhouse gas emissions reduced. In this storyline, planned overhauls to the built environment are often comprehensive, such as in Washington where the 2032 target is to “retrofit 100% of existing commercial and multi-family buildings to achieve net-zero energy standards” (Washington D.C., 2012).

At times this storyline links technology and equity. The distribution of access to these technological upgrades is pivotal here. Minneapolis seeks to ensure that completed whole home retrofits match the distribution of high, middle and low-income households in the city (City of Minneapolis, 2013). Portland also seeks “to ensure that energy efficiency upgrades do not result in increased cost burden to low-income populations and communities of color that are already under financial stress” (City of Portland, 2015). Equitable access to technology is the concern so that these upgrades to the sociotechnical fabric of the city do not exacerbate existing inequalities. This storyline raises the point made by Marres, who argues that the normative register of technologies of carbon management cannot be assumed in advance of their deployment—the value of these technologies as a ‘public good’ should be understood from a performative perspective as an achievement rather than assumed to be normatively positive prior to their usage (Marres, 2012).

4.4.5. In the carbon neutral city, citizens are empowered to be ‘good’

In some places, carbon neutral sociotechnical imaginaries highlight the actions of individuals in ways that remake what it means to be a ‘good’ urban citizen. Citizens are described as potential
agents of change and will be provided with the tools to be ‘good’ citizens, where ‘good’ means reducing GHG emissions both by changing behaviour and purchasing carbon control technologies. In these cases, the way that the sociotechnical imaginary will be solidified in practice is through the actions of individuals through a speculative ethics of the future. A governance document produced by the municipality of Portland calculates a per person carbon budget for the city’s residents (City of Portland, 2015), for example. One goal of the San Francisco municipal government is to “[empower] San Francisco citizens and businesses to cost-effectively reduce GHG emissions associated with their own electric energy usage” (San Francisco Public Utilities Commission, 2011) and policy documents state that “individual New Yorkers could play a significant role in reducing emissions” (New York City, 2013). According to a key vision of life in London in 2025, “Londoners [will] understand their energy use and are increasingly more energy efficient, reducing CO₂ emissions from homes even further” (Mayor of London, 2011). The storyline does not just imagine the ways in which individuals’ lives will be different in a carbon neutral future, but it redefines what it means to be an upstanding, contributing citizen. This is in contrast to storylines that emphasize structural change, such as in Melbourne where “achieving zero net emissions will require substantial structural, economic and policy change” (City of Melbourne, 2014). This storyline makes assumptions about an imagined public, which is a dynamic that has also been found in other research. Here, imagined future citizens shape their behaviour and economic activity around GHG emission reduction, but in other cases the same process of imagining future publics has described imagined users for smart grids that are simultaneously techno-savvy and clueless (Skjølsvold & Lindkvist, 2015) and a public with “misconceptions” about renewable energy that need to be solved through the provision of information (Barnett, Burningham, Walker, & Cass, 2012).

Like several of the CNCA members, Seattle’s carbon policy document has a chapter on ‘What You Can Do’ in its climate plan. Many places break out potential actions that could be taken by citizens in separate sections as a complement to the infrastructural or programmatic responses laid out elsewhere in the policy documents. The chapter for Seattle lays out actions that individuals can take to help the local government meet its GHG reduction goals:

“Once we understand the relationships between what we purchase and GHG emissions, Seattleites – from schoolchildren and families to entrepreneurs and policy makers – can pave the way toward more climate-friendly choices. Our city has set a bold goal of becoming
carbon neutral by 2050. Our individual choices are key to achieving this goal.”
(City of Seattle, 2013)

In this example, information will empower citizens to make good choices. This role for the individual subject is not new; Urban environmental governance has been found to contribute to the constitution of the self-governing individual (Brand, 2007) and others have also noted that individuals have been assigned responsibilities when it comes to carbon control (Marres, 2012). Others have sought to understand the governance of individuals to achieve energy futures, including how individuals perceive their role in energy futures as both a citizen and a consumer (Defila, Di Giulio, & Schweizer, 2018) and governance design to impact energy consumption behaviour (Bornemann, Sohre, & Burger, 2018). It is notable that this study found that efforts to engender behaviour change and individual action were absent or downplayed in policy documents for some cities.

4.5. Discussion: The Problems and Solutions Delimited by Storylines

As previously stated, we argue that these storylines are more than ‘just talk’ that is unsubstantiated by action. Instead, these shared terms and narratives construct the problems that carbon governance will attack as well as delimit potential responses. Our interpretation outlines some diversity in the construction of the problem that needs to be addressed. In some places, the problem is fossil fuel use. In others, the problem is global climate stability. These rationalities share a commitment to deep decarbonization and a scope of transformation beyond actions planned in many other cities, but the variation does mean that the proposed solutions diverge down trajectories with different sociotechnical characteristics. Even though actual interpretations of the term vary, the shared sociotechnical imaginary of ‘carbon neutrality’ nonetheless supports the discourse coalition of the Carbon Neutral Cities Alliance. Their shared discursive terrain allows individuals participating in the Alliance to work together through workshops, reports, shared resources and peer-to-peer mentoring to try and make deep decarbonization a material reality.

The developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice. There is a focus on technological fixes and innovation as solutions, as well as on influencing the behaviour of individuals. Private capital is enlisted as a partner in developing and
delivering solutions (e.g. city as laboratory for corporations and the new economy of carbon control) as opposed to responses that might have been more controlling or even punitive. A picture emerges of citizens bearing personal responsibility for carbon reduction, while private companies are supported to make money through the transformation. Relatedly, the most dominant incorporation of equity was concerned with equitable access to the money that will be made off of the low-carbon transition.

In addition, the ‘city as a laboratory’ storyline suggests some reflexivity in this sociotechnical imaginary about the experimental nature of achieving carbon neutrality. Such political experiments can serve the role of producing new governance arrangements by means of exemplification and demonstration, but also consist of political choices in new technologies, policy instruments and their relations. These choices can entrench reliance on fossil fuel or lead to more radical transformation. This discourse coalition is experimental in the sense that materials, entities and relations are assembled politically and are guided by rationalities, storylines and socio-technical imaginaries of the future. In these experiments, collective imaginaries are generated, yet our analysis suggests that while there are dominant paths of action, these veil local sites and practices of resistance to transformational change as well as contrasting visions of desired future social, material and political conditions.

By uncovering the political implications of the storylines giving shape to carbon neutral imaginaries, and their potential role in empowering communities to shape their own future path of development, our analysis focuses on the ontological politics of discourses. Law (2004) noted that as researchers we tend to ignore the messiness of discursive practices, objects of study, and different knowledge systems, reducing the heterogeneity or multiplicity of objects to a singular reality (Law, 2004). This is important, because local models of nature, society, and desired futures are the basis of current environmental struggles, which should be seen as struggles for the defense of cultural, ecological, and economic difference (Escobar, 1999). What our analysis of carbon neutrality suggests is that this concept refers to multiple realities—hence its deployment may potentially materialize multiple futures. From a performative perspective, the storylines we identified are world-making practices—whose and what knowledge, values, and goals are counted as legitimate and rigorous and are integrated into policy and practice matters to how localities come to see, plan for and adapt to global environmental change.
4.6. Conclusion

We need radical transformation to avoid catastrophic climate change and ‘carbon neutral’ sounds like a term that represents significant transition. As the new field of urban carbon neutral governance emerges, however, the term can act as a black box concealing within it contestations in meaning and power. Assuming a technological determinism and a linear vision of transition from current energy entanglements to a (single) future of carbon neutrality underscores the imagined trajectories of carbon neutrality. We have lifted the lid on the black box in this paper to unpack the imaginaries about carbon neutral futures developed by urban deep decarbonization pioneers. In unpacking the local government led carbon governance documents of the Carbon Neutral Cities Alliance, we have shown that carbon neutral is actually a flexible term. Furthermore, we have analyzed the ways that the storylines in policy discourses inform sociotechnical imaginaries of urban carbon neutrality. We also show how sociotechnical imaginaries are being shaped within and across nations through urban governance networks, directing our attention to the multi-scalars assemblages that carbon neutral discourses are materializing.

This study has demonstrated that one can imagine diverse carbon neutral trajectories in different contexts while still building coalitions across localities using cohesive storylines. In the planned trajectories referenced in policy documents, we can see the potential performance of radical greenhouse gas reduction. But should the carbon neutral city be ‘clean’, ‘renewable’, or ‘fossil fuel free’? The flexibility of ‘carbon neutral’ leads to sociotechnical imaginaries that would drive very different kinds of policy outcomes. It is this very ambiguity, however, that allows the coalition represented by the Carbon Neutral Cities Alliance to be built and to collectively experiment with deep greenhouse gas emissions cuts. The discourse coalition of the transnational network may allow participating actors to share innovations and coordinate effective action.

Despite these possibilities, this paper has also explored the potential pitfalls of mutable terms. The ambiguous use of ‘carbon neutral’ obscures our understanding of what kinds of ideas about sociotechnical objects and relations are becoming powerful and makes it difficult to see that very different configurations are being institutionalized. As talk becomes action, policy outcomes are reinforced and different kinds of cities will result. This momentum is particularly pernicious if imagined urban carbon neutrality actually involves embedding fossil fuels in new ways.
Optimism and ambiguity in the storylines risk downplaying the difficult challenges of energy transitions and potential for negative outcomes, as has been found in other studies of forward-looking narratives (Soutar & Mitchell, 2018).

One of the goals of the Carbon Neutral Cities Alliance is to inspire and teach other local governments as they pursue low carbon transitions. This is particularly important when one considers the rapid urbanization expected in Asia and Africa. The speed and nature of this urbanization (and therefore the impacts on future energy use and emissions) are uncertain, but, regardless, will have a critical influence on the levels of global greenhouse gas emission levels in 2050 (Seto et al., 2014). However, this study was limited to urban areas in wealthy and industrialized nations that are responsible for historical greenhouse gas emissions. While there are lessons to learn about the developing meaning of urban carbon neutrality and the sociotechnical imaginaries driving policy outcomes, the indiscriminate transplant of the approaches taken in these cities would not only ignore the global plurality of urban areas, but also disregard calls within climate governance for redistributive justice between the global North and South. More studies of urban energy futures in the Global South are required (Delina & Janetos, 2018).

There is significant scope for future research as climate governance continues to reach for the transformation of deep decarbonization. Future research can expand on this study to examine other carbon governance sectors, like transportation, and to incorporate adaptation governance. Particularly important will be deeper examinations of the power relations at play, including questioning the underlying assumptions and driving interests of the storylines and whose ideas about carbon neutrality are becoming hegemonic over time. Finally, examinations of the articulation of planned governance into material reality will be an essential task as actors continue to struggle with efforts to transform the urban.
Chapter 5
The Urban Material Politics of Decarbonization in Stockholm, London and San Francisco

5.1. Introduction

Urban decarbonization requires sweeping transformation to not only urban political and institutional systems, but also the material infrastructures supporting urban life (Bulkeley et al., 2011). The enormous scope of the challenge and opportunity for urban low carbon transition is alternately staggering and galvanizing. Despite widespread and growing adoption of local goals to reduce greenhouse gas emissions, however, urban climate change mitigation action has taken a piecemeal rather than systemic approach (Betsill & Bulkeley, 2007; Bulkeley & Betsill, 2013; Reckien et al., 2014; Romero-Lankao, 2012). Furthermore, actors are explicitly experimenting with low-carbon practices that are uncertain both in terms of successful implementation and actual impact on urban greenhouse gas emissions (Castán Broto & Bulkeley, 2013). Some municipal governments have even started to aim for what they call "deep decarbonization" (Carbon Neutral Cities Alliance, 2015), which specifically targets urban transformation. Yet, urban climate response is multi-scalar and also involves diverse actors beyond the local government (Bulkeley & Betsill, 2013; Emelianoff, 2014; Peng & Bai, 2018). There is very little understanding of what all of this activity might amount to when it comes to re-making the socio-material fabric of urban areas. As a result, there is a critical need to engage with the material implications of low carbon practices (Bulkeley, Castan Broto, & Edwards, 2015; Hodson, Burrai, & Barlow, 2016; Lovell et al., 2009; Rutherford, 2014).

The aim of this paper is to interrogate how carbon governance is rendered through urban buildings and energy systems, and the types of governance used to facilitate these changes, in three urban case studies: Stockholm, London and San Francisco. To do so, I delve into the material politics of implemented decarbonization efforts in cities. This approach allows me to examine progress in the implementation of urban carbon governance while still encompassing the messy, materially embedded, and contested nature of infrastructure transformations.
Recent work has developed an essential broad picture of urban carbon governance (Castán Broto & Bulkeley, 2013). Urban responses to climate change (often called ‘urban climate experiments’) have been studied through intracountry comparison (Allman, Fleming, & Wallace, 2004; Burch, Shaw, Dale, & Robinson, 2014; Chu, 2016; McGuirk et al., 2014) and have often focused on specific climate experiments within cities (Blanchet, 2015; Bulkeley et al., 2013; Cloutier et al., 2015; Hodson & Marvin, 2007; van der Heijden, 2016), although there are also notable recent cross-city comparisons (Bulkeley, Edwards, & Fuller, 2014; Burch et al., 2014).

Building on this research, this paper examines the slice of urban carbon governance purportedly aiming for transformative decarbonization to provide a novel deepening of our understanding of urban carbon governance. Furthermore, this paper responds to calls from Rutherford (2014), Edwards and Bulkeley (2017) and Bulkeley, McGuirk, and Dowling (2016) to look at the “‘everyday’ struggles over the urban materialities of energy transition” (Rutherford, 2014). Work in this vein so far has largely focused on a tracing the material politics of particular interventions within a city (Bulkeley et al., 2016; Rutherford, 2014; Silver, 2017). This paper expands on these approaches by using multiple cities in order to learn through comparison.

More specifically, I use a material politics approach to examine patterns in what is being made to matter through the translation of carbon governance into building-energy infrastructure. There is variation in what is made to matter since carbon management is an idea that can be variously deployed to make different things into problems and solutions. In particular, I analyze how carbon governance is impacting relations between people and building-energy infrastructure and consider the politics of these relations. I argue that emerging patterns in urban decarbonization practices carry implications for whether or not cities are on trajectories toward decarbonization. I find that a short-term decision making timeline (e.g. 2020 or 2030) encourages action that incrementally reduces greenhouse gas emissions without fundamentally overcoming carbon lock-in, but that the long-term timeline (e.g. 2050) creates different problems and solutions that can engender decarbonization trajectories. The findings also explore the solutions and tensions advanced through the normative and performative power of spatial configurations of decarbonization. I find that different socio-material solutions are foregrounded when actors focus on different spatial solutions for decarbonization, which has implications for whether or not successful decarbonization trajectories are achieved. Furthermore, actors are harnessing exceptional urban space to overcome the tyranny of cost-effectiveness in maintaining carbon
lock-in, although the use of high value urban land for this process raises concerning implications for justice and uneven development. In addition, there is a pattern of individualization of responsibility for decarbonization, which allows powerful agents in industry continue to operate high carbon assets and maintain political and technological carbon lock-in. Finally, material politics limit the application of low carbon retrofit solutions in the existing built form, which will significantly impede urban decarbonization efforts given that the majority of urban buildings in the cases are expected to remain standing in 2050.

5.2. Material Politics of Urban Infrastructure

5.2.1. Urban infrastructure and building-energy decarbonization

In order to examine the re-ordering of the city as low carbon transitions unfold, one can pay greater attention to the material politics of urban infrastructure. Work in this area sees urban infrastructure as dynamic, contested, and socio-political as much as technical (Hodson & Marvin, 2009; Kaika & Swyngedouw, 2000; McFarlane & Rutherford, 2008; Monstadt, 2009; Rutherford & Coutard, 2014). Urban infrastructure is (re)configured through metabolic circulation and the larger socio-environmental processes influencing these flows (Bulkeley et al., 2014). This is related to an interest in materiality - a more-than-human approach (Whatmore, 2006) - that has revived more broadly across geography. Important here is that materials are not a background on which human controversies play out. Decarbonization cannot be rolled out through an obliging set of technologies, policies and practices. Instead, politics is wrapped up with materials in a diverse range of socio-material assemblages. The actualisation of low carbon transitions means intervening in these assemblages towards particular ends. While this type of intervention requires contested struggle to unfold, this contention is not necessarily bad. In fact, points of contention open up possibilities for change (Bulkeley et al., 2013).

While there has been interest among scholars in urban energy infrastructure, there has been minimal work on buildings as infrastructure (with notable exceptions, for example see Edwards & Bulkeley (2017)), despite the role of buildings as a focal point for the performance of low carbon cities. In this paper, I argue buildings and energy are best understood as an interconnected urban infrastructure since they are spatially and conceptually paired in urban decarbonization practice. The mutual influence of building characteristics and energy in decarbonization can be illustrated through a few examples. First, district energy systems can use low temperature heat
sourced from industry (factories) or city services (sewage waste heat recovery), but buildings must be designed in specific ways to be able to effectively make use of this low temperature heat. Second, investments in energy efficiency retrofits are often rationalized as the cheapest form of energy ’supply’ as opposed to constructing new energy generation facilities to meet demand. In this way, building retrofits conceptually become energy supply. Third, urban renewable energy generation (such as solar photovoltaics) is often integrated into buildings thereby linking buildings and energy spatially. Given these conceptual and spatial pairings, it is more productive to conceptualize the building-energy nexus as an urban infrastructure than as separate sectors. This approach makes it easier to see the ways that carbon governance is socio-materially rendered through low carbon interventions in the urban.

5.2.2. A material politics approach

A material politics approach to urban low carbon transition considers the ways in which urban politics and materialities come to matter as transitions unfold (Bulkeley et al., 2016; Rutherford, 2014). Drawing on Barry’s work on the “material politics” of pipelines (Barry, 2013), recent work has used this approach to examine urban energy transitions. For example, Rutherford (2014) draws on material politics to consider how things come to matter in urban climate change governance in Stockholm, particularly related to contestation, and Bulkeley et al. (2016) take a Foucauldian governmentality reading of the materiality of politics to examine the encounter between climate governance and smart grids in Australia through the configuration of governance assemblages.

Material politics work pushes back against what some scholars have identified as an overemphasis on policy representations in climate governance literature (Rutherford, 2014). This focus on the symbols and policies of climate governance flows from the broader cultural turn in geography in the 1990s (Latham et al., 2009; Rutherford, 2014). As a result, some geographers have argued for rematerialization approaches that theorize the connections between the material and apparently immaterial processes (Latham & McCormack, 2004). Critiques have cautioned scholars to approach ‘re-materialization’ cautiously and, in particular, not to simply equate materiality with the concrete as some perceive was done in the past (Latham et al., 2009).

With this in mind, this paper draws on relational approaches to materiality. Relational materiality work thinks about the co-production of materiality through the assemblages of human and non-
human elements (Latham et al., 2009). In particular, these scholars disrupt the idea of a neat divide between subjects and objects and analyze the ways that materiality is assembled and disassembled through urban processes of circulation and connection. Assembling is an inherently political process and “the political significance of materials is not a given; rather, it is a relational, a practical and a contingent achievement” (Barry, 2013). Some scholars have examined the ways that objects matter politically to consider the relationships between people and objects and the ways that objects are invested with normative and performative powers (Marres, 2012; Meehan et al., 2013; Shaw & Meehan, 2013). Other scholars draw on Foucault to structure their analyses of relational materiality (Bulkeley et al., 2016). Foucault argued that governing is not just concerned with the social world of actors and institutions, but is made up of a “complex of men and things” (Foucault, 2009). This means that governing involves the assemblage of different elements together and a configuration of power through people and things (McGuirk, Bulkeley, & Dowling, 2015). Overall, relational approaches to materiality foreground the material, but, importantly, also consider all of the relations the material represents.

I draw on these relational approaches to materiality that consider the ways that human/non-human as well as material/immaterial elements are drawn together and driven apart through the processes of urban circulation. I follow the idea of materiality defined as “a spatio-temporal process in which the more tangible, physical stuff of the city is a lively participant” (Latham et al., 2009, p. 62, original emphasis). In particular, I examine how low carbon transformations of infrastructure are influenced by the material make up of particular urban systems. Rather than arguing that the materiality of places determines both the path the city will take and the politics of decarbonization, I instead examine the interaction of human and non-human as decarbonization is assembled together. I consider this relational work of assembling the elements of carbon governance to be a political project.

In this chapter, I use a material politics approach in order to delve into the complex social, political and material details of building-energy infrastructure transformation and, in this way, understand the scope and nature of implemented urban decarbonization. Following the application of Rutherford (2014), this chapter focuses on the relations between people and objects, particularly by considering what is made visible, tangible or durable through practices of ordering, circulation or manipulation. In this way, one can consider how things come to matter
by considering how energy transitions are governed, including the acts of formulation, implementation and contestation made visible through artefacts, techniques and practices (Bulkeley et al., 2016). The focus is not on which specific objects come to matter, but, instead, on the ways in which materiality is “present in the connections between things, technologies, people, bodies, signs, texts, etc. with none of these as inherently more material or immaterial than the others” (Rutherford, 2014). A material politics approach to analyze the implementation of decarbonization ensures that the socio-material form that is taken as carbon governance is negotiated and adapted to urban contexts is neither tuned out nor attributed to settled readings of power relations (Bulkeley et al., 2016). Rather, the approach offers “insight on the emergent textures, tensions, limits and possibilities taking shape as the city is increasingly problematised as a site and subject of climate-energy governance” (Bulkeley et al., 2016). This approach contrasts to common practices of evaluating progress in decarbonization using ‘end-of-pipe’ approaches that measure and compare greenhouse gas emissions, which provide a limited picture of the on-going and messy dynamics of infrastructure transitions. Instead, a material politics approach to urban low carbon transitions offers an “alternative way of following and/or measuring energy and carbon flows through the urban environment” (Rutherford, 2014). A material politics analysis of decarbonization implementation allows me to maintain the complexity of urban infrastructure transitions while still considering the broader implications of patterns in decarbonization practice that affect whether or not cities are headed toward decarbonization trajectories.

This chapter is focused on a community of practitioners and policymakers striving to achieve decarbonization in their cities and analyzes what is being made to matter through the translation of carbon governance into building-energy infrastructure. This community’s effort to achieve decarbonization represents a political struggle against entrenched interests embodying pervasive carbon lock-in across social, institutional, technical and economic systems (Bernstein & Hoffmann, 2016; Unruh, 2000). I focus on patterns and tensions developing within the elite community of policymakers, NGO representatives and industry representatives trying to implement decarbonization through buildings. I call them decarbonization actors in this chapter. Of course, this community’s approach to decarbonization is also contested by other groups – such as fossil fuel interests who seek to obstruct carbon governance and grassroots organizations who push back on discourses of de-politicization and technocratic solutions – but that is outside
the scope of this research. The analysis weaves together the voices from across institutional affiliations and urban contexts in recognition of the fact that urban climate governance is being pursued by many groups, not just local governments (Bulkeley et al., 2016; Castán Broto & Bulkeley, 2013).

In the next section, I examine the patterns emerging through decarbonization practice and the reconfiguration of building-energy infrastructure. In the presentation of the evidence, I draw from across the cases in order to learn whether there are aspects of the urban other than direct city to city comparison that are important factors shaping patterns of decarbonization practice. Using a grounded theory approach to analysis, I considered analytic lenses based on categories of practice or target sectors (e.g. new building vs. retrofit), but found that they overburdened the analysis. Instead, I identified time, space and agency as analytically productive and commonly applied lenses in geography and used them to examine patterns in the developing relations between people and building-energy infrastructure and the politics of these relations.

5.3. Practices of Decarbonization

5.3.1. Time

5.3.1.1. Long-term decarbonization frames for infrastructure decisions

The presence (or absence) of a long-term decarbonization frame influences the material shape of energy and building decisions made today. For example, the Greater London Authority mapped heat and energy demand for large urban developments while considering goals and predictions up to the year 2030. Since the study considered cost effectiveness and the characteristics of the broader electricity grid in addition to decarbonization goals, it found that “within that timeframe…gas-fired [combined heat and power plants]” for district energy made the most sense (Greater London Authority environment department employee, interview, Sept 8 2015). Natural gas powered district energy gained salience in London as a central plank in the GLA’s low carbon policies. More recently, work done by the GLA has recognized that when 2050 decarbonization goals are also considered, this new district energy network will need to transition again away from natural gas in the not too distant future. However, the material characteristics of a district energy system must be quite different in order for it to use natural or waste heat sources to replace natural gas, including different locations for pipes and different
building design (Greater London Authority environmental department employee, interview, Sept 8 2015; London development industry representative, interview, Sept 15 2015). Summing up this dynamic, another research participant describes the impact of timeframe on urban low carbon decision-making:

“We’ve got a grid carbon emission factor. So when you do the math for a new flat, gas wins every time because it’s about 40% less carbon intensity that you get from electricity. But that’s only today. We know that we’re involved in a massive, massive political consensus to reduce our grid carbon emissions factor. Surely we should be thinking about that. It’s like…our left arm is planning for this glorious future and the right arm is going ‘Let’s pretend that’s not happening’.”

(London development industry representative, interview, Sept 15 2015)

While natural gas might provide a marginal reduction in greenhouse gas emissions over the short term, in the long term natural gas expansion represents material entrenchment in fossil fuels that is incompatible with 2050 decarbonization goals. When working within a short-term frame, decarbonization actors identified different problems to solve compared to a long-term frame, which results in different building and energy infrastructure in practice.

5.3.1.2. Decarbonization deadlines shape decision-making

Urban actors are starting to put deadlines on decarbonization (e.g. all new homes to be carbon neutral by 2016 in the UK, all new homes to be zero net energy by 2020 in California, or fossil fuel free by 2040 in Stockholm) in addition to more familiar incremental greenhouse gas emission reduction targets (e.g. 20% GHG reduction by 2020). Whether because a larger policy framework makes it seem inevitable or because decarbonization goals become normal for a jurisdiction, the adoption of specific timelines often allowed decarbonization actors to refocus the discussion on *how* to implement decarbonization rather than *when* to do it. For example, in California, one research participant described how setting big, bold energy efficiency targets for the state was about “saying this is where we think we need to go, let’s figure out how to get there rather than spending our time on the goal setting part”, which “has been extremely valuable” (City of San Francisco environment department official, interview, Apr 14 2016). The same dynamic is taking place in Stockholm, where public housing companies understand that “you can’t really say, no we aren’t going to fulfill those [targets]. We have to…it’s a fact” (Stockholm development industry representative, interview, Nov 23 2015) and the discussion has turned to
creating plans and measuring progress. Of course, the existence of a target linked to a timeline does not guarantee success. In the UK, the Zero Carbon Homes goal was abandoned right before the deadline despite an EU directive pushing the UK in the same direction. In addition, California is not going to meet its goal to retrofit half of all existing buildings to ZNE by 2030 (San Francisco consultant, Apr 29 2016).

Nonetheless, a sense of inevitability about decarbonization can be used to shape current urban buildings and energy infrastructure implementation. The Greater London Authority could use the UK’s zero carbon homes goal policy framework as “an extra stick”, for example, where they “could point to the direction of travel and say well you’re going to have to get there anyway” (London consultant and former GLA employee, interview, Oct 5 2015) to support the GLA’s requirements for large urban developments to meet a slightly more ambitious trajectory. Temporal boundaries for decarbonization (not just marginal improvement) can be incorporated into an assumed trajectory for urban infrastructure development and that decarbonization actors can leverage to shape current decision-making.

5.3.1.3. Temporal dimensions of what carbon makes matter

Time is a key factor influencing how urban decarbonization actors pursue building-energy transformations. Furthermore, different understandings of time impact whether actors can effect change that has the potential to lead to decarbonization. A short-term frame creates a different problem to be solved (e.g. relative decrease in greenhouse gas emissions) than a long-term decarbonization frame (e.g. energy transition), which brings different energy generation configurations to the fore as solutions. Depending on the timeframe, different material configurations appear to make sense as solutions, but these configurations are not necessarily reversible and have limited flexibility once they are implemented. New socio-material obduracies are created through building-energy infrastructure investments. This dynamic has implications for decarbonization because, as is clear in the London example, shorter timeframes can drive practices that support the more efficient use of fossil fuels rather than overcoming the entrenchment of fossil fuels to achieve transformation. In sum, when actors filter carbon governance through short timeframes, immediate greenhouse gas emission reduction can come to matter the most. However, the socio-material configurations of these solutions may set up a trajectory toward more efficient fossil fuel use rather than overcoming carbon lock-in.
Furthermore, the evidence from the three cases also shows how targets that put a deadline on decarbonization can become normalized, which can allow decarbonization actors to shift the discussion to tangible acts of implementation and contestation. As others have found, targets nest together scientific and political elements to create normative pressure, including “affirm[ing] what is legitimate to reach, indicat[ing] the direction to be taken and provid[ing] the common language to translate priorities and programmes into a policy outcome” (Morseletto, Biermann, & Pattberg, 2016). The findings show that targets are not always achieved, but they also show that urban decarbonization actors are actively leveraging these deadlines; some urban actors reinforced the inevitability of decarbonization in order to facilitate the implementation of carbon governance practices in current infrastructure development. This links to work on the sociology of expectations (van Lente, 2012), where science and technology scholars have found that actors actively reference what is possible in the future, which fills a performative role and influences technological development. Urban actors are reinforcing expectations about the inevitability of future decarbonization in order to encourage or require the implementation of decarbonization today.

5.3.2. Space

5.3.2.1. Spatial solutions and tensions for building-energy decarbonization

Across the case studies, the spatial approach to decarbonization took two formats: a district-oriented approach or self-sufficient building approach. In the district-oriented approach, chunks of the city are conceptually and materially linked together and made more efficient while being supplied by lower carbon energy sources. In London, for example, new developments are “obligated, if they’re appropriate for district CHP, to go ahead with it” (London consultant and former GLA employee, interview, Oct 5 2015). The thinking is that this new infrastructure would provide some flexibility for London to enable decarbonization. As one GLA employee described, the idea is to “get a heat network up and running and then you can look at supplying it in different ways with fuels… Whereas at the moment we don’t even have that option…we’re just tied into a gas grid and a power grid. At least it would give us a little bit of flexibility to transition at some point in the future” (Greater London Authority environment department employee, interview, Sept 8 2015). For this format, decarbonization actors stressed the importance of networks of new or refurbished infrastructure linking together buildings.
Stockholm heating and electricity supply has been configured using a district energy approach for decades, but renewable fuels have gradually replaced fossil fuels in district heating, notwithstanding one large coal-fired heat and power plant remaining in Värtan (City of Stockholm, 2016). Stockholm has also concentrated decarbonization efforts on eco-districts, which is elaborated on in the next section. Cities like Stockholm have achieved some acclaim in urban circles for the degree of decarbonization enabled by district configurations and, as a result, other cities are copying the district approach.

When pursuing a building-oriented decarbonization format, decarbonization actors largely treat each building as an island in the effort to enhance each building’s decarbonized self-sufficiency. For years, San Francisco has had a building code that has required developers to achieve a higher standard for energy efficiency and renewable energy than the statewide building code. In this approach, the building code is harnessed to try to decarbonize the city one new or majorly altered building at a time. Recently, building code updates have been reoriented to work towards achieving California’s target for all new buildings to be Zero Net Energy (ZNE) by 2030. San Francisco stakeholders have been involved in discussions about “what a ZNE code actually looks like” particularly concerning how much solar electricity can be generated on-site to offset the building’s energy use (San Francisco environmental NGO employee, interview, Apr 20 2016). In a similar demonstration of a building-oriented approach, a planning rule was adopted by the London borough of Merton that stated that 10% of a new building’s energy use must be produced using on-site renewable energy. The Merton Rule was influential and not only spread widely among other London boroughs, but was also adopted by the Greater London Authority (Merton Council, 2016). When buildings are targeted individually, each building is approached as a node and decarbonization actors design building-energy solutions to decarbonize that node.

There is some contestation within the decarbonization actor community about which format is better. People have criticized the self-sufficient buildings approach for a lack of interconnectivity between buildings and a perceived failure to capture the benefits of a systems approach to energy. For instance, one participant in the research highlighted the Merton Rule in London specifically:
“I think one of the most damaging aspect or policy was something called the Merton rule whereby we looked at one building and said that building is going to be sustainable and then you’d spend money on making that building be self-sufficient where actually what you need – a more cost effective way of doing it was to have a community based approach.”
(London development industry representative, interview, Oct 1 2015)

This participant in the research argued that a focus on individual buildings overlooked the opportunities for district energy solutions, particularly from a cost perspective. Another critique is the unintended side effects of a building-by-building approach. A not-for-profit has expressed concern that the ZNE target in California could encourage sprawl “since it might be harder to get a…building to be ZNE in a city where you don’t have space for on site renewables” (San Francisco environmental NGO employee, interview, Apr 20 2016). On the other hand, the district approach has been critiqued as too narrow in focus, which causes it to miss other kinds of low carbon opportunities better suited to individual buildings (e.g. heat pumps) (London development industry representative, interview, Sept 15 2015; London development industry representative, interview, Sept 7 2015). Different decarbonization actors take different approaches and so both kinds of spatial solutions are present to some extent in the urban case studies.

5.3.2.2. Exceptional urban space for learning and overcoming cost-effectiveness

In some cases, spaces within a city are cordoned off as exceptional decarbonization zones. This is the case in Stockholm, where one decarbonization strategy has been to build particular neighbourhoods to very high green standards. The Royal Seaport is a large area of urban land undergoing brownfield redevelopment from port lands to mixed used/residential developments. The city owns the land, and places a number of environmental requirements into the development agreements, including meeting a high energy efficiency standard. In many ways, City of Stockholm decarbonization actors see the Royal Seaport as “a test bed for many new things which then should be generalized and put into ordinary projects” (City of Stockholm planning administration employee, interview, Nov 5 2015). Decarbonization actors also position municipal buildings in San Francisco as exceptional space since publicly owned buildings must meet higher standards than the Green Building code, including LEED Gold certification. In San Francisco, the public mandate of the local government means that they are willing to spend
money on more experimental technologies to achieve additional public good goals (in this case, decarbonization). In the case studies, exceptional spaces are used to facilitate learning and to build capacity in both the private and public sector, whether it is related to cutting-edge efficient building construction techniques or new institutional systems to track and enforce adherence to standards. The theory of change behind this approach draws on niche theory, which explores how learning happens in protected space and then scales up more broadly (A. Smith et al., 2010). That said, there are also concerns that the exceptional nature of these urban spaces makes the experiences incompatible with ordinary projects (Stockholm development industry representative, interview, Nov 24 2015). Many low carbon solutions are often considered to be too expensive without the added support of a public mandate or high value urban real estate.

In addition to supporting learning, the exceptional nature of urban space provides a venue to overcome the tyranny of cost effectiveness in maintaining the status quo. In general across the three cases, urban decarbonization was pursued only as far as was ‘cost effective’ under a particular paradigm, usually using logics development under fossil fuel entrenchment. For example, the measure of cost-effectiveness for building codes in California uses a complicated metric called TDV (Time Dependent Valuation) that effectively prioritizes natural gas:

“The purpose of the TDV metric…is to try to account for the time value, particularly of electricity use. But because of the way they came up with the numbers and just because of the difference in cost between electricity and gas, the electricity TDV values are much higher than the gas TDV values. Ranging from 3:1 at low use hours to like 100:1 at high use, peak summer hours for electricity. And because of that, if you’re comparing an electric appliance to a baseline of a gas appliance, it does not look good.”

(San Francisco environmental NGO employee, interview, Apr 20 2016)

Appliances like gas furnaces can be powered by electricity rather than fossil fuels in California to transition the energy system and reduce greenhouse gas emissions. However, as the previous quote explains, the metric used to measure cost-effectiveness works against this transition since the metric favours natural gas. Because the development of the metric was based on assumptions about a fossil fuel based energy system, cost-effectiveness is now linked to the perpetuation of fossil fuels. As this demonstrates, the fossil fuel entrenchment of the status quo can be perpetuated through requirements to meet ‘cost effectiveness’.
One way decarbonization actors have addressed the tyranny of cost effectiveness has been by leveraging premium urban land to enable the first (and therefore more expensive) explorations into cutting edge decarbonization in practice. Many of these initiatives are concentrated in downtown neighbourhoods. In Stockholm, developers want to participate in the Royal Seaport development despite having to meet higher environmental standards than the rest of the city (and country) because it is high value urban land. A similar dynamic takes place in London: “Because London is such a premium area to want to develop buildings, developers would sometimes go the extra mile or they would actually see the logic of [energy and carbon requirements]” (London consultant and former GLA employee, interview, Oct 5 2015). The GLA is able to require higher energy standards and participation in lower carbon energy generation schemes because of the high value of the real estate in large, central urban developments. Beyond central commercial areas, the city can be more broadly seen as an exceptional space compared to national or international context. Again, this exceptionality relates to disparities in real estate value: “In Stockholm it’s really expensive to buy something also so I mean the builders will also make money even if they have sharper requirements on those buildings. Maybe not in smaller cities…but in Stockholm we don't have that problem....” (City of Stockholm politician, interview, Nov 27 2015). The experiences in cities may shift the market more broadly. In California, one participant noted that the adoption of ‘reach’ codes with higher energy efficiency standards “helps shift the market more and more in that direction which then enables future code additions at state level to increase” (San Francisco environmental NGO employee, interview, Apr 20 2016). Capacity building in the exceptional spaces within and across urban areas can enable decarbonization in broader jurisdictions.

5.3.2.3. Spatial dimensions of what carbon makes matter

Space is a key factor influencing how urban decarbonization actors pursue building-energy transformations. In particular, spatial solutions for urban decarbonization have normative and performative power. Decarbonization actors are trying to enable the performance of decarbonization by following emerging configurations of low carbon districts or building-oriented decarbonization. However, decarbonization actors sometimes positioned the spatial configuration itself as the solution to decarbonization (e.g. district energy is the solution) while other critical material elements are de-emphasized (e.g. natural gas fuel now, but it will transition to renewables ‘later’). This approach depoliticizes the materiality of decarbonization
configurations to represent tangible, physical elements as interchangeable without acknowledging the ways that investment in particular configurations represents the establishment of power relations. As this section has shown, different spatial solutions for decarbonization foreground different socio-material solutions, which has implications for whether or not successful decarbonization transitions are achieved.

In addition, this section highlighted that decarbonization actors felt they were required to justify carbon governance in relation to cost-effectiveness, despite the fact that cost-effectiveness metrics are often deeply intertwined with fossil fuel entrenchment. As a result, cost effectiveness can limit the broad application of low carbon transformation. However, local government decarbonization actors leveraged premium urban space to set higher decarbonization standards since the (perceived and actual) marginal cost of achieving those standards was more than offset by the gains. This exceptional decarbonization space in the city was spatially bounded and often in central commercial neighbourhoods because the flow of high levels of development capital was particularly essential to the strategy. Other literatures have also identified the potential of exceptional urban space as a venue for experimental governance, such as the literature on living labs (Governance of Urban Sustainability Transitions & Urban Europe, 2017; Voytenko et al., 2016). Scholars have also noted the significant issues with viewing urban space as an experiment by reducing it to “a tabula rasa on which new technologies, transitional strategies, and other approaches can be tried and tested, and subsequently rolled out across wider scales” (Caprotti, 2014). Despite the promising role of these niches, they bring up troubling questions about whether there is a growing dynamic of “accumulation by decarbonization” (Bumpus & Liverman, 2008) where privileged central urban spaces for the professional class and multinational commercial sector are disproportionately benefitting from decarbonization. As the previous section showed, some participants in the research (mainly industry representatives) question whether practices appropriate for exceptional urban space can make the leap to universal application. If not, decarbonization may be another force of eco-gentrification with concerning implications for uneven development. This finding connects to critical approaches to urban green re-development that have pointed out the “intensification of environmental and economic inequalities in the geographies of eco-urbanism” (Caprotti, 2014), contested the flattening of complex socio-natures for green building retrofit certification (Knuth, 2015), critiqued the rise of “luxury ecologies” or urban environmental developments benefitting the
professional class and related businesses (Cohen, 2017), and questioned configurations of moral and political responsibilities for urban climate action (Fuller, 2017).

5.3.3. Agency

5.3.3.1. Responsibility for decarbonization and entrenched interests in energy supply

One participant in the research memorably drew my attention to the “elephants and mosquitos” of decarbonization (City of Stockholm planning administration employee, interview, Nov 5 2015). The elephants are large steps towards decarbonization (e.g. shutting down a coal plant) and the mosquitos are the small steps toward decarbonization (e.g. door to door home energy auditing). The participant has found that decarbonization actors often struggle to address the elephants and, as a result, spend too much time focusing on the mosquitos. Powerful entrenched fossil fuel interests are often the reason it is difficult to address the elephants of decarbonization.

In Stockholm, multiple research participants identified the ‘elephant’ as a single combined heat and power plant in Värtan in the northeast of Stockholm that is fired by coal and biofuel. This plant is the single largest source of greenhouse gas emissions in Stockholm (City of Stockholm, 2010). Its continued operation has been a political issue in Stockholm for many years (Rutherford, 2014) and continues to be a source of contention:

"Fortum wants to run it for 10-15 years in the future because it is very cheap for them to use it. But the politicians said…that in 2020 they want that to be closed. But Fortum said “No, we can't do that”. So I will say now that the negotiations [to close it down] are landing in somewhere 2025 to 2028."

(City of Stockholm environment administration employee, interview, Nov 10 2015)

The coal plant was quasi-privatized between 1998 and 2002, but the City of Stockholm retains a 50% influence through half the seats on the board (Rutherford, 2014). In recent years, the company that owns the plant, Fortum Värme, has increased the proportion of fuel from biofuel, but municipal planning documents describe it as technically difficult to fully convert the plant to biofuels (City of Stockholm, 2012). As a result, the coal plant becomes an immovable object that must be navigated around in order to achieve urban decarbonization goals:
"Further reductions will occur when coal use at the Värtaverket power plant is cut in half during the coming 4-5 years. After that, we cannot count on significant reductions within district heating. Therefore, it is important that the City works ambitiously with energy efficiency throughout its property portfolio, and that traffic becomes more and more independent from fossil fuels."
(City of Stockholm, 2012)

Carbon largely becomes the problem of other actors (including individual citizens) to compensate for the continued pollution of the coal fired CHP plant in the pursuit of decarbonization goals. As participants in the research made clear, many feel it is unfair that a company continues to operate infrastructure that produces so much carbon pollution while the rest of the city is asked to decarbonize.

However, this is not to say that entrenched interests in energy supply cannot be overcome. After over 10 years of contestation in San Francisco, a transition is taking place so that the municipally owned utility is now the default electric service provider (although the private utility still owns wires, billing and delivery). Decarbonization actors pursued this transition in order to work towards achieving a 100% renewable electricity by 2030 target. Rather than a simple issue of who will supply electricity, it has been a political and ideological issue that has been on the ballot multiple times and featured contentious negotiations (San Francisco environmental NGO employee, interview, Apr 19 2016). Nonetheless, CleanPowerSF began supplying customers in May 2016.

5.3.3.2. The struggle to retrofit the existing built environment

Decarbonization actors from across the three case studies struggle to retrofit the existing built environment to improve energy efficiency and to introduce low(er) carbon energy supply. While there is substantial progress in setting high standards for new buildings, urban actors struggle to address the challenges posed by the existing built environment. The materiality of the city seemed to resist change. This dynamic was repeated whether it referenced district energy (“When you walk around London and you think how would you put an 8 metre pipe down the road. We had enough trouble just putting in cable TV and that’s a tiny wire” [London development industry representative, interview, Sept 7 2015]); building retrofits and cultural values (“[London is] a very dense city, with a lot of historical buildings which you can’t touch” [London development industry representative, interview, Sept 15 2015]); building ownership
structures (joint ownership in Stockholm where you own 10% of the building as an association member and technically rent your flat from the association where “people that are living in the house are elected to take care of everything during the year. And this is just ordinary people…They don't know so much about energy efficiency” [City of Stockholm environment administration employee, interview, Nov 28 2015]); or commercial buildings (“You try telling the developer ‘Hey, you’re forced to retrofit your building’ – see how far you get” [San Francisco consultant, interview, Apr 29 2016). These examples are just a few of the ways that material politics limit the application of low carbon retrofit solutions in the existing built form.

There are two main agential dynamics at play in the struggle to retrofit the existing urban built environment. First, who should pay? Various approaches to financial loans and incentives have been developed to try to catalyze retrofits. Many efforts have targeted sectors of society described as people ‘able to pay’, such as loans to homeowners or information provision about cost-effective energy retrofits for large commercial buildings. The PACE program in San Francisco is a good example:

> “Everyone recognizes the need to retrofit existing buildings for more efficiency and renewables and it seemed that there was a collective realization that capital to pay for these improvements was something that we need to focus on. PACE stands for property assessed clean energy… private property owners could basically opt in to use the program to fund energy efficiency and renewable energy projects on their properties and pay it back through their property taxes. It was a novel way to address a lot of the traditional barriers to provide capital for these types of projects.”
> (City of San Francisco environment department employee, interview, Apr 12 2016)

In a few cases, efforts have targeted disadvantaged or marginalized actors, such as grants to citizens in environmental justice neighbourhoods to install solar panels in San Francisco or support for retrofits in the UK to counteract ‘fuel poverty’ where a household income is too low to keep a home warm at a reasonable cost. In general across the case studies, retrofits for decarbonization are approached as a material improvement to private property that, while supported by society, largely remains the financial responsibility of building owners.

Second, who must decarbonize? Many building-energy decarbonization initiatives are focused on retrofitting private homes. Some initiatives have started to target large commercial buildings
(e.g. San Francisco’s energy benchmarking and auditing program). Many initiatives target decarbonizing energy supply, but they encounter difficulties overcoming entrenched interests. Participants in the research recognized there were also significant challenges reaching large sectors of society. In particular, participants identified buildings that are rented to tenants and small businesses as especially problematic sectors that are only minimally targeted. As one research participant in London explained, one “sector that we’re not really doing any work with…is the small medium sized enterprises – very difficult group to interact with” (London borough (Croydon) employee, interview, Oct 5 2015). Furthermore, other than energy generation facilities, industry was almost universally absent as a target for decarbonization. By and large, the retrofit of the existing built environment has failed to reach large sectors of society to enable change.

5.3.3.3. Agential dimensions of what carbon makes matter

Space is a key factor influencing how urban decarbonization actors pursue building-energy transformations. An emerging pattern in decarbonization practice is the individualization of decarbonization responsibility. Despite the large carbon impact of fossil fuel energy supply, the strength of entrenched interests makes many decarbonization efforts targeting this sector into drawn out negotiations (see also Blanchet (2015) and Monstadt & Wolff (2015)). When this dynamic takes place, utilities argue for the right to continue operating and collecting profit from high carbon assets while everyone else around them decarbonizes. Powerful entrenched interests make some aspects of building-energy infrastructure immovable (e.g. privately owned coal plant) and some movable (e.g. residential building fabric). Carbon then becomes a problem for homeowners and commercial building owners, usually alongside decarbonization of local government operations. The individualization of low carbon responsibility echoes the individualization of environmental subjectivity more broadly under neoliberalism (Brand, 2007). The unfairness of the dynamic is nonetheless clear; carbon becomes a problem for individuals to solve through their investments and choices immediately, while actors with powerful control over structural levers of fossil fuel entrenchment wait as long as possible to act. Of course, emerging patterns of carbon governance are complex and the emphasis on individual responsibility runs alongside a logic of ‘leading by example’, where local governments decarbonize their own operations and assets.
Decarbonization governance is also coalescing around patterns related to who should be responsible for paying for decarbonization. In particular, many building-energy decarbonization initiatives have framed carbon as a problem that should be solved through investments in private buildings and energy infrastructure. Within this frame, decarbonization actors have struggled with the implementation of retrofits to achieve decarbonization since the materiality of the city and related vested interests resist change. Furthermore, it was widely acknowledged by research participants that large sections of society are not being reached in efforts to decarbonize the existing built environment, including rented residential buildings and small and medium enterprises, which is a troubling challenge for urban actors committed to decarbonization.

5.4. Conclusion

Urban low carbon transitions suggest a substantial re-ordering of urban infrastructure. However, research so far has largely painted a picture of incremental ambitions that have faced struggles in implementation, which means there is a critical need to engage with the material implications of low carbon practices. Here, I have focused on three urban case studies where actors are purportedly aiming for transformation in order to provide a novel deepening of our understanding of urban carbon governance. My focus on the material politics of building and energy infrastructure clarified the shape and scope of implemented urban low carbon action. In applying this approach, I examined patterns in what is being made to matter through the translation of carbon governance into building-energy infrastructure. This analysis of urban decarbonization practices captured the messy, materially embedded, and contested nature of infrastructure transformations, but the emerging patterns I identified across temporal, spatial and agential dimensions of decarbonization practice nonetheless provided insight into whether or not actors are achieving progress in the implementation of urban carbon governance.

Overall, there are important implications for the directions these cities are headed. When decarbonization actors adopt a long-term decarbonization framework (as opposed to short term logic of marginal improvement), it can drive building-energy infrastructure investments that may overcome fossil fuels. New urban space is moving towards decarbonization despite variations in the spatial configurations and specific imaginaries about what that might mean for urban futures (e.g. zero carbon, net zero energy etc.). In particular, decarbonization actors’ efforts to harness the exceptional nature of the urban, particularly related to real estate value for new
developments, show some potential to overcome the tyranny of cost-effectiveness in maintaining the status quo. However, upgrades to existing buildings are limited in scope. The socio-material obduracy of the built environment has required decarbonization actors to develop finely detailed policy customization based on building type, ownership, willingness/ability to pay, and yet participants in the research still identified significant struggle across the urban three case studies. The material politics of building-energy retrofit for decarbonization are proving particularly troublesome and retrofit of the existing built environment is proceeding too slowly to meet long-term decarbonization goals. Finally, there has been some success in decarbonizing energy supply, although the interests entrenched in the socio-material energy system are difficult for decarbonization actors to tackle.

This chapter has also identified a number of concerns based on patterns of decarbonization practice. In particular, this chapter has argued that it is unjust to overemphasize individual responsibility for decarbonization as opposed to overcoming fossil fuel interests and achieving structural change in building and energy systems. Furthermore, large swaths of society (particularly the rental market, small and medium enterprises, and industry) remain hard to reach in efforts to transform the existing built environment. Finally, as some (but not many) participants in the research also identified, uneven low carbon development and retrofit through spatially bounded demonstration sites or eco-districts threatens to drive eco-gentrification. It is necessary to find pathways from exceptional urban space to ordinary applications.

Decarbonization experiences in cities vary and it is important to broadly consider stories of transformation. This chapter has specifically focused on wealthy cities in industrialized nations that bear the bulk of the responsibility for historical greenhouse gas emissions and it is critical that future research also theorizes and empirically examines low carbon development in the urban global South. Future research can also delve more deeply into the patterns identified in this chapter. In particular, research can continue to explore the tension between leveraging the urban as exceptional space and the dynamics of eco-gentrification, the political economies of energy utilities in the context of low-carbon transitions, and ways to overcome the obduracy of the built environment to achieve energy efficiency retrofits.
6.1. Introduction

Urban carbon governance takes many forms and involves many players. Though local governments are playing a pivotal role, other actors such as citizens, business groups and international organizations are also intervening in urban systems to try to reduce urban greenhouse gas emissions (Bulkeley & Betsill, 2013; Castán Broto & Bulkeley, 2013). These urban climate change response activities are growing in scope and prominence. Given the diversity of the responses, evaluating success can be complex. Nonetheless, a limited number of tools to measure success have gained popularity, especially greenhouse gas (GHG) accounting and GHG reduction targets (Bulkeley, Broto, & Edwards, 2012; Erickson & Morgenstern, 2017). However, these calculative approaches to urban carbon governance success often overlook social and political considerations (Fuller, 2017; Rice, 2015), which can make decarbonization appear to be about solving a carbon math problem rather than engaging in a contested political process (van der Ven, Bernstein, & Hoffmann, 2017). Despite their dominance in policy and research, calculative approaches do not provide a complete understanding of progress in urban climate change response.

Evaluations of progress in the implementation of urban carbon governance need to better consider the contested and political aspects of decarbonization. Decarbonization is a struggle played out in political venues since it depends on changing behaviours and norms, creating new policies, and altering rules and institutions (Bernstein & Hoffmann, 2016). The achievement of decarbonization depends on leveraging political tools to trigger trajectories that build towards transformation (Bernstein & Hoffmann, 2016). In particular, actors need to be empowered with new institutions, skills and interactions to develop individual and collective capacity to catalyze transformative change (Wolfram, 2016; Wolfram, Frantzeskaki, & Maschmeyer, 2017).

The purpose of this chapter is to apply a different measure for assessing the effectiveness of urban climate measures – transformative capacity. I demonstrate the use of this concept by empirically evaluating the carbon governance of buildings based on the case studies of
Stockholm, London and San Francisco. Since political dynamics are a key aspect of decarbonization, I focus specifically on the politics of transformative capacity development using a political dynamics of decarbonization framework (Bernstein & Hoffmann, 2016). In so doing, this chapter expands the toolkit available to assess effectiveness in urban carbon governance.

The chapter proceeds in the following sections. In section 2, I review considerations of success in urban carbon governance and argue that decarbonization and transformation offer a new starting place to consider effectiveness in urban carbon governance. In section 3, I outline the framework for this paper, which uses a political dynamics of decarbonization framework to examine the development of urban transformative capacity. I examine the ways in which political mechanisms are enabling carbon governance initiatives to expand and become more durable over time in the three case studies in Section 4. In section 5, I discuss the implications for the development of urban transformative capacity before concluding in Section 6.

6.2. Successful Urban Carbon Governance

6.2.1. Considering progress in urban carbon governance

Urban decarbonization will require multi-scalar low carbon transformations to urban material, political and institutional infrastructure systems (Bulkeley et al., 2011). Decarbonization is the reversal of the entrenchment of fossil-fuel energy systems that has resulted from the co-evolution of technological and institutional systems in industrial economies or “carbon lock-in” (Unruh, 2000). Explicit effort to decarbonize the city is called urban carbon governance (McGuirk, Bulkeley, & Dowling, 2014). Some climate change mitigation efforts in cities are now targeting a transformative scope of change (for example, see CNCA (2015)). However, it is not clear what successful urban decarbonization will look like since urban responses to climate change span a wide breadth of targeted systems, instigating actors, and governance approaches (Bulkeley & Betsill, 2013; Castán Broto & Bulkeley, 2013; Emelianoff, 2014; Peng & Bai, 2018). Research has shown what kinds of climate change policies are being implemented (Castán Broto & Bulkeley, 2013) and that there are an increasing number of urban climate initiatives (Bulkeley & Betsill, 2013), but we do not know which initiatives are successfully addressing climate change since many climate governance practices are experimental and uncertain in their impact (Hoffmann, 2011). Furthermore, the entrenchment of fossil fuels in society creates a policy
inertia that makes it difficult to make systemic change (Unruh, 2002). Therefore, measuring success in urban carbon governance is challenging.

There are many different ways that we could measure success in urban carbon governance, although calculative approaches to GHG emission monitoring dominate. Urban actors have frequently used GHG emission reduction targets (e.g. 20% lower GHGs by 2020 from 1990 levels) and other related indicators (e.g. 100% renewable energy by 2030) (Bulkeley, 2013). Progress toward these goals is measured through data-driven climate change mitigation tools like carbon footprints and greenhouse gas emission inventories. This approach is reinforced when transnational municipal climate governance networks highlight best practices for carbon accounting. For example, 400 city mayors pledged to reduce GHG emissions during COP 21 in Paris and, “as part of these pledges, mayors committed to count and track their emissions using a particular approach, the Global Protocol for Community-scale GHG emissions (GPC)” (Erickson & Morgenstern, 2017). Emissions targets and tracking are a dominant measure of success. In addition, participation in transnational municipal networks for climate governance is increasingly becoming a new form of accountability for local governments (Gordon, 2016). Success is also being measured by adding up the proposed GHG impact of local carbon governance initiatives, which is the approach taken by “orchestration platforms” (van der Ven et al., 2017) run by transnational actors that seek to value the climate governance initiatives of non-state and subnational actors. Studies have also sought to consider success in urban climate governance by comparing outcomes to targets using best practices, indicators, policy representations or greenhouse gas reporting (Kennedy, Demoullin, & Mohareb, 2012; Reckien et al., 2014; Zimmerman & Faris, 2011).

However, there are common limitations to many of these success measurement tools. At times, the lack of political consideration of these tools makes it difficult to consider social and political implications (Fuller, 2017; van der Ven et al., 2017). The contested nature of urban decarbonization is occluded when carbon governance is reduced to GHG emission reduction units deployed through behaviour modification or technological substitution. These approaches to considering success “potentially [reduce] decarbonization to a problem of making the numbers add up” (van der Ven et al., 2017). This approach misrepresents the nature of the challenge of avoiding catastrophic climate change; decarbonization requires the disruption of carbon lock-in through the transformation of societal institutions (Unruh, 2000, 2002). As a result,
“decarbonization interventions must therefore be evaluated not just against the volume of GHG emissions they reduce, but also against how much they contribute to broader transformations in key institutions” (van der Ven et al., 2017). I argue that the evaluation of success in urban carbon governance can be productively expanded by considering transformation and decarbonization.

### 6.2.2. Targeting urban transformation for decarbonization

Decarbonization and transformation offer a new starting place to consider success in urban carbon governance. Decarbonization is the reversal of the entrenchment of fossil-fuel energy systems. These systems have been produced by the co-evolution of technological and institutional systems in industrial economies or “carbon lock-in” (Unruh, 2000). Using the frame of carbon lock-in, the problem of climate response becomes a fractal problem, where carbon is locked-in similarly at every scale of a system (Bernstein & Hoffmann, 2016). There are two implications to this frame. First, climate response must consider long-term dynamics and must consider whether actions are actually overcoming carbon lock-in. Short-term actions can incrementally improve the greenhouse gas emission performance of a system (e.g. replacing coal with natural gas), but a decarbonization frame recognizes that this is only an incremental improvement that fails to reverse the entrenchment of fossil fuel interests. Second, evaluations of success must consider systemic change. If carbon is locked in to social, technical, political and economic systems at multiple scales, decarbonization must catalyze systemic and multi-scalar changes. Our understanding of success in urban carbon governance must therefore take a transformative approach.

Urban transformation “refers to the process and the outcome of changing the systemic configuration of urban areas, and is mostly studied with a view to its sustainability performance or achievements” (Wolfram et al., 2017). The systemic nature of the change is important here, rather than incremental improvement that, despite making activities more efficient, fails to fundamentally alter the path of a system. As an example of an incremental improvement, less GHGs are produced when inefficient oil boilers are replaced with modern natural gas combined heat and power installations, but the fundamental political and technical fossil fuel dependence remains. One commonly applied approach to examine these processes is socio-technical systems (STS) transition research, which uses the term ‘transition’ rather than transformation. STS transition research theorizes how systems change (including low-carbon shifts) using a multi-
level approach in which a nested hierarchy of systems interact to trigger change (Geels & Kemp, 2007). Both STS transitions and transformation examine systemic change, but STS research tends to focus on examining how transitions actually come about while the approach taken in this paper is a forward-looking examination of the potential for transformation. I also use transformation rather than transition because transformation is broader and is used more widely across different literatures and therefore might be considered a boundary object to bring together the related discussions in urban studies, science and technology studies and socio-ecological system studies (Wolfram et al., 2017). I argue that transformation is also a key bridge from these concepts to approaches from political science that share similar analytical goals.

6.2.3. Assessing urban transformative capacity using the political dynamics of decarbonization

This paper responds to Wolfram et al.’s (2017) call to “focus on transformative capacity development as a pre-requisite and key driver of urban transformation”. Transformative capacity is critical for urban transformation and “accounts for the diverse forms of institutions, resources, skills and interactions required to effectively empower actors individually and collectively for effectuating systemic change” (Wolfram et al., 2017). The concept has a particular focus on the agency components of transformation in the consideration of dynamics like empowerment for communities, transformative leadership and inclusive collective action (Wolfram et al., 2017). In reviewing literature across urban studies, science and technology studies and socio-ecological system studies, Wolfram (2016) defines urban transformative capacity as “the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change towards sustainability within and across multiple complex systems that constitute the cities they relate to”. He identifies ten components of urban transformative capacity: 1) inclusive and multiform urban governance 2) transformative leadership (in the public, private and civil society sectors) 3) empowered and autonomous communities of practice (place-based and/or issue-drive) 4) system(s) awareness and memory 5) urban sustainability foresight 6) diverse community-based experimentation with disruptive solutions 7) innovation embedding and coupling 8) reflexivity and social learning 9) working across human agency levels and 10) working across political-administrative levels and geographical scales (Wolfram, 2016).
However, the concept of transformative capacity has not been extensively operationalized. In this chapter, I demonstrate one application of transformative capacity as a way to assess the effectiveness of urban climate measures. Transformative capacity is a broad concept and so I narrow my focus to the politics of the development of urban transformative capacity for decarbonization. More specifically, I use Bernstein and Hoffmann’s (2016) political pathways of decarbonization method as a framework to consider the development of transformative capacity for urban decarbonization.

Bernstein and Hoffmann conceptualize the capacity for systemic change differently than Wolfram’s (2016) urban transformative capacity, but both share a focus on the agential dynamics of catalyzing systemic change and capture similar elements of norm change, learning, scaling dynamics, path dependencies, and collective support. There are two reasons to use Bernstein and Hoffmann’s framework. First, a focus on decarbonization requires an emphasis on the politics of triggering systemic change. Most analyses of decarbonization prioritize technological or economic dynamics, but “disrupting lock-in is fundamentally a political activity because lock-in has significant political foundations: it rests on norms, institutions, capacities, and coalitions that support fossil-fuel dependent systems” (Bernstein & Hoffmann, 2016). Second, the framework allows for forward theorizing and a method of analyzing the potential for transformation (Bernstein & Hoffmann, 2016). This is important given this paper’s focus on nascent carbon governance initiatives. I therefore use a political dynamics of decarbonization framework (Bernstein & Hoffmann, 2016) to consider the politics of the development of urban transformative capacity for decarbonization. Rather than using Wolfram’s ten components, I emphasize the political processes driving transformative capacity development for decarbonization by echoing Bernstein and Hoffmann’s focus on the political mechanisms of normalization, coalition building and capacity building.

Bernstein and Hoffmann’s framework (2016) assumes that decarbonization will be driven by political decisions that enable technological and behavioural change and that decarbonization initiatives will change systems by contributing to the political mechanisms of normalization, capacity building, and coalition building. These three political mechanisms are drawn from literature on the politics of systemic change. Norm change is an influential source for shifts in public interest and what is understood to be ‘good’ governance (Bernstein & Cashore, 2012; Selin & Vandeveer, 2005). Coalition building is the development of economic and political
support for decarbonization by altering incentives or harnessing market forces. Policies that incentivize renewable energy, for example, seek to create new coalitions of support for renewable energy by creating new groups of ‘winners’ (Bernstein & Hoffmann, 2016; Stokes & Warshaw, 2017). Capacity building alters the means to act by providing support through funding, training, technology etc. (Bernstein & Cashore, 2012). Social learning is not usually emphasized in this literature, but literature on transformational change frequently addresses the role of learning. Reflexivity and social learning are key aspects of transformative capacity development based on findings from across transition management, socio-ecological system resilience, and urban institutional capacity strands of research (Wolfram, 2016). As this thesis has noted, decarbonization is being pursued in an experimental fashion that produces knowledge through trial and error. Indeed, research on experimental climate governance positions social learning as a key feature of governance experiments. Governance experiments can be defined as:

“…deliberate field- trials of innovations that operate in a temporary space and scale, are reversible during the trial period, and are designed to challenge and disrupt status quo policies and contribute to [social] learning on how to advance decarbonisation and climate transitions.” (Kivimaa, Hildén, Huitema, Jordan, & Newig, 2017)

As this quote makes clear, this kind of experimentalist governance depends on process of reflexivity, revision and learning (Sabel & Zeitlin, 2011). Therefore, in the analysis, I include social learning as a key aspect of capacity building for decarbonization. The three political mechanisms are considered separately in this framework for analytical purposes, but they frequently interact (Bernstein & Hoffmann, 2016). Since normalization, capacity building and coalition building are thought to be key mechanisms to achieve decarbonization based on the systemic change literature, I focus my analysis on how these mechanisms are contributing to the scaling up and entrenchment of decarbonization initiatives. I consider these political dynamics to be driving the processes of transformative capacity development in these cases and therefore use them as indicators of transformative capacity for urban decarbonization.

Transformative change may be triggered by climate measures that create system wide outcomes by scaling up or becoming more durable over time (Bernstein & Hoffmann, 2016). By looking for the ways that the preceding three mechanisms (norm change, capacity building and entrenchment) enable scaling and entrenchment, I can consider whether carbon governance initiatives are contributing to urban transformative capacity (as opposed to general urban...
Scaling can take many different forms. Decarbonization initiatives can grow in scope (e.g. expand from energy retrofits for commercial buildings to also include residential buildings), but they can also enable a large ecosystem of complementary decarbonization initiatives (e.g. an energy efficiency financial incentive program that spurs capacity building programs and energy audit industry expansion) and inspire policy diffusion in new places (e.g. local green building standards adopted at the national level) (Bernstein & Hoffmann, 2016). In conjunction, policy changes can become entrenched through path-dependent processes. In considering how a policy becomes entrenched over time, it is important to consider any increases in the durability of changes (e.g. incorporated into legislation), the expansion of the populations the changes cover (e.g. new groups join the population originally targeted by the policy), increasing returns garnered by participants in the change, and increased costs for those that do not participate in the change (Levin, Cashore, Bernstein, & Auld, 2012). Initiatives that are scaling up or are becoming entrenched have the potential to contribute to transformative change (Bernstein & Hoffmann, 2016).

One benefit of using a political dynamics of decarbonization framework to consider the development of transformative capacity is that it allows one to consider different aspects of agency. The politics of decarbonization framework is oriented around changes to institutions and rules, but the connection to transformative capacity make the role of individual agents clearer. Scholars of transformative capacity argue that for actors to become agents of transformative change, they need to be empowered through learning, skill building, and new institutions (Wolfram, 2016; Wolfram et al., 2017). This chapter’s transformative capacity for urban decarbonization approach considers how political dynamics trigger change to societal institutions and offers tools to conceptualize how these changes affect individual and collective agency to catalyze transformative change.

In this research, I focused on convergence and contestation within a community of elite actors striving to achieve decarbonization. These actors’ decarbonization efforts are a political struggle against the entrenched interests of carbon lock-in across social, institutional, technical and economic systems (Bernstein & Hoffmann, 2016; Unruh, 2000). As noted in Chapter 2, the limitation of this approach is that it does not capture the voices of people who are contesting elite definitions of carbon governance, particularly those pushing back against technocratic solutions rooted in capitalism. It therefore is important to note that the carbon governance initiatives
referenced in this chapter do not represent a consensus about appropriate and adequate climate change response. Unpacking the dimensions of this type of contestation is necessary work that is beyond the scope of this chapter. Instead, this chapter focuses on the actions of a powerful community of elite actors struggling to transform societal institutions in the face of entrenched fossil fuel interests.

This chapter also makes a unique contribution by drawing across the three urban case studies to consider broader patterns in urban transformative capacity. Rather than comparison between the three cities where it may be tempting to search for a ‘winner’, I organize the analysis around the political mechanisms of normalization, capacity building, and coalition building. Using this approach, I can consider commonalities in the elements of the urban that are influencing transformative capacity development. As the following sections illustrate, the difference between the existing built environment and new urban development emerges as a more important distinction that the differences between the three places.

In summary, this chapter uses a political dynamics of decarbonization framework to consider the politics of urban transformative capacity development. This approach broadens understandings of effectiveness in urban carbon governance. By complementing tools like detailed GHG accounting and reduction targets, the approach expands the toolkit available to consider progress towards decarbonization.

6.3. Political Processes Driving Transformation

In this section, I consider how the development of transformative capacity is being enabled by analyzing how the political dynamics of normalization, coalition building and capacity building are catalyzing the scaling up and entrenchment of carbon governance initiatives in the case studies.

6.3.1. Normalization

Carbon governance is being entrenched into building standards through the support of changing norms about what constitutes ‘good’ urban development. In particular, ‘good’ is starting to align with ‘low carbon’ in some places due to new expectations about urban futures. Decarbonization targets set at multiple scales are creating expectations for the future that urban actors have found they could leverage. As one participant in the research explained, the broader policy context in
the UK supported the more stringent low carbon building requirements enforced by the Greater London Authority (GLA):

“…there was a separate parallel trajectory in [the UK] government called zero carbon buildings and zero carbon homes, so that provided us with an extra stick. We didn’t have [the requirement yet] because that was going to be enforced in the future, but we could point to the direction of travel and say well you’re going to have to get there anyway.”

(London consultant and former GLA employee, interview, Oct 5 2015)

As this quote shows, the broader policy context in the UK influenced expectations about the future. Local government actors in the GLA leveraged these norms about urban development to entrench carbon governance into the GLA’s urban development standards. A similar dynamic is taking place in California. California passed AB 32 (the California Global Warming Solutions Act), which requires the state to reduce its GHG emissions to 1990 levels by 2020. Within this context, the state has aspirational goals for zero net energy for new residential buildings by 2020 and new commercial buildings by 2030 (California Energy Commission, 2007). There is evidence of entrenchment since these goals are significantly influencing state building code standard revisions (San Francisco environmental NGO employee, interview, Apr 20 2016). Despite the fact that ZNE is “a goal without teeth”, “people want to move that direction so this goal helps drive it” (San Francisco environmental NGO employee, interview, Apr 20 2016). The goal represents expectations about future building standards so that, even though nothing happens if the goal is not met, actors can leverage the associated norms about good urban development to entrench decarbonization into the building code. In addition, the normalization of energy efficient building standards at the state level has facilitated the adoption of even higher standards in San Francisco, particularly because energy requirements were already ingrained into the development industry (San Francisco consultant, interview, Apr 19 2016). New urban development norms about the inevitability and desirability of low carbon buildings can catalyze the entrenchment of carbon governance into building standards.

Furthermore, normalization was also a key dynamic facilitating the move from voluntary to mandatory requirements for low carbon buildings and energy. In San Francisco, the local government first established a financial incentive program for solar PV installation in 2008 called GoSolarSF. They did not require solar to be installed through the local green building
code because, as one former municipal employee explained, “we couldn’t get a mandate passed back then. We didn’t even try it because we knew it wouldn’t get passed. But…you do the incentive programs and that gives people the heads up that that’s the direction you’re heading in and then, now they’re looking at the mandate” (San Francisco environmental NGO employee, interview, Apr 5 2016). In 2013, California started to require that new buildings be solar ready, which meant that developers had to leave roof space that is suitable for installing solar available. The development industry had gotten used this requirement by 2016 when the City of San Francisco began to require that some new buildings install solar PV in that saved space (City of San Francisco environment department employee, interview, Apr 14 2016) (while still maintaining the financial incentive program). Similarly in the UK, some building features made familiar to the building industry through voluntary adherence to the green building code BREEAM have been incorporated into the regulated building code (London environmental NGO employee, interview, Sept 21 2015). Norm change can facilitate entrenchment of carbon governance by supporting the progression from voluntary incentives to mandatory requirements.

Cultural and professional norms affecting individuals were key factors enabling decarbonization activities to scale up. Carbon governance for buildings requires that designers, engineers and planners adopt some new practices. Given the reinforcement of norms by professional institutions, it can be difficult to enable broad changes to standards of practice. As a municipal government employee explained, “[Swedish planners] have a planning manual that comprises, maybe 1000 pages…we have to follow standards, we have to follow regulations, we have to follow procedures…As a planning architect, as you get forced into that manual, and bringing in new things is difficult” (City of Stockholm planning administration employee, interview, Nov 5 2015). Clearly, changing norms can be challenging, but the integration of carbon governance into professional norms and institutions is particularly important. For instance, retrofit requires new practices to become accepted in the development sector:

“…Even though a lot of this technology already exists, certain technologies are favoured by designers, certain technologies are favoured by owners or developers… [and] contractors might not be familiar with a certain technology…Because it’s not enough to just say ‘Hey, it’s this great new thing that’s going to save you a lot of energy’. If people don’t know how to install it, don’t know how to maintain it, don’t perceive it to be as easy or easier to use, then they’re not going to
As this quote demonstrates, scaling is facilitated by familiarity with new practices. In the case studies, broader shifts in professional norms were taking place and facilitating the scaling up of carbon governance. In Stockholm, a representative from the development industry described how good development used to mean meeting energy efficiency standards, but “it shifted in the early 2000s. If you didn’t beat the standard by 20% you weren’t really good” (Stockholm development industry representative, interview, Nov 23 2015). In the face of progressively rising energy efficiency standards, normal practice in the development sector can shift. Over time, norms may expand beyond particular professions to become a broader cultural norm connected to a place. In Stockholm, the cultural norm of pursuing transformation for decarbonization supported scaling:

“We have been doing systematic [climate] work for a very long time. And we are doing things that you think, people ask, like you asked, why are the heating companies doing this? And it’s a lot of things. And why is the public transport company putting a lot of biofuels in the buses? Because we want to do something that is good.”

(City of Stockholm environment department employee, interview, Nov 28 2015)

Decarbonization becomes a broader cultural norm and new carbon governance initiatives build on this cultural dynamic. In San Francisco, after decades of climate and energy action, there is “an enlightened business community. Not on every single thing, but in general many of the large developers see the value of green building” (San Francisco environmental NGO employee, interview, Apr 5 2016). Plans to design a new downtown district energy system (which is a rarity in San Francisco) were met with support by developers. This response led one municipal employee to remark, “I think that was a San Francisco thing” that the developers said to themselves, “This is not crazy, and actually, our tenants are probably going to love it” (City of San Francisco planning department employee, interview, Apr 14 2016). Carbon governance activities can be scaled up through shifts in professional norms that, over time, can build into broader cultural norms.

6.3.2. Coalition building

Coalition building within the development sector supported the entrenchment of decarbonization into mandatory standards. In Stockholm, for instance, a downtown neighbourhood called the
Royal Seaport is held to higher environmental standards than the rest of the city. The specific standards were developed through a dialogue between city employees and development sector representatives. One development sector consultant described the collaborative dynamic of the process:

“We were part of that development in the beginning when it came to Royal Seaport where they invited all the developers, their architects, their consultants...to have an open forum discussing the goals, the visions. If this mission is twice as good, how is that going to happen? What does that mean? How can we break it down? What kind of energy goals do we need?...The City of Stockholm was very generous, I think, in their cooperation with all the other actors. They really raised up their hand and invited everyone to participate. And I think that’s one of the main success factors for Stockholm.”

(Stockholm consultancy director, interview, Nov 9 2015)

The development sector was brought to the table as a collaborator to provide feedback on what kinds of targets are achievable and to jointly develop institutional processes. In this way, the development of the eco-district became not just a way to implement low carbon buildings and energy infrastructure, but also a targeted coalition building process with industry. Similarly in the UK, a non-profit organization called the Zero Carbon Hub was established as a place for industry to discuss and inform implementation related to the policy target for all new homes to be zero carbon by 2016. The Hub drew together a broad cross section of the development industry to define ‘zero carbon’ and sort out what implementation would look like. As one employee reflected:

“I think what we successfully did is we created a safe area of debate for the industry. So we had an overall steering group that had representatives from deep green through to commercial house builders and technical planning product manufacturers, building control, everybody in the middle.”

(London environmental NGO employee, interview, Oct 6 2015)

Through Hub workshops, a coalition of support was built for the zero carbon homes target. There was significant outcry when a new UK government withdrew from the zero carbon homes target in 2015, but the coalition was not strong enough to prevent the cancellation. Finally, coalition building with the private sector was also important in San Francisco. Key green building policy initiatives started with formal public-private committees: “The energy performance ordinance came out of a Task Force that was formed of private sector and public stakeholders looking at
Coalition building made carbon governance particularly ‘sticky’ or difficult to withdraw from by offering returns to participants. Industry that joined the coalition shaping the standards for the Stockholm Royal Seaport, for example, gained access to the premium urban land for development. More broadly, an industry association representative in Stockholm explained that “It's good business for our member companies but to build new energy efficient buildings because…you get paid a bit more” (Stockholm development industry representative, interview, Nov 24 2015). Green building becomes a premium offering for developers and a resource for reputation building: “For our own reputation, we’d far sooner have an increased share of the green marketplace than the brown. The green being sustainable buildings and brown being just the average” (London development industry representative, interview, Oct 1 2015). When participation in the coalition brings returns, more actors seek to join the coalition and there is more support for entrenchment of carbon governance in development standards. However, concerns were also noted about building neighbourhoods from scratch:

“…for example, the only people who can afford to live there is white, middle-class people who have a steady income. So, that’s a problem because if you build a completely new district and the average rent or condo prices are really high, how does it look in five years?” (Stockholm development industry representative, interview, Nov 23 2015)

While the use of premium urban land may incentivize corporations to participate, it also increases the cost of decarbonized new buildings, which has equity implications.

Coalition building within local government and agencies also supported the entrenchment of carbon governance, but in different ways than coalition building in the private sector. Municipal governments are major players in urban development; The City of San Francisco, for example, is one of the biggest builders in the Bay Area. However, many municipal departments and agencies do not see environmental action as a key part of their mandate. To address this,
some local government actors sought to entrench carbon governance broadly across government operations using coalition building tactics. In San Francisco, the Environment Department used friendly competition between departments and recognition of progress in order to encourage departments to internalize GHG goals. They found that some departments started to take ownership of low carbon transformation by incorporating energy and GHG targets into internal reporting and job descriptions and by connecting climate and energy action to other priorities (City of San Francisco environment department employees, interview, Apr 11 2016). As a specific example, the airport in San Francisco began going beyond the city’s green building requirements after seeing the impact of the airport’s first LEED Gold building and making the connection to opportunities for reputation enhancement (San Francisco consultant, interview, Apr 19 2016). Relatedly, the Greater London Authority ran a competition to select 10 Low Carbon Zones in local boroughs, which would receive funding that they would leverage into action to achieve greenhouse gas emission reduction. They sought to identify and support “boroughs who genuinely want to do something interesting” (London consultant and former GLA employee, interview, Oct 1 2015) with this competition. Finally, in Stockholm, municipal agencies report on decarbonization targets regularly as a part of regular operations linked to the budget cycle. This institutionalization of decarbonization makes it clearer which agencies were successfully meeting decarbonization targets - essentially identifying the winners of urban carbon governance within local government (City of Stockholm planning administration employee, interview, Nov 5 2015). The tools one can use to motivate support for carbon governance are clearly different across the public and private sector. Nonetheless, coalition building was a key dynamic allowing carbon governance to be entrenched broadly across local government, particularly using the tools of competition, recognition and institutionalization.

6.3.3. Capacity building

In the case studies, urban actors used learning spaces to build capacity in ways that facilitated the scaling up of low carbon initiatives. For example, the Royal Seaport in Stockholm was described expressly as learning space to develop the capacity to deliver the most efficient buildings commercially possible. One municipal employee explained the capacity building role the Royal Seaport plays locally and internationally:

“Many international delegations come…from universities, from cities, from companies and so on, who want to come here and see how we do it
in Royal Seaport. And so it's both a window and for us a little bit of an experiment – to see what is possible to do.”
(City of Stockholm environment administration employee, interview, Nov 10 2015)

The experiences from the eco-district allowed industry to develop technical skills and low carbon supply chains and allowed the local government to experiment with new governance practices. Based on experiences working with developers in eco-districts, the local government added reporting requirements mid-way through the development process as reflexive learning opportunities. These reporting control points are not required for non eco-district development. Because developers were experimenting with new practices, local government employees found that mid-development reporting requirements offered helpful opportunities to jointly assess progress and recalibrate plans. In this way, the learning process expanded the cutting edge of low carbon development. The quote also shows the way that the Royal Seaport has been a learning space for universities and other cities, which shows the ways that these experiences have been scaled up internationally. In London, new developments for the Olympics were required to meet a building standard called Code 4 in the Code for Sustainable Homes. As one representative of the development industry explained, “that was quite challenging for the industry to deliver, but now that it’s delivered, it becomes - well why wouldn’t you do Code 4? Because you’ve got a supply chain with all of the skills and expertise to deliver that” (London development industry representative, interview, Oct 1 2015). Capacity building across the supply chain creates opportunities for development companies to deliver lower carbon homes more broadly as normal practice. Finally, the whole city can function as a learning space that feeds in to state or nation-wide building standards. As one city of Stockholm employee explained, “We think that it’s important that the cities who really have a good market could be in the front improving [building standards]” (City of Stockholm development administration employee, interview, Nov 4 2015).

It is now planned that the Swedish building code in 2021 will require the same energy efficiency standard that is already required for new buildings in Stockholm (City of Stockholm environment administration employee, interview, Nov 10 2015). Similarly, a participant in the research noted that the higher standards adopted by cities like San Francisco helped to broadly shift the market for urban development, which facilitated the adoption of higher state-wide standards (San Francisco environmental NGO employee, interview, Apr 20 2016). Whether capacity relates to low carbon technical skills, governance practices, or supply chains, urban
learning spaces can build capacity that scales up the accomplishment of low carbon new development.

Green building certifications are also supporting capacity building in ways that enable the scaling up and entrenchment of low carbon practices. Green building certifications have created entry level space to facilitate the acceptance of green building practices for new development: “I think the green building certification thing that has been successful, whether you like BREEAM, LEED and whether it actually leads to a more sustainable building or not, it is something that people, developers and investors do understand” (London development industry representative, interview, Oct 1 2015). If they understand certification, some groups begin to demand it for new developments. In Stockholm, commercial buildings that are not built to a certification (e.g. BREEAM or LEED) “would not be possible to rent out” since “tenants are very demanding” and development financiers such as pension funds often require certification (City of Stockholm planning administration employee, interview, Nov 5 2015). Of course, in terms of decarbonization outcomes for buildings, green certification systems “are rather weak sometimes” (City of Stockholm planning administration employee, interview, Nov 5 2015) and “can be treated as a tick box exercise, but at least it ticks the boxes in terms of improving the performance in the design and construction phase of buildings” (London development industry representative, interview, Oct 1 2015). Nonetheless, there can be broader system impacts:

“I think there’s over 2500 or something like that, assessors and so the design team professionals are now very well skilled in understanding how to use BREEAM to benchmark and guide their practice in terms of all of the different areas that it covers, transport, energy etc. So I think there’s been an actual change in terms of design team practice, design practice, and procurement, use of materials, and it’s had an effect on supply chain.”
(London environmental NGO employee, interview, Sept 21 2015)

The adherence to green certification standards can change what is considered accepted practice in building design, procurement and construction. This can lead to scaling up so that green building practices are applied more broadly. In San Francisco, “LEED and energy star [are] being used really extremely widely…And the bulk of it remains voluntary use of those tools. So you have effective market transformation occurring out of those labels” (City of San Francisco environment department employee, interview, Apr 14 2016). Voluntary green certification fills a capacity building role for the private sector in ways that facilitate entrenchment: “BREEAM has
helped the sector trial this new thing out in a safe space, and now they’ve moved on in terms of knowledge and supply chain is there, the product is there, materials etc. So now that could be a requirement and it wouldn’t have undue burden on the sector to achieve it” (London environmental NGO employee, interview, Sept 21 2015). Green certification can therefore support the development of green building capacity in the private sector, which makes it possible to increase related standards enforced through the building code. Nonetheless, this capacity may be limited in critical ways, since scholars have found that some applications of certification programs like LEED fail to reduce energy consumption and GHG emissions compared to non-LEED buildings (Scofield, 2013).

Most of this section has dealt with new development. Existing buildings are also targeted by carbon governance initiatives, but only a limited number of initiatives are successfully scaling up and becoming entrenched. Capacity building is a particularly important dynamic that is facilitating the expansion of some low carbon practices for building retrofits. Many of these capacity building initiatives have focused on technical capacity. In San Francisco, a municipal department has “a full service energy efficiency program focusing on largely government buildings” (San Francisco local public utility employee, Apr 13 2016) that is able to custom tailor energy retrofit proposals to public agencies that lack the financial incentives experienced in the private sector. Through two programs run by the GLA called RE:FIT and RE:NEW, GLA directed technical assistance teams act as specialist and impartial consultants to public and private non-domestic and domestic building owners respectively to facilitate building energy efficiency retrofits. The programs have tried different models for incentivizing retrofits, but have found the most success through acting as consultants to provide energy services expertise to customers (Greater London Authority efficiency program representatives, interview, Sept 25 2015; Oct 2 2015). In addition to offering this technical capacity directly, local government programs are collecting or requiring the collection of key information. San Francisco developed a map of solar resource availability to facilitate investment in solar photovoltaic panels, for example, and the GLA developed a map of renewable heat sources to facilitate the development of district energy. San Francisco also requires large commercial buildings to collect and publish information about their building’s energy use, as well as conduct energy audits highlighting opportunities to save costs through energy efficiency retrofits. This technical information is intended to be a resource that enables decarbonization action to scale up. In addition,
demonstration projects were important vehicles for capacity building related to energy retrofits for existing buildings. Multifamily residential apartment buildings were retrofitted in a Stockholm suburb called Järva, for example, to achieve a 50% energy use reduction (City of Stockholm, 2015). Demonstration projects build the technical retrofit skills in the industry and act as an educational tool to show others that energy efficiency retrofits for these buildings are possible. Nonetheless, retrofitting residential rental buildings can also be controversial, particularly when buildings in low-income areas are upgraded and rents increase as a result: “sometimes there can be fights about raising the rents and people are not very happy about having to move out” (City of Stockholm politician, interview, Nov 27 2015). Overall, some scaling and entrenchment is taking place for technical capacity building. RE:FIT has scaled up from a pilot project for 14 municipal buildings and the model is now being expanded nationwide (Greater London Authority environment department employee, interview, Sept 8 2015). In addition, San Francisco “advanced the state in its thinking” (San Francisco environmental NGO employee, interview, Apr 19 2016) and building energy use benchmarking is now required for state buildings across California.

Financial capacity building frequently complements technical capacity building initiatives. Often, electricity and gas utilities are required to deliver a certain amount of energy efficiency and choose to do so partly by incentivizing residential energy efficiency retrofits (e.g. upgrading insulation). This is the case with energy companies in the UK. Although some wall and attic insulation has taken place in London due to special incentive programs, in general, energy companies have been disinclined to focus on residential buildings in London because so many of the homes have solid walls and insulation retrofits are cheaper for hollow walls. In California, a number of programs have sought to incentivize energy efficiency retrofits, which have often been administered through investor-owned utilities. Efficiency programs have targeted appliances, lighting, HVAC, industrial manufacturers and agriculture using tools like financial incentives, research and development, standards, and education and outreach (CPUC, 2016). Renewable energy generation, particularly solar photovoltaics, is also to be financially supported. For example, incentive programs from the City of San Francisco support solar PV installation. Up to 2013, $15.5 million USD had been provided to reduce the installation costs of PV systems for residents, businesses and community organizations, including additional incentives for identified ‘environmental justice’ neighbourhoods that have experience higher
historical levels of pollution (San Francisco, 2013). Some financial capacity building takes the form of loans. In San Francisco, PACE (Property Assessed Clean Energy) financing programs offers loans to homeowners to do energy efficiency retrofits and renewable energy installation. The idea behind the model was that “it made financing more accessible to a broader range of people and there were hopes that the PACE program would fill a very important gap of how are we going to pay for all of these upgrades” (City of San Francisco environment department employee, interview, Apr 12 2016). Though it originally faced challenges, recently the program has started to expand. A similar UK loan program for home energy retrofits called the Green Deal had poor uptake due to design and implementation problems and was cancelled. The local governments in the case studies are also using various tools available to them to offer financial capacity. The City of Stockholm owns approximately 20% of residential buildings in the city through three public housing companies that rent apartments to a range of incomes. When the energy efficiency requirements housing companies had to meet were increased, they had access to large budgets for energy efficiency retrofits. After a few years when capacity had been built, efficiency upgrades were instead mainstreamed into budgeting (Housing company employee, interview, Nov 16 2015). In this way, energy efficiency retrofitting was entrenched into the operations of Stockholm’s housing companies. Financial capacity building helped local governments entrench and scale up carbon governance in other ways, including the use of local government buying power to spur innovation in low carbon buildings (“using [public spend] almost as trailblazers” [London environmental NGO employee, interview, Oct 6 2015]) and the creation of market demand by mandating higher levels of energy and greenhouse gas performance for municipal buildings (London environmental NGO employee, interview, Oct 6 2015). Technical and financial capacity building can scale up and entrench carbon governance, but experiences so far are fragmented and limited to only some sections of the existing built environment.

6.4. Discussion: Developing Transformative Capacity

The preceding empirical evaluation of buildings and carbon governance demonstrates the conceptual utility of transformative capacity as a method for assessing the effectiveness of urban carbon governance measures. Out of this analysis, it is clear that carbon governance of buildings has been more effective to date in new urban development than in the existing built environment.
Transformative capacity is under development related to new urban buildings. Norm change, new coalitions of support, and capacity building are all allowing carbon governance to scale up and become entrenched in ways that could catalyze systemic change. In particular, new norms about what constitutes ‘good’ urban development are under development providing some momentum for transformative leadership. Furthermore, coalitions of support are being built that target powerful and influential players in urban development. Finally, capacity building is continuing to push forward the cutting edge for decarbonization in new developments. It is particularly interesting to note that reflexivity and learning are key to transformative capacity development. There are notable concerns as well, including the influential role that corporate interests seem to be playing in shaping urban decarbonization and the limited empowerment of citizen groups. This raises issues of unequal access to the decarbonized city, which was also a concern noted by some participants in the research. Who will be able to afford to live in low carbon developments if they are pursued as premium urban space? Who will be blamed for GHG emissions when the rich live in this premium space while the poor remain in inefficient housing?

While not discounting these concerns, the findings show that political dynamics are creating momentum in the expansion and entrenchment of carbon governance for new urban development, which suggests that systemic change may continue to build over time towards decarbonized new urban development.

The development of transformative capacity is more limited in the existing building sector. There has been success when it comes to capacity building and some initiatives that have sought to build technical and financial capacity have scaled up (e.g. GLA’s RE:FIT program replicated at the national scale) and become entrenched (e.g. requirements for municipally owned housing agencies to achieve energy efficiency targets in Stockholm). However, the scope of impact on the existing building sector has been limited, particularly if one considers the scope of the challenge. In order to achieve decarbonization by mid-century, cities in developed countries would need to annually renovate a minimum of 2% to 3% of the total existing buildings to 50% lower energy use than the national average (Architecture 2030, 2014). While there has been success in retrofitting buildings that are directly under local government control, efforts to catalyze retrofits in the commercial or residential sector have encountered barriers. Even when residential energy efficiency programs have been broadly delivered by energy companies, the scope of retrofits has been limited since targets and incentives are incremental rather than
transformative. This is not surprising since energy efficiency is narrowly conceptualized as a technological intervention abstracted from the social world and it is deployed in ways that actually reproduce resource intensive ways of life (Shove, 2017). As a result, the improvements tend to improve the efficiency of the system while failing to fundamentally overcome carbon lock-in. Capacity building is developing only limited pockets of transformative capacity for existing building decarbonization that show limited signs of scaling up or entrenchment.

Two key insights illustrate the usefulness of transformative capacity for urban decarbonization as a new method for evaluating effectiveness in urban carbon governance. First, while specific interventions have been implemented to change the existing built environment, the research findings highlight a lack of political momentum that would suggest that these interventions might trigger change that expands or becomes more durable over time. Stated more broadly, a transformative capacity for urban decarbonization approach highlights the role of political mechanisms in catalyzing the scaling and entrenchment of carbon governance and refocuses attention on momentum along decarbonization trajectories. Instead of focusing on whether every intervention is being implemented, this approach provides a framework to evaluate the potential impact of carbon governance that speaks to its systemic outcomes. Second, using this approach, it becomes apparent that effective carbon governance it is not only a matter of collecting the right economic and technical tools together (i.e. low carbon energy generation technologies, financing for building energy retrofits), but it is also a process of enabling systemic institutional change by harnessing the power of political mechanisms. As the findings show, effective carbon governance targeted an improvement to urban systems (e.g. increased building energy efficiency in the building code) while at the same time harnessing political mechanisms to potentially expand or entrench the improvement (e.g. coalition building among representatives from the development industry).

In light of this analysis, there are two key points that may support the development of transformative capacity for existing buildings in the future. Although norm change and coalition building were important for new buildings, there is limited evidence that these political dynamics are being harnessed when it comes to the existing built environment. Transformative capacity for existing buildings may benefit from increased attention to changing norms and building political and economic support through coalitions. In addition, there is frequently a focus on the instrumental role for an initiative in terms of the solution it offers (i.e. providing information).
Catalyzing building retrofit requires a broad ecosystem of policies and conditions (Jankel, 2015; The Carbon Trust, 2009). Barriers to implementing housing retrofit have been identified as “a lack of information on the true costs and benefits of retrofit, the perception among homeowners and their funders that the business case is weak, fragmented ownership structures, a lack of finance and access to capital, and a lack of a trained workforce” (Jankel, 2015). As a result, there is often a focus on assembling bespoke policies and programs that instrumentally address missing components of capacity. This paper shows that successful carbon governance for existing buildings filled instrumental needs in addition to facilitating broader political dynamics. Therefore, transformative capacity is not just about making sure the tools are available, but it is also a process of triggering political dynamics that build momentum. Future carbon governance of existing buildings should consider the complementary roles of instrumental solutions and political dynamics to develop transformative capacity.

6.5. Conclusions

This chapter applies the concept of transformative capacity as a different measure for assessing the effectiveness of urban climate measures. To complement dominant approaches focused on accounting for GHG emissions, this chapter considered the politics of transformative capacity development using a political dynamics of decarbonization framework. The findings showed that new urban development is often low carbon and is building transformative capacity through norm change, new coalitions of support, and capacity building. However, urban actors’ efforts to change the existing built environment have faced challenges and there has been limited development of transformative capacity that would allow urban actors to change the existing buildings sector.

The approach taken in this chapter expands the options available to examine success in carbon governance in key ways. In particular, GHG emission accounting requires waiting years for implementation to unfold and emission data to be collected in inventories. Instead, an approach focused on the political dynamics of decarbonization and the development of transformative capacity allows for the consideration of the seeds of success present in nascent carbon governance initiatives. In addition, the empowering and forward looking nature of the framework allows one to consider how urban actors might continue to leverage political tools to develop transformative capacity to decarbonize the existing built environment. Since most of the
buildings that exist now in the case study cities are expected to still be there in 2050, it is critical that we better understand how to develop the capacity to transform the existing built environment.

This research focused on a community of elite actors striving to achieve decarbonization. A limitation of this approach is the exclusion of actors from grassroots organizations who are critical of the carbon governance approach taken by municipal governments and other elite actors, which is a critique that has been raised before in climate governance literature (Swyngedouw, 2010). Although all sustainability projects are subject to scoping and agenda-setting actions that act to exclude particular groups and solutions, some have argued that climate governance tends to overuse technical and managerial discourses in ways that neutralize political contestation dynamics that may actually be essential aspects of successful carbon governance (Kenis & Lievens, 2017). Therefore, it is important to note that the carbon governance initiatives referenced in this paper do not represent a consensus about the nature of climate governance. Future research can continue to unpack contestation between groups of decarbonization actors about the necessary scope and nature of climate governance, as well as examine the development of transformative capacity among grassroots decarbonization actors.

This chapter’s theorization of decarbonization from different urban contexts also offers insights into how other urban actors can catalyze low carbon transformations. Carbon governance can be entrenched into standards for new buildings through the development of new urban development norms about the inevitability or desirability of low carbon buildings. Furthermore, shifts in professional norms can be key to facilitate the implementation of carbon governance. Over time, these norms can build into broader cultural norms that support further decarbonization activities. In addition, coalition building with the private sector can support the entrenchment of carbon governance for new development, particularly through deliberative participation and increasing returns. Coalition building is also important within local government, where tools like friendly competition, recognition and institutionalization can broadly entrench carbon governance even in municipal agencies with no clear climate change mandate. Finally, special physical spaces in cities for capacity building can support the scaling up of carbon governance initiatives through the development of technology, governance, and skills for both new and existing buildings. Green certification can fill a similar capacity building role for new development. The development of technical and financial capacity can scale up some carbon governance initiatives
targeting existing buildings, although existing buildings have so far been challenging to decarbonize.
Chapter 7
Conclusion

“Avoiding the most destructive effects of climate change requires reimagining and reinventing our great urban centers…to put them on a path toward a zero-carbon future.”
(Carbon Neutral Cities Alliance, 2015, emphasis added)

Urban transformation for decarbonization is a significant challenge. This is not only because it requires fundamental change to urban political, institutional and material infrastructures, but also because there is no blueprint for this transformation – it requires the creative work of reinvention and re-imagination. There are no decarbonized cities to look to and there is no process to follow. Instead, the reconfiguration of urban infrastructure is being pursued in a nebulous, contested, multi-scalar, and experimental fashion. While the scope of the transformation is daunting, the process of reimagining and reconfiguring cities can also open the door for new possibilities.

This dissertation has examined how urban decarbonization is being imagined and accomplished and has evaluated whether urban carbon governance is engendering transformation. While there have been other examinations of urban climate responses, this dissertation takes a novel approach by focusing on urban areas explicitly targeting decarbonization. Using buildings as a point of entry into carbon governance, I analyzed what the low-carbon future is imagined to be in documents produced on behalf of cities striving for carbon neutrality, critically interrogated how carbon governance is materially rendered through buildings in three urban case studies, and evaluated whether carbon governance efforts are putting cities on transformative decarbonization trajectories. This dissertation expands our understanding of the material, social and political elements being assembled under urban carbon governance since it was not previously clear what a carbon neutral city might look like. Furthermore, given the limitations of the available methods to evaluate progress in urban carbon governance, it is not clear that we would recognize an urban decarbonization trajectory even if it was underway. This dissertation therefore developed new approaches to consider effectiveness in the material and political translation of carbon neutral governance into the urban built environment.
7.1. **Key Findings**

The central question I answered with my research was ‘How are urban actors governing carbon in cities that are striving to become carbon neutral and are those efforts putting cities on decarbonization trajectories?’ My findings focused on the ways in which urban decarbonization is imagined, implemented and evaluated. First, I argued that the developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice and that different imaginaries of energy futures are sending cities down divergent sociotechnical paths. These findings answered my first sub-question: ‘What are the visions for the built environment in carbon neutral urban futures and what are the narratives driving those urban imaginaries?’ I unpacked the socio-technical configurations that are planned to be mobilized to constitute carbon neutral built environments and found three key building and energy configurations: 1) The District Energy City, 2) The Zero Net Energy City, and 3) The Natural Gas Transition City. Furthermore, urban imaginaries of carbon neutrality are incorporating complex configurations of socio-technical objects while, at the same time, distinct socio-technical configurations are being favoured in individual places. In addition, sociotechnical imaginaries of urban carbon neutrality are driven by the stories told about the nature of a future carbon neutral city. By analyzing the storylines in the policy documents of the founding members of the Carbon Neutral Cities Alliance, I argued that the developing sociotechnical imaginary of urban carbon neutrality is structuring shifts in policy and practice, including a focus on technological fixes and innovation as solutions where private capital is a fundamental partner, as well as reflexivity about the experimental nature of achieving carbon neutrality. Rather than ‘just talk’, these policy documents shape expectations about possible and desirable futures and do political work as they pave the way for policy outcomes.

Second, I examined patterns in what is being made to matter politically through the translation of carbon governance into building-energy infrastructure by urban decarbonization actors in Stockholm, London and San Francisco. These findings answered my second sub-question: ‘How is carbon governance rendered through the material landscape of urban buildings in cities striving for carbon neutrality and what types of governance facilitate these changes?’ Using a material politics approach, I found that emerging patterns in urban decarbonization practices carry implications for whether or not cities are on trajectories toward decarbonization. In particular, I found that a short-term policy timeline (e.g. 2020 or 2030) encourages action that
incrementally reduces greenhouse gas emissions without fundamentally overcoming carbon lock-in, but that long-term timelines (e.g. 2050) creates different problems and solutions that have the potential to engender decarbonization trajectories. The findings also showed that different socio-material solutions are foregrounded when actors focus on different spatial solutions for decarbonization, which has implications for whether or not urban areas are tracking towards decarbonization trajectories. Furthermore, actors are harnessing exceptional urban space to overcome the tyranny of cost-effectiveness in maintaining carbon lock-in, although the premium added to this development has concerning implications for justice and uneven urban development. In addition, I found a pattern of individualization of responsibility for decarbonization that allows powerful agents in industry continue to operate high carbon assets, which maintains political and technological carbon lock-in. Finally, the implementation of low carbon retrofit solutions is being limited by the material politics of the existing built form, which will significantly impede urban decarbonization efforts if it continues to be a challenge.

Third, I argued that transformative capacity is useful method for evaluating the effectiveness of urban decarbonization measures. The related findings answered my third sub-question: ‘Are practices of urban carbon governance putting cities striving for carbon neutrality on potentially transformative trajectories?’ I argued that a transformative capacity for urban decarbonization approach offers a framework to evaluate the systemic outcomes of carbon governance by considering whether carbon governance interventions are building political momentum that could catalyze the broad expansion or entrenchment of decarbonization. I demonstrated the use of transformative capacity by empirically evaluating the carbon governance of buildings based on the case studies of Stockholm, London and San Francisco. I found that new urban development is often low carbon and is building transformative capacity through norm change, new coalitions of support, and capacity building. However, urban actors’ efforts to change the existing built environment have faced challenges and there has been limited development of transformative capacity that would allow urban actors to change the existing buildings sector.

7.2. Theoretical Implications and Contributions

My research makes several contributions to carbon governance research with theoretical implications. First, my research found that one cannot assume meaning for the term carbon neutral as a normatively positive end goal. A single carbon neutral future assumes a
technological determinism and linear vision of transition that is not borne out in this research. Furthermore, the differences that the common term conceals are not straightforward, but instead represent a flexibility that has both positive and negative implications. On one hand, the ambiguous use of ‘carbon neutral’ obscures our understanding of what kinds of ideas about sociotechnical objects and relations are becoming powerful and makes it difficult to see that very different configurations are being institutionalized – including configurations that perpetuate fossil fuel dependence. On the other hand, the idea of carbon neutrality is acting as a boundary object for urban actors interested in pursuing deep decarbonization. Under this policy umbrella, sharing and learning is taking place among the members of the Carbon Neutral Cities Alliance. Carbon neutral discourses are materializing multi-scalar assemblages through urban governance networks that offer opportunities to push the boundaries of urban carbon governance practice.

Second, this dissertation has developed a deeper understanding of urban carbon neutrality, which is a new scope of action that has not yet been the subject of much study. Chapter 3 broke down the building blocks of planning decarbonization into constituent socio-technical elements. I found that decarbonization planning documents emphasize district energy, energy efficient technology, and solar power while leaving other socio-technical objects and policies out and that, overall, urban deep decarbonization pioneers are planning to use a complicated suite of objects and tools to reach their goals. These building blocks are assembled into particular configurations and different configurations are favoured in different locations. This suggests that the socio-material nature of different cities influences their imagined path towards carbon neutrality. These findings are important because different imaginaries about the socio-technical nature of carbon neutrality will result in different kinds of cities as socio-technical imaginaries are institutionalized and embedded into material systems and norms (Jasanoff & Kim, 2015). This deeper understanding of carbon neutrality also engaged with the storylines present in carbon neutral policies. These stories are powerful because they shape our understanding of what the future will be, which is then incorporated into the on-going construction, demolition and maintenance of urban systems. By combining these findings, this research moved beyond the technological components of carbon neutrality to consider the narratives describing carbon neutral futures. This links to research on the role of stories as an engaging way to imagine energy futures (Smith et al., 2017).
Third, I expanded the literature that has recently examined the material implementation of urban climate and energy transitions. Work in this vein so far has largely focused on tracing the material politics of particular interventions within a city (Bulkeley et al., 2016; Rutherford, 2014; Silver, 2017), but I contributed to the methodological evolution of the material politics approach by applying it to three urban case studies. Chapter 5 demonstrates the usefulness of this application in considering the complex nature of infrastructure transformations.

Fourth, my research advanced efforts to assess progress in carbon governance in ways that encompass the messy and materially embedded transformation of infrastructure. The approach I take in Chapter 5 allowed me to maintain the complexity of urban infrastructure transitions while still considering the broader implications of patterns in decarbonization practice that affect whether or not cities are headed toward decarbonization trajectories. Empirically, this analysis describes the nature and scope of decarbonization governance, where practices that may reinforce carbon lock-in rub together with those that may overcome it, and identifies social justice concerns taking shape in the uneven character of decarbonized urban development. These findings answer crucial questions about the ‘who’ and ‘how’ of decarbonization practices. Theoretically, this approach offers a way to delve into the complex social, political and material details of building-energy infrastructure transformation.

Fifth, my research expands the toolkit available to consider effectiveness in urban carbon governance by proposing transformative capacity as a different method for assessing the effectiveness of urban climate measures. By demonstrating the use of this concept empirically in Chapter 6, I argue that a transformative capacity for urban decarbonization approach highlights the role of political mechanisms in catalyzing the scaling and entrenchment of carbon governance and refocuses attention on momentum along decarbonization trajectories. Instead of focusing on whether every intervention is being implemented, this approach provides a framework to evaluate the potential impact of carbon governance that speaks to its systemic outcomes. This method complements dominant approaches that are focused on GHG emission accounting since it allows for the consideration of the potential impact of nascent carbon governance initiatives.
7.3. Practical Implications

The theoretical findings of this research offer several insights for other urban actors pursuing decarbonization, but there are also practical implications. Overall, both the theoretical and practical implications address my final research sub-question: ‘What can other cities learn about urban carbon governance and decarbonization?’

This research has demonstrated the ways in which a decarbonization frame can change the nature of the problem. Re-orienting policy action towards decarbonization makes a difference to decisions made today about infrastructure investments. If the benefits of policy action are only calculated out to 2020 or 2030, it will create incentives to invest in infrastructure that creates short-term and incremental greenhouse gas emission reductions (e.g. natural gas CHP plants to replace energy derived from a coal heavy grid). As this research has argued, these investments are durable once they are made since the replacement of natural gas in the future is not a straightforward technological task and, instead, would require toppling entrenched political interests and replacing physical infrastructure all over again. With a long-term lens that focuses attention on an end goal of zero emissions, long-term infrastructural investments can be aligned with a transformative sociotechnical imaginary rather than incremental change.

In addition, the dissertation offers insights into how other urban actors can catalyze low carbon transformations beyond the case study cities. In particular, the findings show how political levers can be pressed to make change. The development of new norms about the inevitability or desirability of low carbon buildings helped urban actors to entrench carbon governance into standards for new buildings. Shifting professional norms was a particularly important target for decarbonization practices that helped to facilitate the implementation of carbon governance. The political lever of coalition building can also be important; practitioners have used tools like competition and recognition to entrench carbon governance into the activities of agencies that have no clear climate change mandate. Urban actors in the case studies also found carbon governance could be entrenched into mandatory standards for new developments through coalition building with the private sector that offered opportunities for deliberative participation and increasing returns. Finally, special decarbonization zones in cities for capacity building can help carbon governance initiatives to scale up through the development of technology, governance, and skills for both new and existing buildings.
Urban practitioners should also note the concerns and limitations arising from carbon governance practices so far. In particular, carbon governance practice needs to find a way to pursue equitable decarbonization of buildings. Since carbon governance is finding success in urban carbon governance for new buildings in premium urban areas, unequal access to the decarbonized city is developing. Future decarbonization practice can seek to find ways to address this imbalance. In addition, urban carbon governance should beware overemphasizing individual responsibility for decarbonization, which lets powerful owners of high carbon assets off the hook for decarbonization.

Finally, retrofits for existing buildings continue to be a challenge. There are well known barriers to the implementation of building energy retrofits and carbon governance policies often seek to instrumentally address these missing components of capacity with bespoke policies and programs. This research found that successful carbon governance for existing buildings filled instrumental needs in addition to facilitating broader political dynamics. Transformative capacity is not just about making sure the tools are at hand (information about building energy use, loans for energy upgrades), but it is also a process of triggering political dynamics that build momentum. Future carbon governance can take this into account by considering the ways in which initiatives foster both an instrumental solutions and catalyze political dynamics that may expand or entrench the initiative. To this end, practitioners may want to consider the ways in which norm change and coalition building can be harnessed in order to improve the effectiveness of building retrofit initiatives. While these political dynamics were important for carbon governance of new buildings, they were underemphasized in policies related to existing buildings.

7.4. Future Research

There will be diverse stories of transformation as urban actors around the world work to implement decarbonization. I have offered insight into early attempts to pursue decarbonization among the Carbon Neutral Cities Alliance founding members and on behalf of Stockholm, London and San Francisco. While I identify lessons other urban actors can learn about the politics and practices of carbon neutrality, care should be taken when applying these insights. It is important to consider the limited geographic scope of this analysis to wealthy cities in the global North when considering the transferability of the findings. Future work can examine paths
to transformation in different places. In particular, more work needs to be done on urban climate and energy transformations from the perspective of urban areas in the global South. In addition, I have argued that buildings offer a useful perspective into processes of urban decarbonization since they are a focal point for the performance of low-carbon cities, but this focus has also limited my analysis. Future research can also expand on this study to examine carbon governance in other sectors, including transportation. The nature of the material and political accomplishment of decarbonization may be different in different sectors since the social, political, economic and technical components of the systems may be assembled differently. Climate change adaptation is frequently pursued at the same time as mitigation in urban policy and future research can examine the intersections these efforts in both the construction of urban imaginaries and the material implementation of governance.

Several findings of this research suggest tasks for future research. My findings show that there are evolving storylines about what it means to be a carbon neutral city. Future work can question the underlying assumptions and driving interests of the storylines since these narratives are not politically neutral and they represent the advancement of particular interests. Further research should consider whose ideas about carbon neutrality are becoming hegemonic over time.

Decarbonization pathways are still nascent and future research can continue to examine the material expression of carbon governance. Within this mandate, I identify three key areas of inquiry that researchers can continue to explore: 1) the tension between leveraging the urban as exceptional space and the dynamics of eco-gentrification 2) the political economies of energy utilities in the context of low-carbon transitions, and 3) ways to overcome the obduracy of the built environment to achieve energy efficiency retrofits.

My research findings on transformative capacity also suggest potential avenues of inquiry. First, future research can expand the application of transformative capacity for urban decarbonization. For instance, the approach can be applied to consider the seeds of effective carbon governance present in carbon governance targeting one urban area or could be used to consider the development of transformative capacity through the activities of a transnational municipal climate network. Second, the research findings highlighted the critical need to better understand how to develop the capacity to transform the existing built environment. Most of the buildings that exist now in cities like London, Stockholm and San Francisco are expected to still be there
in 2050, which means that developing transformative capacity for urban decarbonization of existing building-energy infrastructure is an essential task for urban decarbonization. Future research can consider how norm change and coalition building can be harnessed to facilitate the transformation of existing buildings. Finally, future research can more deeply explore the issues of unequal access to the decarbonized city.

7.5. Concluding Thoughts

Urban decarbonization requires such a large scope of change that it can be overwhelming. Responding to the climate crisis means disruptive change to many of society’s systems in order to avoid catastrophe. Yet, transformation can also be galvanizing. Participants in the research who have been involved in decarbonization initiatives looked forward to carbon neutral futures with practicality, hopefulness, pragmatism, imagination, and skepticism all at once. This perspective reflects the experimental nature of urban carbon governance and the complexity of grappling with transformations to fundamental social, political and material building blocks of society. But beyond that, this perspective also reflects the fact that carbon neutrality is not one end point to be achieved, but, instead, represents an on-going and contested negotiation about the nature of urban life in a climate changed future.
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Interview Guide – Public Sector

Can you tell me a little more about your role with [government]?

I’m interested in the work being done to try to decarbonize [city], but I’m particularly interested in work focused on trying to change buildings as a way to reduce greenhouse gas emissions. I’ve noticed its emphasized in the city’s climate mitigation plans. Can you tell me more about that work? What is the government’s strategy when it comes to buildings and the low-carbon transition?

Prompts:

- Why buildings?
- Is this a different focus from before? Why the change?

How does changing buildings work in practice?

Prompts:

- How do you change buildings you don’t own?
- How do you get people to implement the changes - what kinds of mechanisms or tools will you use?
- Is it working so far?

Can you tell me more about what it is about buildings that you’re trying to change to make them low-carbon?

Prompts:

- Energy production and buildings – which technologies?
- Energy efficiency – technology and behaviour

Who do you work with to make these changes and how do you work together?

Prompts:

- Other levels of government? Utilities? Other cities? The private sector? Community groups?

What has been hard to change and what has been easy to change?
Prompts:

- Has there been resistance to the changes?
- What do you have a lot of control over? What do you have little control over?

If the [insert name of energy/climate/sustainability strategy] is achieved and the city keeps moving in that direction, what will the built environment look like in your city in 10 years and 40 years?

Do you think the energy and greenhouse gas reduction targets in the city will be met?

Interview Guide – Private Sector

Can you tell me a little more about your role with [organization]?

I’m interested in the work being done to try to decarbonize [city], but I’m particularly interested in work focused on trying to change buildings as a way to reduce greenhouse gas emissions. I’ve noticed buildings are emphasized in the city’s climate mitigation plans. Can you tell me more about that work here in [city] and how you are involved?

Prompts:

- When it comes to low-carbon transitions, how important is it to change buildings?
- Has this emphasis changed over time?

How does changing buildings work in practice?

Prompts:

- Can you tell me about going through the process of retrofitting a building to make it low-carbon?
- Do you have to convince clients to retrofit or build low-carbon?
- Has there been widespread change in buildings here?

Why did you decide to retrofit your building? Who made the decision? What changes did you make?

Can you tell me more about what it is about buildings that you’re changing to make them low-carbon?

Prompts:

- Energy production and buildings – which technologies?
Energy efficiency – technology and behaviour

What is your interaction like with the city government when it comes to low-carbon buildings?

Who do you work with to make these changes and how do you work together?

Prompts:

• Other levels of government? Utilities? Other companies? Community groups?

What has been hard to change and what has been easy to change?

Prompts:

• Has there been resistance to the changes?

• What do you have a lot of control over? What do you have little control over?

What do you think the built environment will look like in your city in 10 years and 40 years?

Interview Guide – NGOs

Can you tell me a little more about your role with [organization]?

I’m interested in the work being done to try to decarbonize [city], but I’m particularly interested in work focused on trying to change buildings as a way to reduce greenhouse gas emissions. I’ve noticed buildings are emphasized in the city’s climate mitigation plans. Can you tell me more about that work here in [city] and how you are involved?

Prompts:

• When it comes to low-carbon transitions, how important is it to change buildings?

• Has this emphasis changed over time?

How does changing buildings work in practice?

Prompts:

• Do you have to convince people to retrofit or build low-carbon?

• Has there been widespread change in buildings here?

• Can you tell me about going through the process of retrofitting a building to make it low-carbon?

Can you tell me more about what it is about buildings that you’re trying to change to make them low-carbon?
Prompts:

- Energy production and buildings – which technologies?
- Energy efficiency – technology and behaviour

Who do you work with to make these changes and how do you work together?

Prompts:

- Governments? Other organizations? The private sector?

What has been hard to change and what has been easy to change?

Prompts:

- Has there been resistance to the changes?
- What do you have a lot of control over? What do you have little control over?

What do you think the built environment will look like in your city in 10 years and 40 years?
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