ACCELERATING THE TRANSITION TO LOW-CARBON CITIES

STRATEGIES FOR SCALING-UP LOCAL INITIATIVES

Didi van Doren

Cover design courtesy of Paulrommer
Lay out: Legatron Electronic Publishing, Rotterdam, the Netherlands
Printed by: Ipskamp Printing, Enschede, the Netherlands

ISBN/EAN: 978-94-028-0902-2

ACCELERATING THE TRANSITION TO LOW-CARBON CITIES:

STRATEGIES FOR SCALING-UP LOCAL INITIATIVES

Een versnelde transitie naar energiezuinige steden:
strategieën voor het opschalen van lokale initiatieven
(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht
op gezag van de rector magnificus, prof.dr. G.J. van der Zwaan,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen

op woensdag 17 januari 2018 des middags te 12.45 uur

door

Didi van Doren
geboren op 28 juni 1987
te Rotterdam

Promotor:	Prof.dr. P.P.J. Driessen
Copromotoren:	Dr. H.A.C. Runhaar Dr. M. Giezen

Dit proefschrift werd mogelijk gemaakt door financiële steun van Climate-KIC.

ACKNOWLEGDMENTS

Reflecting on the process of writing this dissertation, I realize that the trajectory actually shows quite some resemblance with the low-carbon initiatives studied in this research. Similar to these initiatives, research projects cannot be accomplished by one person, but require the resources from many different persons. Therefore, I would like to take this opportunity to express my gratitude to these people.

First and foremost, I sincerely would like to thank my promotors and co-promotors. I would like to thank Peter Driessen for encouraging me to do a PhD and for always, despite his busy schedule, being available for offering support. During my master thesis I had already worked together with Peter Driessen and learned that he is an excellent supervisor with whom it is a pleasure to cooperate. He always gave me a lot of freedom in organizing my research, but thanks to his structural and organizational talent I was able to stay on the right track and could not wander off.

Also, I would like to thank Hens Runhaar for his continuous enthusiasm and encouragement. I was always amazed by the speed in which he was able to offer detailed and solid feedback. He also proved to be invaluable for his advice not to stay behind a computer in a room all day, but to go out for walks, as according to him, the best ideas and insights could be acquired during such moments.

Having recently finished his PhD research, Mendel Giezen was always very good in putting himself in my shoes. Due to his relaxed and positive attitude, working together was always very pleasant. Even though he moved to the University of Amsterdam during my PhD trajectory, he was always available for offering critical feedback.

I am also very grateful for the support and constructive feedback of Rob Raven and my colleagues at the Environmental Governance Group at Utrecht University. The inspiring working environment and the never-ending supply of tea in room 1118 made Utrecht University a pleasant place to work.

I also would like to thank all the people with whom I cooperated during the execution of my empirical work. Climate-KIC proved to be invaluable for offering me the resources and connections required for this research. In particular I would like to thank Carolina Mateo Cecilia from the Valencian Institute of Buildings and Jørgen Abildgaard, Klaus Bundgaard and Mariann Anderson from the City of Copenhagen, for inviting me to Valencia and Copenhagen, connecting me to interesting initiatives and allowing me to learn so much about these wonderful cities. Also, I would like to thank all the people I interviewed over the last years, in the Netherlands and abroad, and the people that I worked with during PhD summer schools and courses. It was a great pleasure to get to know so many interesting people.

Above all, I would like to thank my family, friends, and my beloved fiancé Martijn for their never-ending support and for always making me smile.

TABLE OF CONTENTS

1 INTRODUCTION

Cities worldwide are at the frontline in the fight against climate change and show farsighted leadership in accelerating the transition to low-carbon societies (Betsill & Bulkeley, 2006; Bulkeley & Castán Broto, 2013; Collier, 1997; C40, 2017; ICLEI, 2016; Mulugetta, Jackson, & van der Horst, 2010; Romero-Lankao, 2012; Schreurs, 2008; Williams, 2013). In their endeavor to promote low-carbon development, pioneering local governments, urban communities and businesses are involved in the implementation of low-carbon initiatives (henceforth: LCIs or initiatives) in which they experiment with low-carbon, socio-technical innovations that have the potential to contribute to societal change fostering low-carbon development (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley 2013; Hoffman, 2011; Sengers, Wieczorek, & Raven, 2016). Examples include the large-scale retrofitting of housing blocks, creation of community energy initiatives, and development of eco-districts. Such LCIs play an important role in nurturing the low-carbon transition as they demonstrate how urban development and climate mitigation can go hand in hand. In particular, LCIs that focus on energy conservation in existing buildings are considered to be a highly cost-effective measure for decarbonizing European cities as the building stock is responsible for 40% of energy consumption and 36% of GHG emissions and because at least two thirds of existing buildings will still be there in 2050 (EU, 2016; Levine et al., 2007; UNEP, 2009, 2011).

While LCIs are proliferating, scholars and practitioners underline that there is a need to scale up LCIs and to move beyond local, isolated, small-scale initiatives towards systemic, societal change fostering low-carbon development (e.g. Castán Broto & Bulkeley, 2013; Deloitte, 2015; Evans, Karvonen, & Raven, 2016; Hoffman, 2011; Kivimaa et al., 2017; McGuirk, 2015; UNDP, 2016; van Winden & van den Buuse, 2017). Yet, while the need for scaling-up LCIs is widely acknowledged, there is a lack of knowledge on the factors and strategies that can support such a process.

The goal of this PhD dissertation is to explore the factors and strategies that can influence the scaling-up of LCIs. The findings of this research contribute to theory and practice on urban climate governance by addressing the governance of the scaling-up of LCIs, implemented in the European Union, focused on energy conservation in the existing urban building stock. This is done in three key stages. The first stage involves the operationalization of the concept of 'scaling-up'. While the need for scaling-up is widely recognized by scholars and practitioners, it is unclear how LCIs can increase their impact in terms of promoting low-carbon development through scaling-up processes. An unequivocal understanding of the concept of 'scaling-up' is required to establish whether scaling-up is taking place and to identify factors and strategies that can influence such a process. The second stage consists of identifying factors influencing the scaling-up of LCIs. Although various studies have identified barriers and drivers to realizing LCIs, lessons learned are highly fragmented and tacit and an overall overview consisting of the variety of factors influencing the uptake and scaling-up of LCIs is lacking. To do this, an explanatory framework is developed that can be used to explain the uptake of LCIs and to identify

drivers and barriers to their scaling-up. Subsequently, in stage three, strategies are identified that can be implemented by local government and private actors involved in the implementation of LCIs, to accelerate the scaling-up of LCIs.

1.1 RESEARCH BACKGROUND AND PROBLEM OUTLINE

1.1.1 Accelerating the transition to low-carbon cities

1.1.1.1 *The need for a low-carbon transition*

Global climate change represents an urgent and potentially irreversible threat to human societies and the planet. Over the last decades, studies have provided evidence for the likely impact of anthropogenic climate change and the need for substantial and sustained reductions of GHGs. As concluded by the IPCC, based on many independent scientific analyses from observations of the climate system:

> *"Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system"* (IPCC, 2014, p. 2)

Rising sea levels, increased precipitation, floods, cyclones and storms and periods of extreme heat and cold have been observed in the last decades and are expected to increase as the global climate changes (IPCC, 2014). While the intensity and nature of these impacts on the economy, environment and human development will vary per region (IPCC, 2007), it is indisputable that continued GHG emissions pose severe, pervasive and irreversible risks for people and ecosystems (IPCC, 2014).

During the 1992 United Nations Framework Convention on Climate Change (UNFCC), the international community established that there is a need to limit global warming to well below 2 degrees above pre-preindustrial levels to prevent the most severe impacts of climate change. In the Paris Agreement, signed at the Paris Climate Conference (COP21) in 2015, the international community reaffirmed the 2-degree limit, and expressed the ambition to limit temperature rise to a maximum of 1.5 degrees. Urgent action is required to achieve these goals (UNEP, 2016). The longer it takes to takes to address climate change, the greater the economic and social challenges will be (IPCC, 2014; Stern, 2007).

The international political community has introduced the notion of 'low-carbon development' to encourage states "*to mitigate emissions to avoid dangerous climate change, while at the same time achieving social and economic development*" (Urban & Nordensvard, 2013, p. 7). Mitigation can be defined as "*an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases*" (IPCC, 2007) and can be accomplished through energy conservation, renewable energy generation, the creation of natural sinks, and fossil carbon management (e.g. carbon capture and storage) (IPCC, 2014; Lemos & Agrawal, 2006). As the circumstances, challenges, needs and possibilities in terms of climate mitigation and development can vary significantly between states, there is no one-size-fits-all

solution for low-carbon development (Urban & Nordensvard, 2013). While low-carbon development (LCD) can materialize itself in different ways, this dissertation regards the concept as a subset of 'sustainable development', which can be defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987, p. 43). Sustainability implies that development is favorable for society ('people'), the environment ('planet') and the economy ('profit') (Cam, 2013; Jordan, 2008; WCED, 1987).

Stabilizing temperature increase to below 2 degrees and realizing low-carbon development constitutes an unprecedented challenge and will require an urgent and fundamental departure from business as usual (IPCC, 2014). After all, "*greenhouse gas production goes to the heart of energy, transport, agriculture, and industrial policy in all developed states and increasingly in developing ones too*" (Birnie, Boyle, & Redgwell, 2009). Fundamental changes in societal systems of production and consumption are therefore needed (Elzen, Geels, & Green, 2004; Hoogma, Kemp, & Schot, 2002). Socio-technical systems in core sectors need to be transformed and decarbonized to ensure that human activities remain within ecological boundaries (IPCC, 2007). Given this, a growing number of practitioners and scholars are calling for the need for a 'sustainability transition' (e.g. Grin, Rotmans, & Schot, 2010; Markard, Raven, & Truffer, 2012) or 'societal transformation towards sustainability' (e.g. Driessen et al., 2012; Feola, 2015). At the core of these concepts lies the assumption that a process of structural institutional change in societal systems is required to accomplish low-carbon development. It involves a change in the dominant 'rules of the game' and a process where established high-carbon technologies and societal practices must be replaced or decarbonized (Meadowcroft, 2009). Hence, the low-carbon transition not only encompasses the introduction of low-carbon technologies and practices, but rather involves a process of wider institutional change where institutions favoring high-carbon growth are reoriented towards low-carbon development (Bulkeley, 2013; van Buuren & Loorbach, 2009; Smith, & Raven, 2012).

1.1.1.2 *The urban site as a critical site for accelerating the low-carbon transition*

Scholars and the international community increasingly recognize the urban scale as a critical site for accelerating the low-carbon transition (e.g. Betsill & Bulkeley, 2007; Bulkeley, 2013; Collier, 1997; Grimm et al., 2008; IEA, 2009; Newman, Beatley, & Boyer, 2009; Troy, 2014; World Bank, 2010). The great potential for addressing climate change on the urban scale is reflected by the increase in inter-governmental networks and agreements such as C40, ICLEI and the Compact of Mayors and is discussed in, amongst others, the United Nations' 2030 Agenda for Sustainable Development[1] and the New Urban Agenda[2].

Within policy documents and literature, three key rationales can be found for the relevance of cities in accelerating low-carbon development. Firstly, cities are centers of energy consumption. Although cities cover less than two per cent of the earth's surface, they are responsible for approximately 78% of the world's energy consumption and 60% of global GHG emissions and these statistics are expected

[1] Goal 11 of the 2030 Agenda for Sustainable Development explicitly addresses the role of the urban scale by its call to *"make cities and human settlements inclusive, resilient and sustainable".*

[2] The New Urban Agenda, adopted in 2016 during the HABITAT III the United Nations Conference on Housing and Sustainable Urban Development, highlights the importance of implementing the Sustainable Development Goals and Paris Agreement on the local, urban scale and subscribes that climate action should be at the core of urban policies.

to aggregate in the light of worldwide urbanization trends (Batty, 2011; Grimm et al., 2008; UN-Habitat, 2011, 2016). To illustrate, 75% of the European population lives in urban areas and this is expected to increase to more than 80% by 2050 (EEA, 2017; UN, 2014). Secondly, while cities are greatly responsible for global GHG emissions, they are at the same time also highly vulnerable to the effects of climate change (Grimm et al., 2008; Hunt & Watkiss, 2011; Stern, 2007). Climate-related risks that cities face relate to sea-level rise, extreme events, energy security, water availability, and associated health threats (Hunt & Watkiss, 2011). To illustrate, heatwaves can make life in cities unbearably hot and lead to the increased use of air conditioning and thus changes in energy demand (Grimm et al., 2008). Increased and more intense precipitation, flooding, and storms can damage critical social and technical infrastructures located in cities, leading to high public and private costs and a reduction in the quality of life in cities (IPCC, 2014; UN Habitat, 2017). Thirdly, as hubs of innovation and economic development, cities can also be sources of innovation and societal transformation (Romero-Lankao, 2012; UN Habitat, 2011). Cities can play an important role in climate innovation due to economies of scale, agglomeration and localization and their density provides efficiency benefits for the development of low-carbon infrastructures. To sum up, while cities are important causes of the global climate change problem, the urban scale is also critical in offering solutions. Accountability, vulnerability and innovative strength of urban regions offer cities the chance to be agents of societal transformation.

1.1.1.3 *Decarbonizing the urban building stock to foster the transition to low-carbon cities*

Energy conservation in the building stock is regarded as a highly cost-effective measure for climate mitigation (Energy Union Strategy, 2015; Levine et al., 2007; UNEP, 2009, 2016). In Europe, the building stock is responsible for approximately 40% of final energy consumption and contributes to approximately 36% if EU's GHG emissions (European Commission, 2015; Pérez-Lombard et al., 2008). Because energy consumption requirements for new buildings are tightened regularly in line with the European Directive on the Energy Performance of Buildings and at least two thirds of existing buildings will still be there in 2050, the greatest challenge lies in decarbonizing existing buildings (European Parliament, 2016; UNEP, 2011; Ravetz, 2008).

Energy conservation in buildings is a key opportunity for decarbonizing the existing building stock. The term energy conservation is used throughout this dissertation to describe a total net reduction in the amount of energy consumed by a building per year. The term energy conservation is used to account for the rebound effect that can occur when only focusing on energy efficiency, which means that savings from energy efficiency are offset by an increase in carbon-intensive conduct and thus actually lead to an increase in energy consumption (for instance by leaving the lights and heating on and using more water because of the reduction in costs) (Jenkins, Nordhaus, & Shellenberger, 2011). Building energy retrofits are particularly regarded as a critical means for promoting energy conservation in existing buildings (BPIE, 2016; Bresaer, 2015). While there is no internationally agreed upon definition of (deep) energy retrofits, it can be described as a building renovation that leads to (significant) lower energy needs for the building through a variety of energy conservation measures, such as insulation, air sealing, energy-efficient equipment, or controlled ventilation. A distinction can be made between energy retrofits and deep energy retrofits. Whereas energy retrofits reduce the

energy demand of buildings through individual energy conservation measures, such as upgrading lighting equipment and double-glazed windows, deep energy retrofits encompass integrative whole-building construction processes and integrative design concepts to achieve highly energy-efficient buildings, such as passive houses (Feist Schneider, Dorer, & Haas, 2005), zero-energy buildings (Erhorn & Erhorn-Kluttig, 2014; New Building Institute, 2017), or energy-positive buildings (de Groote, Lefever, & Reinaud, 2016). Standard measures to achieve such standards include thermal isolation of the housing shell, triple glazing, heat pumps, and mechanical ventilation. On-site renewables, such as PV, are often integrated in these concepts.

Aside from climate mitigation impacts, energy conservation in the building stock can also generate a variety of environmental economic and social co-benefits, for instance through lowering energy costs, improving indoor climate, local employment, and minimizing investments in renewable energy production (Boardman 2010; Immendoerfer, Winkelmann, & Stelzer 2014; Levine et al., 2007; UNEP, 2009). However, while the climate and co-benefits of energy conservation in buildings are numerous, there is a need to accelerate efforts to reach this potential and accomplish international and European climate mitigation goals (EEFIG, 2014; European Parliament, 2016; de Groote et al., 2016; IEA, 2013, Levine et al., 2007; UNEP, 2009, 2011, 2016; Ravetz, 2008).

1.2.2 Urban climate governance for accelerating the transition to low-carbon cities

1.2.2.1 *Urban climate governance*

Governance deals with the question of how and by whom society is governed. It can be described as "*a process of -more or less institutionalized- interaction between public and/or private entities ultimately aimed at the realization of collective goals*" (Lange, Driessen, Sauer, Bornemann, & Burger, 2012, p. 406). In the encompassing sense, governance refers to all modes of political steering involving public and/or private actors, with the object of guiding the actions of others and governing society (Driessen, Dieperink, van Laerhoven, Runhaar, & Vermeulen, 2012; Heritier, 2002; Jordan, 2003). Governance implies that 'central government '(formal institution of the state) is not the only actor involved in the management of societal issues, and that non-state actors are increasingly involved in the process of societal steering (Driessen et al., 2012; Kersbergen & Waarden, 2005; Rhodes, 1996; Stoker, 1998; Lange et al., 2012).

This dissertation subscribes to the view that governance is important for accelerating the low-carbon transition, because it involves a process where practices by public and private actors must be reoriented to reduce their carbon footprint. As noted by Driessen et al. (2012), "*the transformation into low-carbon, sustainable and resilient societies cannot occur without some kind of governing to induce governments, businesses, NGOs and citizens to transform their practices*" (ibid, p. 7). While the concept of governance is broad and can apply to a variety of fields, literature on urban climate governance particularly studies the governance of climate change on the local, urban scale (Bulkeley & Betsill, 2003, 2005; Bulkeley et all., 2009; Evans & Karvonen, 2014).

In recent years, there has been more and more attention paid to the role of urban climate governance in accelerating the low-carbon transition, due to two important developments. The first development relates to the fact that local governments worldwide are showing farsighted leadership in promoting low-carbon development. As discussed in section 1.1.1.2, cities are increasingly recognized as a great source of – but also a solution to -the global climate change problem. In consequence, municipal governments in cities worldwide have started to mobilize around the issue of climate change. Many local governments have set decarbonization goals that are more ambitious than the goals of their national counterparts and demonstrate international political leadership in the fight against climate change. To illustrate, more than 1000 European cities are pushing for more ambitious and stringent European policy on energy efficiency and renewable energy (Energy Cities, 2014; ECR, 2017) and Mayors of the world's 52 greatest cities are urging the G20 to create urgent reforms and investments for climate action (C40, 2017). Various studies have reflected on municipal responses to promoting low-carbon development and highlight the importance of a facilitative local political environment and political leadership to encourage urban responses to addressing climate change (e.g., Azevedo, Delaruee, & Meeus, 2013; Betsill, 2001; Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2005; Bulkeley & Kern, 2006; Schroeder & Bulkeley, 2009; Williams, 2013). However, due to the relative immaturity of the field of urban climate governance, there is a need to deepen the knowledge base about approaches and strategies that can guide municipalities in achieving their targets (Anguelovski & Carmin, 2011; Bulkeley & Kern, 2006; Bulkeley, 2013; Rutherford & Jaglin, 2015). Studies thus far have found that local governments can play an important role in accelerating the low-carbon transition by reducing the carbon footprint of their own operations and buildings, but also by 'enabling' others to do so through the provision of supporting structures and resources (Bulkeley & Kern, 2006; Castán Broto & Bulkeley, 2013).

The growing significance of this 'enabling' role of local government is related to the second development that has led to increased attention to the importance of urban climate governance, namely the growing involvement of private actors in developing local responses to climate change (Castán Broto & Bulkeley, 2013; Evans & Karvonen, 2014; UNEP, 2016). There is an increase in progressive citizens and urban communities that seek to encourage low-carbon practices in the search for, amongst others, self-sufficiency, local regeneration, community resilience, and sustainability (Hargreaves, Hielscher, Seyfang, & Smith, 2013; Hoppe & van Bueren, 2015; Seyfang & Haxeltine 2012; Smith, Hargreaves, Hielscher, Martiskanen, & Seyfang, 2016). At the same time, private companies are also increasingly promoting low-carbon practices, as we can see a rise in social entrepreneurship and business models attempting to generate social value (Murphy & Sachs, 2013; Wilson & Post, 2013). The increase in uptake of non-governmental responses for the provision of societal functions and for addressing global problems, such as climate change, has been termed 'the energized society' (Hajer, 2011) or 'the big society' (Lowndes & Pratchett, 2012). Yet, while private actors can be sources of creativity and innovation and can demonstrate an alternative set of interventions for addressing climate change, they generally lack the capacity or resources to develop strategic interventions and thus tend to focus on particular buildings and localities (Bulkeley, 2013; Bulkeley & Betsill, 2013).

1.2.2.2 *Experimentation with low-carbon initiatives as an instrument of urban climate governance*

In their endeavor to instigate the low-carbon transition, pioneering local governments, urban communities, and businesses are involved in the uptake of low-carbon initiatives (Arentsen & Bellekom, 2014; Boon & Dieperink, 2014; Hoppe & van Bueren, 2015; Seyfang, 2010; Seyfang, Park, & Smith, 2013; Walker, 2008). Low-carbon initiatives can be described as forms of experimentation with low-carbon, socio-technical innovations – on the local, urban scale - that have the potential to contribute to societal change fostering low-carbon development (Castán Broto & Bulkeley 2013; McGuirk, Dowling, Brennan, & Bulkeley, 2015; Sengers et al., 2016). LCIs can involve experimentation with low-carbon technologies, such as retrofitting concepts, but also with new institutional arrangements, such as new working methods or organizational models, that can support low-carbon practices and technologies (van Buuren & Loorbach, 2009; Hoffman, 2011). A distinct feature of LCIs is that they encompass initiatives where low-carbon innovations are implemented collectively, at the level of building blocks, districts or communities, which offers benefits not only in terms of carbon reduction, but also offers benefits, such as reducing installment and transaction costs and generating community capital. Due to their voluntary nature, they can be regarded as bottom-up approaches, as they depart from the statutory, expert-led top-down central government governance on climate mitigation (Selman & Parker, 1997).

Many LCIs focus on decarbonizing the built environment, which is a key strategy for climate mitigation (see section 1.1.1.3), but LCIs can also focus on reducing the carbon footprint of other sectors, such as transport and water and energy infrastructures (Castán Broto & Bulkeley, 2013). Pioneering and captivating LCIs demonstrate that climate mitigation can become attached to different urban development needs and that decarbonization can generate significant local benefits, while at the same time contributing to mitigating the global problem of climate change (Chmutina, Wiersma, Goodier, & Devine-Wright, 2014; Klein Woolthuis, Hooimeijer, & Bossink, 2013; Seyfang & Haxeltine, 2012). For instance, the 'Elih-Med project' in Valencia (chapter 3), encompassing the retrofitting of apartment blocks, demonstrates how energy conservation in social housing can lead to a reduction in fuel poverty and thermal discomfort among residents, while the 'Ryesgade' building block in Copenhagen (chapter 5) shows that energy retrofitting can be reconciled with restoring a city's architectural heritage. Community-led energy initiatives in Utrecht (chapter 3) illuminate that the low-carbon transition can be started on the local scale and that collective retrofitting can foster social capital and community wellbeing.

The implementation of LCIs – as a form of climate experimentation – is increasingly recognized as an important approach through which (urban) climate governance is conducted (Bulkeley, 2013; Castán Broto & Bulkeley, 2013; Evans et al., 2016; Kivimaa et al., 2017; McGuirk et al., 2015). LCIs can contribute to low-carbon development through their direct climate mitigation and urban development impacts, but also because they enable the community of practitioners to learn about the effects of (limited) interventions which can be used for the development of large-scale responses fostering low-carbon development (Kivimaa et al., 2017). In addition to literature on urban climate governance, other bodies of literature also point to the role that experimentation can play in the governance of societal transformation towards sustainability. Literature on socio-technical regimes is particularly relevant in this respect. This body of literature studies how socio-technical systems can transform to become

more sustainable through changes in technology, but also through changes in the institutional context surrounding the previously prevailing technology (Markard et al., 2012). Experimentation with emerging innovations in protected 'niches' is considered to be an important aspect of the governance of sustainability transitions, as such niches can provide a catalyst for structural socio-technical change (Berkhout, Angel, & Wieczorek, 2009; Geels & Raven, 2006; Schot & Geels, 2008; Smith & Raven, 2012).

1.2.2.3 *Strategies for scaling-up low-carbon initiatives*

While LCIs are proliferating, some critical scholars and practitioners state that LCIs are stand-alone initiatives, implemented in a variety of local contexts that are not applied on a larger scale, and question their potential to contribute to the low-carbon transition (e.g. Arentsen & Bellekom, 2014; Deloitte, 2015, van Winden & van den Buuse, 2017). When LCIs remain local, stand-alone projects they may generate a variety of local benefits, but are unable to play a significant role in climate stabilization efforts and the low-carbon transition. Therefore, scholars and practitioners widely recognize the need to scale-up LCIs and to move beyond local, isolated, small-scale initiatives towards systemic, societal change fostering low-carbon development (e.g. Castán Broto & Bulkeley 2013; Deloitte, 2015; Evans et al., 2016; Hoffman, 2011; Kivimaa et al., 2017; McGuirk et al., 2015; UNDP, 2016; van Winden & Buuse, 2017). Yet, while the need to 'scale-up' LCIs is widely recognized, the concept is often used in an ambiguous manner and it is not clear how LCIs can increase their impact through scaling-up processes. Moreover, while the local scale is increasingly acknowledged as an important scale in the low-carbon transition, the issue of strategies that can be applied to accelerate scaling-up processes by actors operating at the local level remains underexplored. Due to the lack of institutionalization of the field of urban climate governance, there is still an absence of strategies that can guide local governments and private actors engaged in LCIs in accelerating scaling-up processes, thereby accelerating the transition to low-carbon cities (Angeluelovsky & Carmin, 2011; Bulkeley, 2013; Castán Broto & Bulkeley, 2012; Burch, 2010; Hoppe & van Bueren, 2015; Rutherford & Jaglin, 2015).

In this dissertation, strategies are defined as consciously intended courses of actions and guidelines- by public and/or private actors – oriented towards the scaling-up of LCIs, thereby accelerating the transition to low-carbon cities (Driessen et al., 2012; Mintzberg, 1987). Strategies have two key characteristics, namely that they are developed in advance and that they are developed consciously and purposefully (Mintzberg, 1987). As this dissertation supports a perspective of urban climate governance, the focus will lie on strategies that can be applied by local governments and private actors, such as urban communities, civil society groups or businesses engaged in LCIs on the local scale, to promote scaling-up processes.

It is proposed that evaluation of individual LCIs can generate valuable lessons that can be used to inform and develop strategies for scaling-up. While LCIs are implemented in a temporary space and scale, they constitute valuable learning environments that enable the community of practitioners to learn from experiences, outputs and results of experimenting with socio-technical innovations that can foster the low-carbon transition (Bulkeley, 2006; Hoffman, 2011; Kivimaa et al., 2017; Sengers et al., 2016). An in-depth understanding and accurate diagnosis of factors – which can act as barrier or driver – influencing the uptake of initiatives can be used to inform strategies that can address and create

drivers, thereby accelerating scaling-up processes. However, although various studies have identified barriers and drivers to realizing LCIs, lessons learned are highly fragmented and tacit and an overall overview consisting of the variety of factors influencing the uptake and scaling-up of LCIs is lacking.

1.3 RESEARCH AIMS AND QUESTIONS

The previous section highlighted that it is important to promote the scaling-up of low-carbon initiatives because:

— Low-carbon initiatives are forms of experimentation with socio-technical innovations that have the potential to contribute to societal change fostering low-carbon development.
— While LCIs are proliferating in cities, the transition to low-carbon cities can only be achieved when they are scaled-up beyond local, isolated initiatives and lead to structural low-carbon societal change.

Furthermore, it was discussed that it is relevant to examine strategies for scaling-up that can be applied by local government and private actors involved in LCIs on the local scale because:

— Cities and urban regions worldwide have expressed their ambition to promote low-carbon development, thereby demonstrating that the local scale is an appropriate scale on which strategies will be implemented.
— While local governments are leading and enabling experimentation with LCIs and there is a growing involvement of private actors in LCIs, the issue of strategies that can guide them in governing scaling-up processes remains underexplored.

Finally, it was indicated that this dissertation will study factors and strategies for scaling-up LCIs focused on energy conservation in the existing, urban building stock because:

— The building stock is responsible for 40% of global energy consumption and offers cost-effective mitigation potentials.

In view of the above, the goal of this dissertation is:

> **To analyze factors that influence the scaling-up of low-carbon initiatives focused on energy conservation in the existing urban building stock and to explore strategies that can promote scaling-up processes.**

In order to achieve this research goal, various sub-questions have been formulated:

The sub-questions:

RQ1| *What does the concept of scaling-up entail and how can the scaling-up of low-carbon initiatives contribute to the transition to low-carbon cities?*

The goal of this question is to offer conceptual clarity on the concepts of 'low-carbon initiatives' and 'scaling-up'. While there appears to be consensus on the importance of scaling-up LCIs to realise systemic, low-carbon societal change, limited conceptual clarity on the meaning of the concept exists and it is unclear how through scaling-up processes LCIs can increase their impact in terms of promoting low-carbon development. A lack of an unequivocal understanding of the concept of scaling-up makes it difficult to assess whether scaling-up is actually occurring or not and to identify factors and strategies that can influence scaling-up processes. This research question is addressed in Chapter 2 but also constitutes a guiding question for the remaining chapters. The answer to this research question shows that there are two ways in which LCIs can scale-up – horizontal and vertical pathways to scaling-up -thereby reaching a higher impact in terms of low-carbon development. While horizontal pathways to scaling-up involve the spatial growth of LCIs as a result of their growth, their replication or the uptake of similar initiatives, vertical pathways to scaling-up occur when the knowledge derived from LCIs forms the basis for wider institutional change, fostering low-carbon development.

RQ2| *What factors influence the uptake and scaling-up of low-carbon initiatives focused on energy conservation in the urban building stock?*

LCIs promoting energy conservation in the existing, urban building stock are considered a highly cost-effective approach to decarbonizing cities and accelerating the low-carbon transition. An in-depth understanding and accurate diagnosis of factors – which can act as barrier or driver – influencing the uptake and scaling-up of such initiatives is required to be able to develop strategies directed at scaling-up. Chapter 2 presents a preliminary explanatory framework of factors expected to influence the uptake and scaling-up of LCIs. The framework presented has a generic nature and can, in theory, be applied to LCIs applying different mitigation strategies in different sectors (e.g. newly-built and renovated buildings, energy conservation and renewable energy). The explanatory framework is applied and further refined in succeeding chapters.

RQ3| *What strategies can be applied to promote the scaling-up of low-carbon initiatives?*

The goal of this research question is to explore strategies that can be applied by local government and private actors involved in LCIs to accelerate scaling-up processes. This is done by revealing strategies that are applied by private actors to address barriers and create drivers to the scaling-up of LCIs (Chapter 3 and 4) and by exploring strategies they deem appropriate for implementation by local government (Chapter 3). In line with the taxonomy of the concept of scaling-up, a distinction is made between strategies advancing horizontal pathways to scaling-up (Chapter 3) and strategies to encourage vertical pathways to scaling-up (Chapter 4).

RQ4| *How can local governments learn from low-carbon initiatives in order to contribute to their scaling-up?*

Local governments are increasingly leading and enabling the implementation of LCIs in order to learn how the transition to low-carbon cities can be advanced. However, while experimentation with LCIs is considered an important tool for urban climate governance, the role of local government in governing learning processes remains underexplored. To be at the forefront of climate governance, local governments need to learn from previous experiences and embed relevant knowledge from LCIs into local decision-making structures so that it can be used for scaling-up processes. Chapter 4 will address this research question by exploring the complex relationship between LCIs and learning processes at the level of the local government.

1.4 RESEARCH STRATEGY

1.4.1 Qualitative case study design

To achieve the research objective, a multiple case-study design was adopted (Yin, 2014). A key advantage of the case study approach is the depth of the analysis of the research object (Gerring, 2004) and its ability to allow the researcher to deal with the subtleties and intricacies of complex social situations (Denscombe, 1998). The comparative case study is especially valuable for this research as it offers insights into possible causal processes that influence the phenomena studied (Seawright & Gerring, 2008). Through the comprehensive study of a small number of cases, the researcher can gain an understanding of the causal processes that influence observed similarities and differences (Pickvance, 2001) and this knowledge can be used to build and refine theories concerning the issue at hand (Burnham et al., 2008).

This PhD dissertation contains two key types of cases that are studied: LCIs and strategies. The comparative design is set up to allow for a comparison of factors influencing the uptake and scaling-up of LCIs focused on energy conservation in the urban building stock, as well as comparison between different strategies to promote scaling-up processes. In the chapters, a comparison is made between the cases or within a case, between the embedded cases. Each chapter contains a paragraph that will specify and explain the selected cases in detail. Inferences made about the cases are descriptive, qualitative and focus on the comparison of the case results and the interpretation of the results in the light of existing studies (Gerring, 2004; Verschuren & Doorewaard, 2005).

1.4.2 Case selection

Because of the different research questions addressed in the different chapters, the case selection varies per chapter. The section below will briefly discuss the research cases per chapter. A more elaborative description of the case selection can be found in the individual chapters. The case selection

is also made for pragmatic reasons; for instance, the EU's Climate-KIC program funding the research and providing access to interesting cases (some of the cases studied in this dissertation are connected and financed by this program).

Chapter 2

Chapter 2 presents an explanatory framework consisting of factors expected to contribute to the impact and scaling-up of LCIs. Two government-led LCIs initiated in Dutch cities, City of the Sun in Heerhugowaard and the GWL-district in Amsterdam, are studied to illustrate the applicability of the explanatory framework. Both cases are considered best practices in terms of low-carbon urban development.

Chapter 3

Chapter 3 applies a comparative embedded case-study design to learn more about barriers to the uptake of LCIs and strategies that can be applied to address these barriers. The analysis contains LCIs promoting energy conservation in two different types of building stock (commercial and residential buildings) that are implemented in different cities. It has been chosen to compare LCIs implemented in different urban contexts as it allows the comparison of similarities and differences in terms of barriers related to the contextual environment in which LCIs are implemented. The cities of Valencia and Utrecht are chosen because they are both faced with the challenge of reducing energy consumption in the building stock, and because both cities have set objectives in terms of accelerating low-carbon urban development (Municipality of Utrecht, 2011, 2015; Municipality of Valencia, 2014). The variation between Western European and Mediterranean contexts allows the exploration of differences in terms of socio-cultural, market, policy, and built and geographical contextual environment. In addition, it has been chosen to compare barriers to the uptake of LCIs implemented in commercial and residential buildings, because these two building stocks are collectively accountable for most energy consumption in the urban building stock (UNEP, 2009).

Chapter 4

To explore strategies that can be applied to accelerate vertical pathways to scaling-up, a selection has been made of front-running actors in the Netherlands that actively promote institutional change in favor of low-carbon, socio-technical innovations that can offer a solution to reducing the carbon footprint of the building stock ('institutional entrepreneurs'). Selection criteria included: that the actors advocate innovations that offer a solution to reducing the carbon footprint of the building stock, that they leverage resources to create and transform institutions, and that they had been involved in various LCIs where the innovations were applied.

Chapter 5

To explore what and how local government can learn from LCIs to promote scaling-up processes, an embedded case study design was adopted. We have chosen the city of Copenhagen as our general case, and have studied seven LCIs, focused on energy conservation in the existing building stock, within the City as sub-units of analysis. The city of Copenhagen constitutes an interesting case as it has set the goal to become the first carbon neutral capital by 2025 (see City of Copenhagen, 2012) and is actively supporting the implementation of LCIs to learn how the transition to a low-carbon Copenhagen can be achieved.

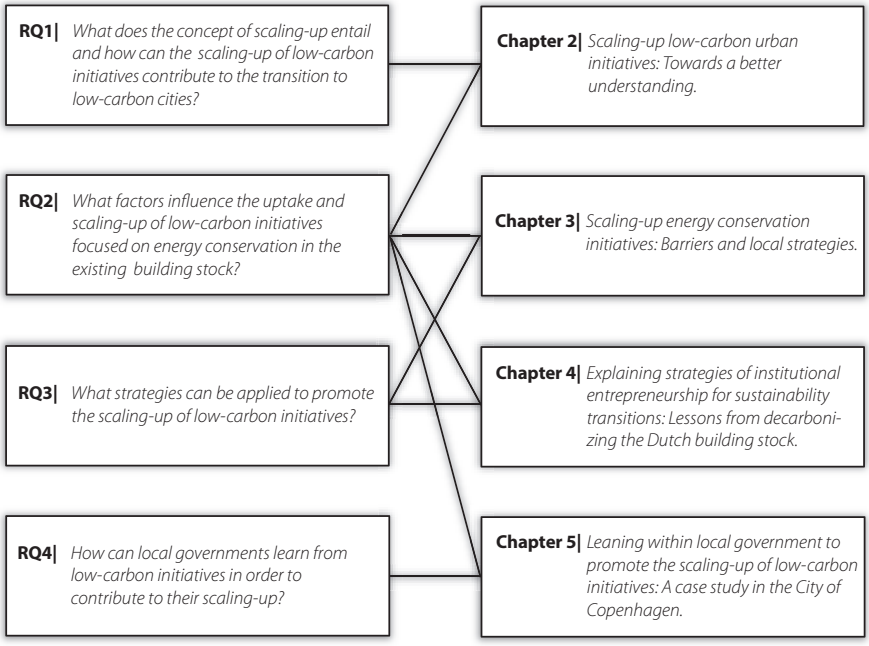

Figure 1.1 Overview of the research questions addressed in the different chapters of the dissertation.

1.4.3 Data collection

The following techniques were used to collect the empirical data required to answer the research questions addressed in this dissertation:

— ***Desk research.*** This encompasses a content analysis of policy documents, planning documents, reports, newspaper articles, websites, and videos about the cases studied at hand. Desk research was conducted to study, amongst other things, key characteristics of the LCIs studied, factors influencing their uptake, and strategies applied by initiators to promote scaling-up pathways. The content analysis served to prepare for the interviews and enhance the internal validity of the interview findings.

— ***Interviews.*** In-depth, semi-structured interviews formed the primary means of data collection for the different empirical chapters. In total, 72 interviews were held during the period March 2014 – March 2017. Most interviews were held with stakeholders in relation to a specific case. These were key stakeholders involved in the respective LCI and who had a comprehensive perspective upon the LCI ('helicopter view'). These interviews were relevant for the examination of factors and strategies influencing scaling-up processes, because these stakeholders have practical experience with realizing and scaling-up an LCI (Chapter 2–5). In addition, interviews were held with local, regional or national operating experts who had been involved in multiple LCIs and who could reflect on factors influencing scaling-up due to their wider experience in the field (Chapter 3). To examine how local governments can learn from LCIs, interviews were also organized with

policymakers (Chapter 5). A topic list or questionnaire was used to structure all the interviews (see Appendices). The interviews lasted between one to two hours and were recorded, transcribed and summarized.

1.5 SOCIETAL RELEVANCE OF THE DISSERTATION

As cities are at the forefront of the low-carbon transition, the study and implementation of factors and strategies influencing the scaling-up of low-carbon initiatives is greatly needed. By exploring strategies that are applied and suggested to accelerate scaling-up processes, this research not only contains an analysis ***of*** *urban climate governance* – but also an analysis ***for*** *urban climate governance* – directed at accelerating the low-carbon transition. From a societal point of view this dissertation is relevant as it offers practical insights into strategies that can be applied to accelerate scaling-up processes, relevant for practitioners and policymakers working on different scales. First, the findings are relevant for local governments and private actors operating at the local scale that are involved in, or have an interest in, scaling-up LCIs. The findings offer practical instructions on what and how strategies can be applied to address barriers and create drivers to the scaling-up of initiatives focused on energy conservation in the existing building stock. The findings of chapter 5 are particularly relevant for local governments as this chapter offers insights into learning practices and organizational frameworks within local government that can support the capitalization of knowledge from LCIs required for accelerating scaling-up processes. Second, the identification of strategies for scaling-up is also relevant for actors working in the field of national and global environmental governance as it can offer analytical benefits of, and insights into, complementary or alternative approaches for fostering low-carbon societal change (Grimm et al., 2008; Rutherford & Jaglin, 2015). To sum up, the local, urban scale can function as an experimental laboratory that can offer inspiration concerning the different interpretations and manifestations of the low-carbon rhetoric, and insights into strategies to foster the low-carbon transition.

1.6 OVERVIEW OF THE DISSERTATION

This PhD dissertation consists of six chapters, four of which were written in the form of articles. Two of these articles have been published, one article will be revised after review, and another one is under review. Although the research questions posed in the articles do not entirely correspond to the research questions, the findings within these four articles conjointly can be used to answer the research questions. Chapter 2 introduces the concept of scaling-up and provides an initial understanding of what the concept entails and how scaling-up processes can be assessed. A conceptual distinction is made between horizontal and vertical scaling-up, and this distinction is applied throughout the following three chapters. Chapter 3 discusses barriers to the scaling-up of LCIs focused on energy conservation in the building stock, and identifies strategies that can be applied on the local scale by initiators of LCIs and local governments to promote horizontal pathways to scaling-up. Chapter

4 explores strategies that can be applied by initiators of LCIs to foster vertical scaling-up pathways, thereby transforming the institutional environment in favor of low-carbon innovations. Chapter 5 reflects on the role of local government in governing learning processes from LCIs to accelerate scaling-up processes. The dissertation concludes with a synthesis on research findings.

2 SCALING-UP LOW-CARBON URBAN INITIATIVES: TOWARDS A BETTER UNDERSTANDING

Abstract | In cities worldwide, low-carbon urban initiatives (LCUIs) are realized by pioneers that prove that climate mitigation strategies can be integrated in urban development trajectories. Practitioners and scholars reflect on the need to scale-up such initiatives in order to accelerate the transition to low-carbon cities. Yet, limited conceptual clarity exists regarding the meaning of the concept of 'scaling-up' and the factors driving this process. This article aims to contribute to practice and theory on low-carbon urban development by presenting a taxonomy on the concept of scaling up. Moreover, an explanatory framework is presented consisting of factors expected to contribute to the impact and scaling-up of LCUIs. Two case studies were conducted to illustrate the explanatory framework. The studies are illustrative but suggest that the explanatory framework allows for a systematic understanding of how the impact of former initiatives can be explained, and how their scaling-up can be promoted.

Published as | Van Doren, D., Driessen, P.P.J., Runhaar H.A.C. & M. Giezen (2016). Scaling-up low carbon urban initiatives: towards a better understanding, *Urban Studies*, DOI: 10.1177/0042098016640456.

2.1 INTRODUCTION

As cities constitute centers of commerce, industry and development, and account for approximately 70% of overall primary energy use, the municipal level is increasingly recognized as an appropriate level for addressing climate change and promoting low-carbon urban development (Betsill & Bulkeley, 2006; Bulkeley et al., 2009; Collier, 1997; Mulugetta et al., 2010; Romero- Lankao, 2012, Schreurs, 2008; Williams, 2013). The term 'low-carbon urban development' (henceforth LCUD) refers to the reconciliation between urban development and the mitigation of anthropogenic climate change (Urban & Nordensvard, 2013).

Climate mitigation in the building sector is considered a key priority for promoting LCUD. 'Buildings' constitute a key energy consuming sector, contributing to approximately 30–40% of final energy consumption (Perez-Lombard et al., 2008; UNEP, 2009). However, despite the potential of mitigating climate change in the built environment, efforts have been piecemeal (Bulkeley et al., 2009; UNEP, 2009). Nevertheless, worldwide innovative low-carbon urban initiatives (from this point forward: LCUIs or initiatives) prove that urban development can meet societal demands without any, or with limited, carbon dioxide emissions (Mulugetta et al., 2010). Examples include the large-scale energy retrofitting of housing blocks and the establishment of eco-districts. Unfortunately, successful initiatives are often not applied at a larger scale or in other cities while at the same time energy and resources are absorbed elsewhere in the process of 'reinventing the wheel'. Moreover, the pressing question is how to go from such incremental interventions to systematic and large-scale change (Bulkeley & Castán Broto, 2013). This research proposes that in order for these initiatives to play a significant role in climate stabilization efforts, they need to be scaled-up beyond 'islands of excellence'. This article has two objectives. First, it provides a taxonomy on the concept 'scaling-up', inspired by different bodies of literature. While there appears consensus on the importance of scaling of initiatives to realize large-scale systemic change (Kemp et al., 1998; Mulugetta et al., 2010), limited conceptual clarity exists on the meaning of the concept in the context of LCUD. Second, an explanatory framework is presented consisting of factors expected to contribute to the impact and scaling-up of LCUIs. The explanatory framework presented can be applied to structurally assess and explain an initiative's influence and to identify lessons for scaling-up. The systemic evaluation and sharing of lessons of former LCUIs is a need often underlined by scholars (Bai, Roberts, & Chen, 2010; Corfee-Morlot et al., 2009). As LCUIs render the low-carbon rhetoric both visible and practical, their evaluation could provide helpful lessons in terms of technological, organizational or contextual factors that can enable local policy makers and local community actors to better understand how scaling-up processes can be encouraged.

2.2 METHOD

As a point of departure, a thorough interdisciplinary literature analysis has been conducted to develop the taxonomy on the concept of scaling-up. Second, using desk research, an explanatory framework was developed consisting of factors that are expected to contribute to the scaling-up of

LCUIs. Empirical papers reporting on factors contributing to, or impeding, the realization, success or impact of LCUIs have been studied to develop the explanatory framework. Two case studies of LCUIs have been conducted to illustrate the applicability of the explanatory framework. Six semi-structured interviews (1–1.5 h) were conducted with the main stakeholders who were involved throughout the entire planning phase and who had a comprehensive perspective upon the project ('helicopter view'). Interviewees were asked questions pertaining to the success of the initiative in terms of LCUD, its scaling-up, and the relative importance of the factors from the framework for the success and scaling-up of the initiatives. In addition, a content analysis of various sources, including evaluation reports and media documents, was used in order to enhance the internal validity of the case study analysis. The cases are illustrative rather than representative as the main goal is to illustrate how the analytical framework can be used to explain the impact of former initiatives and to identify lessons for scaling-up.

2.3 ANALYTICAL FRAMEWORK

2.3.1 Low-carbon urban initiatives

Low-carbon urban initiatives (LCUIs or initiatives) are defined as initiatives in cities that integrate climate mitigation strategies in urban development projects. Important features of LCUIs are that they are initiated at community scale rather than at individual household level, which has benefits not only in terms of carbon reduction, but also in terms of reducing transaction and installment costs and strengthening community networks and ownership. This paper further operationalizes LCUIs as interrelated systems of measures for LCUD and operational arrangements. Measures for LCUD relate to the physical objects (hardware measures such as PV, thermal insulation, heat pump, etc.) and/or instructions or skills (software measures such as instructions for sustainable behavioral change) that can contribute to climate mitigation. The successful implementation of measures for LCUD is dependent on operational arrangements at the organizational level of the initiative and influenced by the wider institutional environment outside the initiative.

2.3.2 Scaling-up low-carbon urban initiatives: A taxonomy

The term 'scale' concerns the spatial, temporal, quantitative or analytical dimension that is used to study processes and is often understood in terms of hierarchy (Gibson et al., 2000; Gillespie, 2004). A level is a unit of analysis located on a position on a scale (Gibson et al., 2000). 'Scaling-up' refers to progression in degrees or levels that are located at different positions on a scale. It involves a mechanism where information from one scale is transferred to another, thereby reaching a higher level of scale and a greater impact (Gibson, Ostrom, & Ahn, 2000; Schneider, 2001). The concept of scale is used in various scientific disciplines that attribute different meanings to it. In the ecological and natural sciences, scale is considered as an objective entity, such as space, time or quantity (Schneider, 2001). Political sciences can examine jurisdictional or administrative scales or levels of public choice (see Gibson et al., 2000). On the other hand, literature on politics of scale in human geography regard

scale as a social construct that is not pre-given, but a way of framing conceptions of political-spatiality, which can embody and materialize in social reality (Smith, 1990; Swyngedouw, 1997). Since our study focuses on the scaling of initiatives, we will mainly make use of literature on the upscaling of grassroot organizations or programs (see Douthwaite et al., 2003; Gillespie, 2004; Uvin, 1995; Uvin, Jain, & Brown, 2000) and sustainable niches or experiments (Geels, 2011; Rotmans & Loorbach, 2006).

2.3.3 Definition and pathways to scaling-up

The term scaling-up can be used with reference to scaling-up *means* (initiatives or programs), or scaling-up *ends* (social-economic and environmental impact) (World Bank, 2003). While the two are often interrelated, this research will primarily refer scaling-up *means* (i.e. successful LCUIs). Individual LCUIs can go to scale (means), thereby reaching a higher impact in terms of LCUD (ends). The definition of scaling-up adopted for this paper is as follows: to increase the impact of LCUIs in terms of promoting LCUD from a small to a larger scale of coverage. Inspired by the work of IIRR (2001) and World Bank (2003) and building on the different sources of literature discussed above, we present a taxonomy of scaling, where we distinguish two pathways to which individual LCUI scan go to scale, thereby reaching a higher impact in terms of LCUD: horizontal and vertical pathways to scaling-up.

Horizontal pathways to scaling-up

Horizontal scaling-up pertains to the spatial growth of an initiative or parts thereof. Related terms include 'diffusion' (Rogers, 1995), 'quantitative scaling-up' (Uvin, 1995; Uvin et al., 2000), 'spatial scaling' (Douthwaite et al., 2003), 'organisational growth' (World Bank, 2003), 'scaling-out' (Douhwaite et al., 2003), 'duplication' (Bai et al., 2010) or 'replication' (Rotmans & Loorbach, 2006). Horizontal scaling-up implies a process where the initiative extends its coverage, reaches more people and a greater impact in terms of LCUD (Uvin et al., 2000). First, horizontal pathways to scaling-up can result from the spatial growth and expansion of the scale of an initiative by increasing its constituency within one area or city. For instance, an initiative can expand from street to neighborhood and from neighborhood to city level. The growth or expansion of an initiative will likely require initiatives to increase their organizational strength (Uvin, 1995). Second, horizontal scaling-up can occur through the replication or transfer of initiatives to other cities or areas, within a country or abroad. In practice, both the internal growth and replication of LCUIs lead an increase in the spatial scale and coverage of LCUIs and thus a greater impact in terms of LCUD.

Vertical pathways to scaling-up

While horizontal pathways to scaling-up are important, scaling-up is not just about copying success, but should also be about structural learning and changing the institutional roots of carbon-intensive development. The second pathway to scaling-up is referred to as 'vertical scaling-up'. Vertical scaling-up refers to the process where the information concerning ideas, values, knowledge or other lessons from individual LCUIs inform institutions at higher administrative and organizational levels with wider-reaching impact. It thus implies a process where individual LCUIs serve as the basis for wider policy and/or institutional change. Related terms include 'political scaling' (Gillespie, 2004; Uvin, 1995), 'institutionalization' (North, 1990), 'mainstreaming' (Bai et al., 2010) and 'translation' (Smith, 2007). We propose that vertical scaling has occurred when an initiative has influenced formal institutions (policy

goals or instruments) and/or informal institutions (values, ideas) of policy networks, thereby creating an enabling environment for change and changing the structural causes of fossil-fuel based urban development. A policy network consists of the interdependent governmental, private and civil society actors that participate in the policy area of LCUD (see Kickert et al., 1997). The institutions that can be influenced can be found at different spatial levels of political jurisdictions: local government, regional, national or international authorities. Individual LCUIs can apply indirect strategies, through the sharing of new practices and ideas, or direct strategies, through advocacy, to promote vertical scaling-up.

Synergizing horizontal and vertical pathways to scaling-up

There is great potential for synergies between horizontal and vertical pathways to scaling-up (see Figure 2.1). The more horizontal scaling-up occurs, the greater are the chances that the initiative will inform institutions (vertical scaling-up). Vertical scaling-up in turn leads to a facilitative institutional context, thereby promoting horizontal scaling-up and the instigation of new initiatives. The processes of horizontal and vertical scaling are both required in pursuance of LCUD. Without vertical scaling-up, initiatives remain little more than 'islands of excellence' in an institutional environment that is not facilitative of LCUD (see Uvin et al., 2000). Likewise, a facilitative institutional context alone is not sufficient: political rhetoric and institutions at the macro level need to be put into practice.

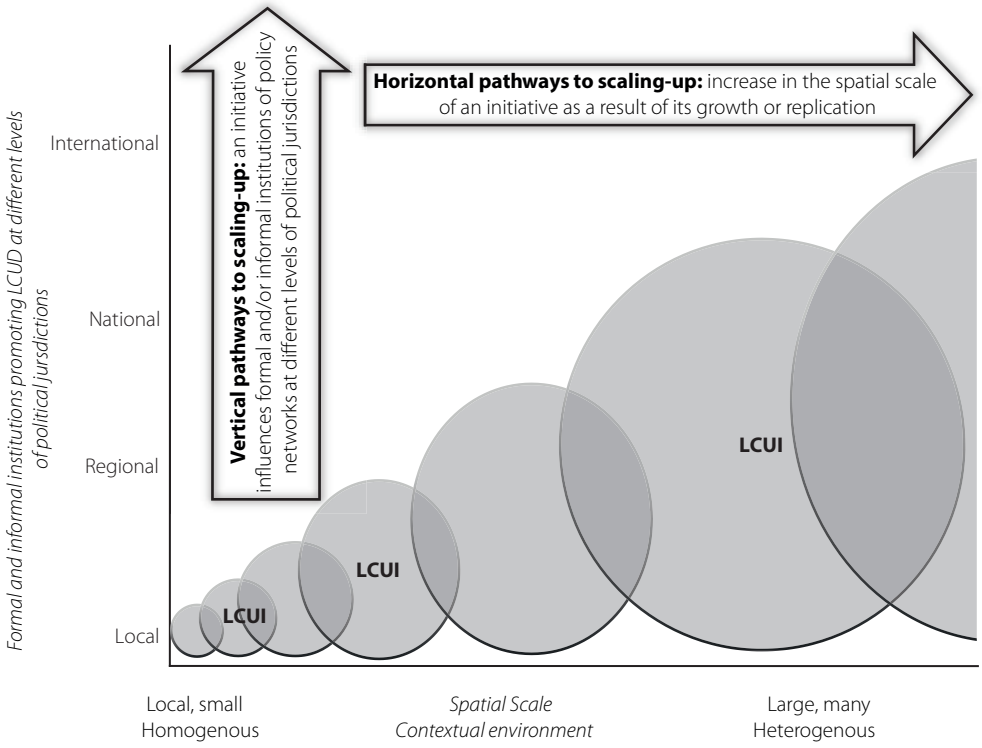

Figure 2.1 Horizontal and vertical pathways to scaling-up low-carbon urban initiatives.

2.3.3 Factors driving scaling-up: An explanatory framework

Mapping out the internal dynamics and external factors that contribute to, or impede, the success and impact of initiatives can be used to inform strategies for scaling-up. Based on the identification of drivers and barriers to the successful realization of LCUIs, theoretical propositions can be developed on factors or conditions that need to be present for the horizontal scaling-up of LCUIs. To identify lessons for vertical scaling-up, one must study the processes that have enabled or hampered the initiative to influence its institutional environment. Of course, it can be debated to what extent specific, contextual knowledge can 'scaled-up' to universal and standardized guidelines (see Cash et al., 2006; Gibson et al., 2000). We propose that observations at the level of individual LCUIs can be useful to develop lessons for the scaling-up of LCUIs, but that one should treat lessons carefully for possible adaptation to new institutional contexts. Table 2.1 provides an overview of factors that we expect to contribute to horizontal and vertical pathways to scaling-up LCUIs. The framework presents a summary of factors found in a sample of empirical, peer-reviewed papers reporting on factors contributing to the realization of LCUIs and the accomplishment of LCUD in general. The framework consists of six sets of explanatory components that correspond to the different dimensions of an initiative and its contextual environment. Internal factors focus on the characteristics of the measures for LCUD applied by the LCUIs and the operational arrangement of the initiative. Context factors concern conditions outside the scope of the LCUI, and can relate to the policy, market, social-cultural, and geographical and built context. The framework provides an overview of the following information: the factor, its operational definition, the empirical studies that discuss its influence, and whether and how we expect that the factor can contribute to horizontal and/or vertical pathways to the scaling-up of LCUIs.

2.4 ILLUSTRATION OF THE ANALYTICAL FRAME-WORK

2.4.1 Introduction to the cases

A qualitative case study methodology has been applied to illustrate the applicability of the explanatory framework. The explanatory framework is used to identify which factors have contributed to or limited the success and impact of initiatives. These insights can be used to inform strategies for scaling-up. Two government-led LCUIs in the Netherlands are studied: City of the Sun (SoC) and the GWL-district (GWL). Both the GWL and CoS case are considered pioneer showcase projects in terms of LCUD (Femenias, 2004; van Hall, 2000; Verhoef et al., 2009). City of the Sun is a project realized by the Municipality of Heerhugowaard, during the period 1992–2008. The LCUI is developed in accordance with the *Trias Energeticas* principle, a three-step approach for realizing an optimal sustainable energy solution through (1) reducing energy demand, (2) promoting renewable energy sources, and (3) maximizing energy efficiency. In practice, the application of this principle led to 2900 newbuild houses that make use of passive solar energy, are highly insulated (ISO++), and have heat pumps and PV panels integrated into their design. The 2900 new-build houses generate 3600 MW of solar power in total. Three wind turbines ensure that the district is CO2 -neutral.

Table 2.1 Factors that can influence horizontal and vertical pathways to scaling up LCUIs

FACTOR	OPERATIONAL DEFINITION	SOURCES	EXPECTED INFLUENCE ON HORIZONTAL PATHWAYS TO SCALING-UP	EXPECTED INFLUENCE ON VERTICAL PATHWAYS TO SCALING-UP
		MEASURES FOR LCUD		
Financial advantage	The profitability of investing in measures for LCUD by project developers and end-users.	Ang & Wilkinson (2008); van Bueren & Priemus (2002); Brown & Vergragt, 2008; Cooke et al. (2007); Dowson et al. (2012); Farreny et al (2012); Hoffman & Henn (2008); Hwang & Tan (2012); StieB & Dunkelberg (2013); Sullivan et al., (2013); van der Waals et al. (2003); Williams & Dair (2007); Zhang et al., (2011).	Can enhance market demand for LCUIs, thereby promoting the growth or replication of LCUIs.	—
Reliability	The reliability of measures for LCUD in terms of technical, environmental and economic performance (at scale).	Dowson et al. (2012); Hwang & Tan (2011); StieB & Dunkelberg (2013); Sullivan et al. (2012).	Can enhance market demand for LCUIs, thereby promoting the growth or replication of LCUIs.	—
Low Complexity	The degree to which measures for LCUD are difficult to install by the project team and use and managed by end-users.	van Bueren & Priemus (2002); Dowson et al. (2012); Hoffman & Henn (2008); StieB & Dunkelberg (2013); Zhang et al. (2011).	Can enhance market demand for LCUIs, thereby promoting the growth or replication of LCUIs.	—
		OPERATIONAL ARRANGEMENTS		
Leadership	A person who guides or directs a group in realizing and scaling-up the initiative.	Chmutina et al. (2014); van Bueren & Priemus (2002); Hoffman & Henn (2008); Klein Woolthuis et al. (2013); Seyfang & Haxeltine (2012); van der Waals et al. (2003); Walker (2008); Williams & Dair (2007).	A leader can motivate and coordinate stakeholders, promote commitment and mobilize resources required for the growth or replication of LCUIs.	A leaders can place the initiative on the political agenda and can challenge old, and initiate new, institutions in favor of the large-scale growth or replication of LCUIs

Table 2.1 Continued

FACTOR	OPERATIONAL DEFINITION	SOURCES	EXPECTED INFLUENCE ON HORIZONTAL PATHWAYS TO SCALING-UP	EXPECTED INFLUENCE ON VERTICAL PATHWAYS TO SCALING-UP
		OPERATIONAL ARRANGEMENTS		
Stakeholder involvement	The participation of representatives of organizations, communities and/or interest groups that have a direct interest in the initiative.	Bai et al., 2010; van Bueren & Priemus (2002). Chmutina et al. (2014); Feige et al. (2011); Hoffman & Henn (2008); Kasioumi (2011); Klein Woolthuis et al. (2013); Lawhon & Murphy (2011); Seyfang & Haxeltine (2012); Walker (2008).	Can contribute to the support and mobilization of resources required for the growth or replication of LCUIs.	Stakeholder engagement enables parties to exchange their experiences and allows them to reflect on institutional adjustments required for the large-scale growth or replication of LCUIs
Resource mobilization	The mobilization of financial, human, information, and technical resources.	Ang & Wilkinson (2008); Brown & Vergragt (2010); Haxeltine (2012); Hoffman & Henn (2008); Middlemiss and Parrish (2010); Romero-Lankao, 2012; Seyfang & Smith (2007); Walker (2008); Williams & Dair (2007), Williams et al. (2012).	Can contribute to the growth or replication of LCUIs.	—
Communication	The exchange of information and ideas within the project team ('internal communication') or to external actors ('external communication').	Cooke et al. (2007); Hwang & Tan (2012); Klein Woolthuis (2013).	Can enhance the coordination of resources of stakeholders and can foster market demand for the growth or replication of LCUIs.	Internal and external communication on experiences and lessons learned can promote institutional adjustments required for the large-scale growth or replication of LCUIs
		POLICY CONTEXT		
Regulatory policy instruments	Policy instruments that use authoritative force to promote LCUD.	Azevedo et al. (2013); Baek & Park (2012); van Bueren & Priemus (2002); Betsill (2001); Chmutina et al. (2014); Painuly (2001); Schreurs (2008); StieB & Dunkelberg (2013); Tuominen et al. (2015); Yao et al. (2005).	Can enhance demand for the growth and replication of LCUIs and reduce uncertainty among investors	—

Table 2.1 Continued

FACTOR	OPERATIONAL DEFINITION	SOURCES	EXPECTED INFLUENCE ON HORIZONTAL PATHWAYS TO SCALING-UP	EXPECTED INFLUENCE ON VERTICAL PATHWAYS TO SCALING-UP
		POLICY CONTEXT		
Financial policy instruments	Policy instruments that influence the profitability of actions by providing financial incentives.	Azevedo et al. (2013); StieB & Dunkelberg (2013); Tuominen et al. (2012); Williams (2013); Yao et al. (2005).	Can positively influence the perceived financial advantage of measures for LCUD and thereby promoting the growth or replication of LCUIs.	—
Informative policy instruments	Policy instruments that make use of information and communication strategies conducive to offering actors insights into the environmental and economic implications of their behavior.	Ang & Wilkinson (2008); Azevedo et al. (2013); Hoffman & Henn (2008); Hwang & Tan (2012); StieB & Dunkelberg (2013); Tuominen et al (2012); Williams (2013).	Can enable consumers to understand the connection between their energy use and the environment, thus potentially improving citizens' knowledge and attitudes to, and demand for, measures for LCUD and LCUIs.	—
Political leadership	Government leadership in promoting LCUD at the national and/or local level.	Ang & Wilkinson (2008); Bomberg & McEwen (2012); Seyfang (2008); Sullivan et al., (2013), Walker (2008).	Can promote trust in the policy framework and can encourage private and civil society actors to initiate, replicate and expand LCUIs.	Can enhance the chance that political leaders are willing to learn from LCUIs and change formal and informal institutions of the policy network in favor of LCUD.
Trust in the policy framework	The level of trust in the stability and reliability of the policy framework by professional actors in the building sector.	Hwang & Tan (2012); Painuly (2001); Sullivan et al., (2013); Tuominen et al (2012).	Can promote the growth and replication of LCUIs as project developers are more likely to invest in LCUIs when there is a stable political climate that supports LCUD.	—
		MARKET CONTEXT		
Low capital and instalment costs	The purchase and instalment costs of measures for LCUD.	Baek & Park (2012); Beck & Martinot (2004); Dowswon et al. (2012); Painuly (2001)	Can influences the financial advantage of measures for LCUD and thus can enhance market demand for LCUIs.	—

Table 2.1 Continued

FACTOR	OPERATIONAL DEFINITION	SOURCES	EXPECTED INFLUENCE ON HORIZONTAL PATHWAYS TO SCALING-UP	EXPECTED INFLUENCE ON VERTICAL PATHWAYS TO SCALING-UP
		MARKET CONTEXT		
	The purchase and instalment costs of measures for LCUD.	Baek & Park (2012); Beck & Martinot (2004); Dowswon et al., (2012); Painuly (2001)	Influences the financial advantage of measures for LCUD and thereby promoting the growth or replication of LCUIs.	—
Expertise and skills of supply actors	The level of expertise and skills regarding measures for LCUD of supply actors	Beck & Matrinot (2000); Painuly (2001); Tuominen et al. (2012).	Can reduce the instalment costs of measures for LCUD, thereby increasing the financial advantage and market demand for LCUIs.	—
Information availability	The level of objective and reliable information available on measures for LCUD.	Baek & Park (2012); Painuly (2001); Tuominen et al. (2012).	Can enhance certainty and reliability regarding measures for LCUD, and thus enhance market demand for LCUIs	
Access to credit	The extent to which project developers and consumers can access credit to invest in LCUIs and measures for LCUD	Beck & Matrinot (2000); Painuly (2001).	Can allow developers and consumers to initiate or engage in LCUIs.	—
Energy price	The financial price paid for energy consumption	Geels (2007); Sullivan et al. (2013); van der Waals et al., (2003)	Can influence the financial advantage of measures for LCUD, thereby influencing the market demand for LCUIs.	—
		SOCIAL-CULTURAL CONTEXT		
Environmental awareness and attitudes	The level of awareness and attitudes of the (future) residents concerning measures for LCUD	Baek & Park (2012); Dowson et al. (2012); Schimschar et al. (2011); Tuominen et al. (2012)	Can strengthen consumer acceptance and demand for LCUIs, thereby enabling the growth and replication of LCUIs	—
		NATURAL AND BUILT CONTEXT		
Technical compatibility	Compatibility of the measures for LCUD with geographical conditions and technological infrastructure	Bueren & Priemus (2002); Farreny et al (2012); Painuly, (2001); van der Waals et al. (2003); Williams & Dair (2007).	Can influence the potential and cost-effectiveness of measures for LCUD, thereby influencing the feasibility to expand or replicate LCUIs.	—

The GWL-district is a sustainable city district in Amsterdam that was developed by the City Council Westerpark between 1995 and 1998 at a brown-field site of the former city waterworks. It comprises a sustainable, green and car-free district in the city of Amsterdam, with 600 sustainable dwellings, offices and shops. Various measures for LCUD were applied, including high insulation (cavity walls, roof, energy efficient windows), use of passive solar energy, sustainable building materials, a CHP plant, green roofs and sustainable water collection systems on roofs. While the initiative applied various measures for LCUD, the innovative aspect of the district was primarily the integrated character of sustainability and sustainability and the car-free design (Femenias, 2004).

2.4.2 Lessons for horizontal pathways to scaling-up

At present, the SoC has already been replicated in the Chinese city Wuhan and in India, near New Delhi (ND, 2012). Moreover, the municipality of Heerhugowaard is also building a new residential suburb ('de Draai'), where they repeat the approach taken by SoC, but apply different measures for LCUD (Verhoef et al., 2009). Many (foreign) local governments have expressed an interest in the SoC and might in the future develop similar initiatives (respondent local authority). The GWL-district has not been expanded or replicated. Respondents argue that the initiators were primarily focused on realizing this initiative in order to improve the neighborhood, rather than actively promoting the replication of the initiative elsewhere.

Measures for low-carbon urban development

The GWL-district was primarily realized out of ideological ideas on sustainability, and did not have much financial advantages compared with conventional projects. Yet, respondents note that for the large-scale expansion of similar initiatives, long-term *financial advantage* is a critical condition. The project team of the SoC case was also not financially driven, but did initiate the project because it expected that future residents' reduced energy costs would enhance the financial attractiveness of the neighborhood. Yet, interviewees note that for the majority of the buyers the high-level energy efficiency of the buildings was not the main attractant and reason for buying the houses. At that time, there was low market demand for PV panels owing to limited awareness and perceived uncertainty concerning their long-term financial advantage. Respondents noted that many consumers over-discount the future and require their returns on investments to be close to immediate. This meant that the prices of the houses with integrated PV panels could not be much higher compared with conventional new-build houses and that the initiators were highly dependent on subsidies and financial support to realize the initiative. Respondents from both cases noted that in order for horizontal pathways to scaling-up to occur, consumers should be more aware of the long-term financial advantage of measures for LCUD and pay accordingly, so that the project's organization is less dependent on subsidies and other forms of public support. The measures for LCUD applied in SoC were reliable, not complex in use and did not require adaptation in user behavior. '*The residents live in a CO2 -neutral district but don't really have to think about it or adapt their behavior*' (respondent city council). On the other hand, in the GWL-district some sustainability measures were chosen that were rather experimental and unproven (e.g. water collection system and water-efficient toilets). Lack of experience and knowledge on the performance of some measures (at such a scale) made it difficult for the environmental advisor involved in the project to determine what the environmental and financial performance would be (*reliability*), leading

to an increase in time and transaction costs (respondent city council). The measures are also perceived as complex as they required some adaptation of user behavior (e.g. car-free design). The initiators ensured compatibility of the measures for LCUD and the values of the residents by actively recruiting future residents who advocated sustainable lifestyles and values and were willing to live accordingly (*environmental awareness and values*). The case reflects that residents with environmental values engage in LCUIs because they enjoy the process and goal, and might be less concerned with factors such as 'reliability' and 'low complexity' of the measures applied. However, respondents confirmed that to expand LCUIs beyond green-minded consumers who are not primarily driven by environmental concerns, but rather by benefits such as cost savings, reputation or comfort levels, measures for LCUD must be low in complexity, reliable and guarantee a long-term financial advantage.

Operational arrangements

Both cases are pioneering projects, of which the success had not yet been proven. Strong leadership was accordingly essential to the realization of both projects. A respondent from the local authority involved in the SoC case notes: *"Few people had believed that the project was realizable. The realization of the project can fundamentally be traced back to determination of a few people, who despite several setbacks continued to have faith in the project and ensured continuous stakeholder commitment throughout the 10-year development period."*

Stakeholder involvement was great (planners, architects, developers, engineers, solar panel companies, provincial authorities) in order to access financial, technical and human resources (*resource mobilization*). Continuity in the municipality's project team, a flat organization and short *communication* lines with other stakeholders promoted long-term commitment and support. The local government had set clear goals and had primarily a steering role throughout the process. *'As a municipality, limit yourself to the ambition and the goal, leave the means to the implementing stakeholders wherever possible'* (respondent local authority). The case reflects the importance of stakeholder involvement in order to mobilize sufficient technical, informational, human and financial resources. Even when the project encountered various financial setbacks when the expected subsidy scheme of the national government was cancelled (see below), alternative forms of financial support were realized thanks to the project team's strong vision, lobbying skills and broad stakeholder network.

Strong leadership and intensive *stakeholder involvement* were also highly important for the successful realization of the GWL-district. The city council was highly motivated to profile itself as a pioneer in sustainable urban development, 'a concept not well articulated at that time' (respondent local government). The continued presence, cooperation and communication between key stakeholders, including housing associations, architects and environmental advisors, is considered an important success factor of the GWL case (see Femenias, 2004). The local government proactively mobilized technical, human and informational resources through hiring technical experts and involving local stakeholders (*resource mobilization*). Financial resources were made available by a large urban renewal fund of the local government and by the housing associations (respondent building company). Given the environmental focus of the district and uncertainty on the performance, it was difficult to get private investors on board. Future green-oriented residents were actively involved throughout the planning process, during which they worked with interdisciplinary teams on the vision, design and management of the district. While this fostered ownership of the initiative among residents, it also

required much time and effective coordination and communication (van Hall, 2000). Moreover, it led to lengthy discussions during the design stage because the specific goals and means of the project were not clearly articulated and the local residents' ambitions were higher than the goals of the project organization. While public participation is a valuable goal in itself, the case indicates that it can also lead to high costs and communication problems when the goals and means of the project are not clearly articulated by the initiator. In all, the case highlights the importance of clear and realistic goals for efficient internal and external *communication*, a sound time plan and an accurate calculation of the financial budget required for all design stages, taking into consideration the unreliability of subsidy schemes (see Femenias, 2004).

Policy context

Both cases demonstrate the value of a supportive political environment and *political leadership*. The case of the GWL-district shows that the presence of green parties in the local coalition can be an important driving force for the instigation of LCUIs. The local district council, run by a coalition of green and labour party members, opened up ground for sustainable urban development and initiated the project. In SoC, the political color of the administration changed over the course of the project, but the political commitment and support by the local government, alderman, province and EU continued through effective leadership and stakeholder management. The two cases also denote the importance of a facilitative and stable policy environment for the large-scale growth and replication of LCUIs. The lack of a stable and reliable subsidy scheme throughout the planning period (*financial policy instruments*) endangered the realization of the SoC. At that time especially, the high upfront costs and the fact that PV had to compete with other forms of energy generation rendered subsidies and financial support essential. Yet, the national subsidy scheme (Energy Premium Scheme) was altered multiple times and even cancelled because of depletion of funds, which endangered the financial support offered by the European Union. As noted above, the changing policy framework required the project team to mobilize alternative financial solutions. The GWL-district did not benefit from extensive subsidies, but some 'green loans' were received by the national government. Yet, the project team of the GWL case also experienced problems resulting from the ending of the subsidy scheme for the building of social housing in 1994 – because of the privatization of the housing associations – which resulted in a rush in the construction phase as 45% of the buildings would be social housing (GWLterrein, 2010). These experiences indicate the uncertainty of public funding schemes and the importance of accurate planning in order to ensure that public funding is attained within the planning period of realizing the LCUIs. In all, a stable policy framework is deemed important as it enhances stakeholders' *trust in the policy framework* and their willingness to engage in similar projects. National *regulatory policy instruments* influenced both cases. For both the GWLdistrict and the SoC the energy performance coefficient (EPC) of the buildings was set significantly lower than the legal limit at the time. Yet, respondents note that they have learned that when planning for long-term projects, you need to take account of projected regulatory standards. While in both cases the targets were more ambitious than the national regulations at the time, environmental regulations continue to be tightened, rendering the EPC level of the districts soon outdated after completion (Femenias, 2004; van Hall, 2000).

Market context

The cases reflect that *high upfront costs* and market fluctuation can lead to financial challenges during a project's realization. In the SoC, the PV panels could not be financed without public support. Whereas

the plan relied on a price drop of PV panels, they did not become cheaper but rather more expensive as a result of the dramatic rise in worldwide demand for PV, caused by numerous subsidy schemes (Verhoef et al., 2009). Through effective cooperation between stakeholders and the fact that the developers did, for moral reasons, not want to earn from the PV, it was possible to achieve a price breakthrough of 4.50 euro. This drop in price was a required condition so that the homeowners, who invested in the PV panels, could expect a payback time of seven years (Verhoef et al. 2009). Moreover, because of limited experience with the application of the measures for LCUD (at such scale), the installation and production costs were significant for both cases. Yet, increased *expertise and experience of supply actors* – partly as a result of pioneering cases such as SoC and GWL-district – will contribute to a reduction in installation costs, thereby likely improving the financial advantage of measures for LCUD and market demand for LCUIs. Also, an increase in the *energy price* is expected to promote horizontal scaling-up processes as it will enhance the financial advantage of measures for LCUD. As a result of public funding in both cases, there was no need for external access to credit in both cases. Yet, *access to credit*, appropriate loan conditions for consumers and project developers and *information availability* on measures for LCUD and loan opportunities are perceived to be important conditions for the horizontal scaling-up of LCUIs.

Social-cultural context

Respondents from both cases indicate that *societal values on environmental sustainability*, resulting from amongst other informative policy instruments, will likely enhance market demand for projects such as the GWL and SoC. The GWL-district is an exemplar pilot project that attracted green-oriented citizens, who were willing to actively engage in the initiative and who were aware of the environmental and social benefits generated by the initiative. The residents living in the SoC district were not 'energy fanatics' when they moved to the neighborhood, but did become enthusiastic about sustainability after they lived there for a while (Verhoef et al., 2009). *'Residents enjoy the PV panels and there are competitions between neighbors on who generate the most energy'* (respondent city council). The observation that consumers can become enthusiastic about low-carbon behavior and energy efficiency measures through experience and being exposed to it, can also be used as an argument that governments and key institutional players involved in development projects have to lead by example and actively pursue low-carbon developments, rather than waiting for a market pull.

Geographical and built context

Respondents from both cases confirmed that when replicating or growing an initiative, project designers and initiators should critically examine the *technical compatibility* of the measures for LCUD with the geographical conditions and existing infrastructure. During the scoping stage, careful inspection of the site and building characteristics are required to assess what measures are most effective from an environmental and economic perspective, as this is context and site-specific.

2.4.3 Lessons for vertical pathways to scaling-up

Respondents from both cases find it difficult to identify vertical scaling-up processes and establish direct links between the projects and changes in the formal and informal institutions within policy networks. Yet, respondents involved in the CoS case note that the initiative has provided the evidence

base for the success of the model and the benefits it generates for residents and local businesses. Moreover, the CoS has influenced national guidelines on LCUIs, developed by The Netherlands Enterprise Agency (part of the Ministry of Economic Affairs) that are meant to assist entrepreneurs in successfully developing similar projects (Agentschap NL, 2010). Finally, the success and feasibility of the project has definitely supported the policy goals of the municipality of Heerhugowaard itself. The municipality aims to be carbon neutral in 2030, which requires that both new and existing buildings are low-carbon. The GWL-district has received considerable attention worldwide and is often referred to as a best practice case for sustainable urban design (van Hall, 2000; Femenias, 2004). While the initiative has attracted urban planners, policy makers and scientists from all over the world, respondents find it difficult to establish to what extent it influenced formal and informal institutions of policy networks. In both cases, the project organizations applied indirect strategies, rather than direct strategies such as lobbying, to promote vertical pathways to scaling-up through the sharing of results and information about the initiatives. Based on the results, we maintain that factors related to the operational arrangements and local political leadership are important for promoting vertical pathways to scaling-up.

Operational arrangements

While it is, for both cases, difficult to establish to what extent vertical scaling-up has occurred, the cases suggest that continued *stakeholder involvement, leadership, resource mobilization* and *external communication* can raise awareness on the evidence base of the initiative and contribute to lesson sharing, thereby potentially influencing formal institutions (policy goals or instruments) and informal institutions (values, ideas) of policy networks. The cases reflect that after the completion of the initiative, it is important to organize various meetings with stakeholders in order to reflect on the lessons learned throughout the realization of the initiative. For the CoS case, continued stakeholder involvement after the completion of the project and evaluation of the project, resulting from effective leadership, encouraged reflection on the project and identification of lessons learned. Unlike the SoC case, the organization and stakeholder network of the GWL district were soon dissolved after completion, leading to the fact that there was not a comprehensive evaluation of the project and limited dissemination of lessons learned to other actors (Femenias, 2004). In both cases, external communication and knowledge dissemination was encouraged in order to enhance awareness on the benefits and impact of the LCUIs. In the GWL-district an information center has been established that organizes guided tours in the district to professionals and interested parties in order to promote awareness about the initiative. The project team of the SoC case proactively initiated and engaged in knowledge dissemination activities, such as symposiums for politicians, in order to enhance awareness of the project among public and private actors in the Netherlands and abroad (Verhoef et al., 2009). Moreover, the local alderman and project manager have regularly given guided tours and presentations about the initiative to (local) government officials from the Netherlands and abroad. During such occasions drivers and challenges encountered were shared. In addition to guided tours and presentations, an information center has been set up and a book has been published (Verhoef et al., 2009) to promote lesson sharing. The cases imply that the availability of human, information and financial resources can support the dissemination of results.

Policy context

The CoS case reflects that *political leadership* at the local level can contribute to vertical pathways to scaling-up. As noted above, the success of the initiative has influenced the Municipality's goals to be climate-neutral in 2030. Lessons and experienced from the SoC influence this policy target because the local political leaders were willing to learn from previous experiences and adapt their policy goals accordingly.

2.4.4 Reflection on the analytical framework

The taxonomy of scaling-up and the explanatory framework were helpful to identify the drivers and challenges encountered by the project team and the drivers required for the scaling-up of the LCUIs. Even though the case studies primarily have an illustrative function, some interesting observations can be made based on the first application of the framework. First, the cases indicate that different drivers contribute to the processes of horizontal and vertical pathways to scaling-up. On the one hand, in order to encourage the large-scale growth and replication of LCUIs (horizontal scaling-up), factors related to the measures for LCUD, operational arrangements and contextual factors are highly relevant. On the other hand, especially factors related to the operational arrangements are critical when promoting lesson learning and institutional change (vertical scaling-up). To encourage vertical pathways to scaling-up, it is important that lessons learned are captured in collaboration with stakeholders and that these are spread within policy networks.

A second observation is that the cases imply that there can sometimes be a difference in factors contributing to the success of (pilot) LCUIs and the conditions required to encourage horizontal pathways to scaling-up. To illustrate, limited financial advantage and high complexity of the measures for LCUD are not a key issue of concern for pilot projects, because the actors involved are eager to learn from the projects and are often intrinsically motivated to be engaged. In both cases, the project teams were not driven by financial motivations, but rather by a willingness to pioneer and to demonstrate 'that it can be done'. The innovative character and uniqueness of both LCUIs enhanced the willingness of leading actors in the field to be involved in the project and led to the successful mobilization of technical, informational, human and financial resources. Yet, the cases suggest that high financial advantage, high reliability, low complexity of the measures for LCUD are required to horizontally scale-up LCUIs beyond 'sustainability-minded' project developers and consumers. Moreover, it can be argued that for the large-scale growth and replication of pilot LCUIs it is important that there is a solid business case and that need for external public funding is limited. This requires a stable market, sufficient skills and expertise of supply actors, clear market rules and access to capital for project developers and consumers. Moreover, if public funding is required, a stable policy framework is deemed essential in order to enhance consumers and project developers' trust in funding schemes and their willingness to use it. The above illustrates the difference between the factors contributing to the successful realization of pilot projects and the conditions required for their horizontal scaling-up. Finally, the application of the framework shows that the evaluation of vertical scaling-up is more challenging compared with horizontal scaling-up because it is difficult to establish causal relationships between the initiative and changes in formal institutions (policy goals or instruments) and informal institutions (values, ideas) within policy networks at different levels of political jurisdictions. To promote vertical scaling-up, more

empirical studies should be conducted on how an LCUI can actively challenge barriers deriving from the institutional environment in which the initiative is embedded. In addition, attention should be devoted to endogenous and exogenous factors to an initiative that can encourage discursive processes and learning so that LCUD becomes meaningful to local actors and decision-makers.

2.5 CONCLUSION

This article started with the proposition that in order to promote LCUD, successful LCUIs need to go to scale. New initiatives do not have to reinvent the wheel; valuable lessons can be distilled from former initiatives. This article has presented a taxonomy of scaling-up. A distinction is made between horizontal and vertical pathways to scaling-up, whereby the former concerns the replication and quantitative growth of initiatives and the latter the process where initiatives influence the formal institutions (policy goals or instruments) and informal institutions (values, ideas) of policy networks at different levels of political jurisdictions. The explanatory framework presented in this paper can be used to systemically identify factors that influenced the success and impact of initiatives and to develop lessons for scaling-up. Two case studies of LCUIs were described to illustrate the practical applicability of the explanatory framework. The studies are illustrative but suggest that the framework allows for a systematic, integrated and richer understanding on how the success of former initiatives can be explained, and how their scaling-up can be promoted. We propose that it is relevant to apply the explanatory framework to more cases, in different institutional contexts, so that it can be further verified and refined. In particular, it is deemed important to gain in-depth insights into the processes of horizontal and vertical scaling-up and policy arrangements that can be applied in order to accelerate these processes.

3 SCALING-UP ENERGY CONSERVATION INITIATIVES: BARRIERS AND LOCAL STRATEGIES

Abstract | Energy conservation in residential and commercial buildings is considered a key challenge and opportunity for low-carbon urban development. In cities worldwide, energy conservation initiatives have been realized that demonstrate the social, financial, and environmental benefits that energy conservation can generate. However, in order to accomplish international goals pertaining to climate mitigation, these initiatives need to go to scale and reach a greater and broader audience. To accelerate the scaling-up of such initiatives, an in-depth understanding of barriers hampering this process and local strategies that can be applied to address these barriers is required. While scholars and practitioners underline the importance of local solutions to the global problem of climate change, little is known about strategies that can be applied at the local level to overcome barriers. This paper has three general findings that can make a valuable contribution to theory and practice on urban climate governance. First, it sketches the context-specificity of barriers to scaling-up energy conservation initiatives and reflects on similarities and differences in barriers to energy conservation in residential and commercial building stocks in two European cities: Utrecht and Valencia. Second, this paper presents several local strategies that can be applied to overcome barriers, thereby improving our understanding of the relation between barriers and solutions. Finally, the findings of the paper suggest that while many barriers have national or international origins, the local environment appears to be a promising scale to address barriers.

Published as | Van Doren, D., Giezen, M., Driessen, P.P.J & H.A.C. Runhaar (2016). Scaling-up energy conservation initiatives: barriers and local strategies, *Sustainable Cities and Society*, 26, pp. 227–239.

3.1 INTRODUCTION

The retrofitting of residential and commercial buildings is considered a key challenge and opportunity for low-carbon urban development (Immendoerfer, Winkelmann, & Stelzer, 2014; Levine et al., 2007). In Europe, the building stock is the greatest contributor to carbon emissions and contributes to approximately 40% of final energy consumption (Pérez-Lombard, Ortiz, & Pout, 2008; UNEP, 2009). Energy conservation is seen as the fastest and most cost-effective way to mitigate climate change and reduce global greenhouse gas emissions (GHG) (Levine et al., 2007). Energy conservation initiatives (henceforth 'EIs' or 'initiatives') in the existing building stock – focused on the implementation of technological or behavioral energy conservation measures to reduce energy consumption and abate GHG emissions are regarded effective means to accelerate the transition to low-carbon cities. In addition to their climate mitigation impacts, EIs are associated with various co-benefits, including job creation, business opportunities, and increased comfort, health, and quality of life of citizens (Boardman, 2010; Immendoerfer et al., 2014; Levine et al., 2007; UNEP, 2009). In European cities, EIs have been realized that demonstrate the financial, social, and environmental benefits of energy conservation. Previous studies have reflected on success factors to the realization of such initiatives and indicate that successful initiatives are often initiated by actors who are intrinsically motivated to engage in the process due to their levels of environmental concern and willingness to pioneer (Chmutina et al., 2014; Klein Woolthuis, et al., 2013; Seyfang, 2010; van Doren, Driessen, Runhaar, & Giezen, 2016). However, what are barriers to the increase in uptake, spatial growth, and replication – i.e., the scaling-up (van Doren et al., 2016; World Bank, 2003) – of such EIs? And what strategies can initiators of EIs and other actors with an interest in the scaling-up of EIs apply in order to address these barriers? In order to develop effective urban governance arrangements for accelerating the low-carbon transition, we need to develop an integrative understanding of barriers to scaling-up and local strategies that can address these barriers. First, an accurate diagnosis of the diversity of barriers hampering the scaling-up of EIs is required. Studies often emphasize different barriers, and there is a need to combine these various perspectives in order to obtain an integrative overview of the full spectrum of barriers that need to be addressed. Moreover, while studies suggest that barriers to energy conservation are context-specific and interconnected, there is a need to further enhance our understanding of these issues (Fleiter, Schleich, & Ravivanpong, 2012; Kranzl et al., 2014; Stieβ & Dunkelberg, 2013; Trianni & Cagno, 2012). Second, local strategies need to be identified that can address the different barriers. A focus on the local level is deemed justified because cities, municipalities, and urban regions worldwide have expressed their interest in promoting low-carbon urban development, demonstrating that the local context is an appropriate scale at which strategies to address barriers will be put into action (Betsill & Bulkeley, 2006; Burch, 2010; Schreurs, 2008; Selman, 1998). However, due to the relatively immaturity and lack of institutionalization of the field of urban climate governance (Anguelovski & Carmin, 2011), there is still limited knowledge on strategies that public and private actors can apply to further the low-carbon transition. Previous studies have focused primarily on strategies that can be applied at the international and national level by state actors (Baek & Park, 2012; Kranzle et al., 2014; Tuominen, Klobut, Tolman, Adjei, & de Best-Waldhober, 2012) and scholars stress the need for a greater understanding of how local strategies can contribute to mitigating the global problem of climate change (Anguelovski & Carmin, 2011; Burch, 2010; Rutherford & Jaglin, 2015).

This paper aims to contribute to theory and practice on urban climate governance by diagnosing the nature of, and relations between, barriers to scaling-up EIs and by exploring local strategies that can address these barriers. While EIs are realized in different types of buildings, the focus of analysis will lie on scaling-up initiatives in residential and commercial buildings, because these two building stocks are jointly accountable for the major share of energy consumption (UNEP, 2009). A comparative analysis is conducted of two European cities, Utrecht and Valencia, in which the local governments aim to accelerate low-carbon urban development and various EIs have already been realized (Municipality of Valencia, 2014; Municipality of Utrecht, 2011). The variation in terms of socio-cultural, market, policy, and built and geographical context allows us to explore the context-specificity of barriers and general conditions required for scaling-up. The paper will proceed with an introduction to our analytical framework. Section 3.3 will elaborate on the method applied. Subsequently, section 3.4 will present the results of our analysis, followed by a comparative analysis and reflection on the findings in section 3.5.2.

3.2 ANALYTICAL FRAMEWORK

3.2.1 Barriers to scaling-up energy conservation initiatives in the existing building stock

Energy conservation initiatives refer to initiatives where energy conservation measures (ECMs) are applied. Examples include the retrofitting of streets or neighborhoods, housing blocks, or business districts. There is an extensive array of technological and behavioral ECMs that can be applied to reduce energy consumption and abate GHG emissions in existing buildings. Measures to save energy can relate to, amongst others, the building's thermal envelope, heating system, HVAC, energy management, lightning, water management, appliances and electronics, and occupant behavior (Abdellatif & Al-Shamma'a, 2015; Levine et al., 2007). In addition to climate mitigation, EIs can also generate co-benefits such as improvement in health, productivity, comfort, and local employment (Boardman, 2010; Immendoerfer et al., 2014; Levine et al., 2007; UNEP, 2009). While the retrofitting of existing buildings – through EIs – has the potential to reduce Europe's building sector's emissions with 30–36% by 2030, there is a need to accelerate the scaling-up of EIs in order to reach this potential and accomplish international and European climate mitigation goals (EEFIG, 2014; IEA, 2013; Levine et al., 2007; UNEP, 2009). While the concept of scaling-up can encompass various meanings, we interpret it as a process where there is an increase in uptake, growth, or replication of EIs ('horizontal pathways to upscaling', see van Doren et al., 2016, World Bank 2003). At present, EIs are primarily realized by actors who are driven by environmental concern and a willingness to demonstrate that 'it can be done' (Chmutina et al., 2014; van Doren et al., 2016; Klein Woolthuis et al., 2013; Seyfang, 2010). However, to accomplish the low-carbon transition, such initiatives need to be scaled-up beyond green-minded actors and reach a wider public. Yet, the widespread scaling-up of EIs remains a challenge due to various barriers to energy conservation that the wider public, such as households and enterprises, are confronted with. An adequate assessment of barriers experienced by this group is required to deepen the knowledge base on conditions that need to be addressed to accelerate the scaling-up of EIs. We define barriers to scaling-up EIs as any condition or factor that impedes households, enterprises, or

other demand-side actors from initiating, engaging in, or replicating EIs, thereby limiting their upscaling. Table 3.1 presents a summary of factors found in empirical peer-reviewed papers and scientific reports, from different scientific disciplines, reporting on factors that can positively or negatively influence energy conservation, thereby appearing as driver or barrier. Building on the categorization of van Doren et al. (2016), the factors identified in literature were classified into four general categories of the contextual environment of EIs. The socio-cultural context refers to a collection of factors related to the characteristics of the demand-side actors, including their level of awareness, values, attitudes, and capacity. Factors regarding the market context relate to the characteristics of ECMs, skills and experience of supply-side actors, and the conditions that enable demand-side actors to invest in the ECMs, such as information and credit availability. The policy context concerns the policy framework, such as legislation and policy leadership, which influence the ability and attractiveness to invest in ECMs. The built and geographical context, such as building characteristics and the climate, determine the potential for energy conservation. We expect that barriers to scaling-up might be diverse and depend on the type of building stock and urban context. This corresponds to the notion that while some barriers are always mentioned in studies, others are reported incidentally.

3.2.2 Local strategies to address barriers

The identification of barriers leads to knowledge on the conditions that need to be addressed in order to support the scaling-up of EIs. It is assumed that by removing a broad variety of barriers and creating facilitative conditions, the scaling-up of EIs can be accelerated. In this paper, we explicitly look for local strategies that can address barriers. Strategy is defined following Mintzberg (1987) as a "*consciously intended course of action, a set of guidelines to deal with a situation*" (p. 11). A strategy has two key characteristics, namely they are made in advance of the actions to which they apply, and that they are developed consciously and purposely (Mintzberg, 1987). We search for strategies that have been applied by initiators of EIs to address barriers, and strategies that they deem appropriate for implementation by local government. Special attention is paid to strategies that can be applied by local governments because local governments worldwide have been allocated, or have taken up, the policy mandate to promote energy conservation and low-carbon urban development (Khakee, 2010; Schreurs, 2008). Moreover, in their capacity to construct and operate urban infrastructures, oversee planning processes and establish local policies, local governments are deemed well equipped to implement local strategies that correspond with local needs and possibilities (see Agenda 21 UNCED; Caputo & Pasetti, 2015).

Building on the typology of governance instruments proposed by Bemelmans-Videc et al. (1998), Jordan et al. (2003) and Vedung (1998), and strategies found in empirical studies (see Baek & Park, 2012; Farreny et al., 2011; Stoknes, 2014; Tuominen et al., 2012), we apply a fourfold configuration of local strategies: informative, cooperative, financial, and regulative strategies. Informative strategies focus on the provision of information and advice, such as informational and advice programs or centers. Cooperative strategies are aimed at process guidance and improving the quality and efficiency of realizing EIs through partnerships, participatory management, and training programs. Financial strategies, such as purchasing agreements, trading mechanisms subsidies, and tax reliefs, strive to make EIs financially feasible and attractive. Finally, regulatory strategies, including building codes, zoning regulations, and installation performance specifications, are coercive measures to incentive the scaling-up EIs.

Table 3.1 Empirically observed factors influencing energy conservation, which can appear as barrier to the scaling-up of EIs. * signifies non-peer reviewed, 'grey' literature.

CATEGORY	CONDITION	OPERATIONAL DEFINITION	SOURCES
Socio-cultural context	Environmental awareness	The level of awareness of demand-side actors on the possibilities and benefits of investing in ECMs	Baek & Park 2012; Dowson et al., 2012; Emmert et al., 2011 *; IEA 2008*; Kranzl et al.,2014*; Schimschar et al. 2011; Schleich 2009; Sherriff, 2014; Steg, 2008; Steg & Vlek 2009; Tuominen et al., 2012
	Environmental values and attitudes	The values and attitudes of demand-side actors, such as concern for the environment and a moral commitment to use energy efficiently.	Ang & Wilkinson, 2008; Baek & Park, 2012; van Bueren & Priemus, 2002; Bradford & Fraser, 2008; Dowson et al. 2012; Emmert et al., 2011*; Farreny et al., 2011; Hoffman and Henn 2008; IEA, 2008*; Kranzl et al., 2014*; Schimschar et al., 2011; Schleich, 2009; Sherriff, 2014; Steg, 2008; Steg & Vlek, 2009; StieB & Dunkelberg 2013; Sullivan et al., 2013; Tuominen et al., 2012; van der Waals et al., 2003; Williams & Dair 2007; Zhang et al., 2011
	Resource capacity	The financial or informational resources and/or expertise that demand-side actors have to invest in ECMs	Ang & Wilkinson, 2008; Baek & Park, 2012; Bradford & Fraser 2008; van Bueren & Priemus, 2002; Decanio, 1998; Emmert et al., 2011*; Kranzl et al., 2014*; Hoffman & Henn, 2008; IEA, 2008*; Kostka et al., 2013; Middlemiss and Parrish, 2010; Schleich, 2009; Seyfang & Haxeltine, 2012; Steg, 2008; Sherriff ,2014; Steg & Vlek 2009; Stieß & Dunkelberg, 2013; Tuominen et al., 2012; Walker 2007; Williams & Dair 2007; Williams et al. 2012
Market context	Capital and installment costs	Purchase and installment costs of ECMs	Baek & Park, 2012; Brown & Vergragt 2008; Kranzl et al., 2014*; Emmert et al., 2011*; Farreny et al., 2011; Hoffman & Henn, 2008; IEA, 2008*; Reddy & Painuly, 2004; Schleich, 2009; Sherriff, 2013; Sullivan et al., 2013
	Credit availability	Opportunities for demand-side actors to access credit to invest in ECMs	Beck & Martinot, 2004; Emmert et al., 2011*; IEA, 2008*; Kostka et al., 2013; Kranzl et al., 2014*; Reddy & Painuly 2004; Schleich, 2009; Sherriff, 2013; Tuominen et al., 2012
	Skills and expertise of supply-side actors	The technical, financial, and business development skills on ECMs among supply-side actors	Beck & Martinot, 2004; Emmert et al., 2011*; Kranzl et al. 2014*; IEA 2008*; Reddy & Painuly 2004; Sherriff 2014; Tuominen et al. 2012
	Information availability	The level to which demand-side actors have low-cost access to good and reliable information on ECMs.	Baek & Park, 2012; Emmert et al., 2011*; IEA 2008*; Kranzl et al , 2014*; Reddy & Painuly, 2004; Schleich, 2009; Sherriff, 2014; Tuominen et al., 2012.

Table 3.1 Continued

CATEGORY	CONDITION	OPERATIONAL DEFINITION	SOURCES
Market context	Energy price	The financial price paid for energy consumption	Emmert et al., 2011*; Geels, 2007; IEA, 2008*; Sullivan et al., 2013; van der Waals et al., 2003
Policy context	Policy leadership	The level of ambition to address climate change of national and/or local governments	Betsill, 2010; Emmert et al., 2011*; Granberg & Elander, 2007; Romero-Lankao, 2012; Schreurs, 2008; Sherriff, 2013; Sullivan et al., 2011
	Policy instruments	The regulative, financial, cooperative, and informative policy instruments influencing demand-side actors' decision to invest in ECMs	Allen et al., 2010; Ang & Wilkinson, 2008; Baek & Park, 2012; Bomberg & McEwen, 2012; Emmert et al., 2011*; Farreny et al., 2012; Hoffman & Henn, 2008; Seyfang, 2010; StieB & Dunkelberg, 2013; Tuominen et al., 2012; Walker, 2007; Williams et al., 2012; Zhang et al., 2011
Built and geographical context	Built environment	The characteristics of the local built environment (such as urban form, grids for public utilities, building characteristics, and the ownership structure of buildings)	van Bueren & Priemus, 2002; Farreny et al., 2011; Kranzl et al., 2014*; Nijkamp & Pepping, 1998; Pelenur & Cruickshank, 2010; Tuominen et al., 2012; Williams et al., 2012
	Geographical environment	The characteristics of the local geographical environment (such as natural resources and climatic conditions)	van Bueren & Priemus, 2002; Farreny et al., 2011; Kranzl et al., 2014*; Nijkamp & Pepping, 1998; Pelenur & Cruickshank, 2010; Williams et al., 2012

3.3 RESEARCH DESIGN

We apply a comparative embedded multiple-case study design in order to learn more about the barriers and local strategies to scaling-up EIs. This means that the analysis contains more than one sub-unit of analysis (Yin, 2014). We believe that an analysis of sub-units allows for a more detailed level of enquiry. The first sub-unit of analysis concerns the type of building stock: residential and commercial buildings. We have chosen EIs focused on energy conservation in these two building stocks because they are collectively responsible for the largest part of energy consumption in the urban building stock (UNEP, 2009). We assume to find differences pertaining to barriers related to the socio-cultural context as these two building types have different purposes and because the demand-side actors – households and commercial enterprises- that have to make the decision to conserve energy differ in terms of their motives and resource capacity. The second sub-unit of analysis refers to the contextual environment in which the EIs reside. We have chosen to compare different cities as it allows us to analyze similarities and differences in barriers related to the contextual conditions of the EIs. The cities of Utrecht and Valencia are selected for a number of reasons. Both cities are faced with the challenge of de-carbonizing the building stock. The local governments have set objectives in terms of low-carbon urban development, which implies a readiness to address the barriers to scaling-up EIs (Municipality of Utrecht, 2011; Municipality of Valencia, 2014). Moreover, various EIs focused on energy conservation in the existing building stock have already been realized in both cities (AViTeM & Government of Catalonia, 2014; Municipality of Utrecht, 2011). However, the cities significantly differ in terms of, amongst others, economic development, climate, urban form, and political climate. This variation between the Northern European and Mediterranean context allows us to explore differences in terms of socio-cultural, market, policy, and built and geographical contextual conditions that can act as barriers to the scaling-up of EIs.

Internal validity and richness of the data is achieved through triangulation. A combination of information sources is used including desk research and 28 stakeholder interviews. Through an analysis of EIs in the cities under analysis, stakeholders were recruited that have been directly involved in EIs. Their perspectives are deemed valuable because they have practical experiences concerning the barriers related to the uptake and growth of EIs. Moreover, as these actors are, or have been, proactively involved in trying to grow the initiative and involve a greater audience, they are also well informed about the barriers that impede other demand-side actors from engaging in EIs and how – and to what extent- such barriers can be addressed at the local level. Also, various interviews have been held with regional and national operating experts, who can reflect on the barriers and local strategies due to their wider experience in the field of energy conservation. Appendix I provides an overview of the initiatives and respondents, who have been anonymized in order to maintain respondent confidentiality. The interviews followed a basic script that contained -in line with our analytical framework- questions on barriers and local strategies to address barriers. For the identification of local strategies, a distinction has been made between strategies that have been applied by actors involved in EIs and strategies that are considered appropriate for implementation by local governments. A document analysis of (local) studies, policy documents, and reports on the EIs was conducted to enhance the internal validity of our interview findings. Conclusions in this paper are based on the inter-subjectivity of the responses: the agreement or consensus between respondents (Scheff, 2006). Yet, important disagreements between

respondents are, when applicable, also noted. Responses on barriers were coded according to the analytical framework (see Table 1) and factors were recorded as general barriers if they were reported by the majority of stakeholders (more than 50%). The results in the following section are presented in comparative perspective in order to improve our understanding of the context-specificity of barriers. Quotes of the respondents are used to illustrate the occurrences of barriers and local strategies.

3.4 RESULTS

Table 3.2 and 3.3 provide an overview of respectively the barriers and local strategies to the scaling-up of EIs in residential and commercial buildings, identified by the majority of respondents in Utrecht and Valencia. The results will be discussed per type of building stock: residential (3.4.1) and commercial buildings (3.4.2). As a point of departure, an account will be provided of the barriers, categorized in accordance with our analytical framework, followed by an overview on local strategies that have been applied and suggested by the respondents.

3.4.1 Scaling-up energy conservation initiatives in residential buildings

3.4.1.1 *Barriers*

Socio-cultural context

Respondents in both cities note that while households are generally aware of the societal importance of climate change mitigation and energy conservation, they are often not well informed about the of the financial, health, and wellbeing benefits ECMs can generate for their own household. *"There is often still a lack of knowledge about the possibilities and personal advantages of energy conservation measures"* (respondent U3). It is argued that individuals with greater values and attitudes promoting sustainability are more likely to engage in EIs, but that even these actors do not always translate their values into practice due to other priorities within the household. *"Many people are in doubt. They are interested but push the decision forward because of practical concerns and priorities within the household"* (respondent U1). Moreover, even when households are aware and motivated to engage in EIs, they might lack the expertise, information, time, or financial capacity to do so. Respondents note that the issue of energy conservation can be perceived as complex and many households do not possess the expertise or information required to make a decision. Lack of financial resources by households can also obstruct them from engaging in EIs and this barrier is especially prominent in the city of Valencia. Due to the impact of the financial crisis of 2008 (unemployment rate of 25%), households experience limited financial capacity to finance ECMs without external access to capital or funding opportunities.

Table 3.2 Barriers to scaling-up EIs. Barrier perceptions by the majority of respondents in Utrecht and Valencia.

	RESIDENTIAL BUILDINGS		COMMERCIAL BUILDINGS	
CONDITION	**BARRIERS IN UTRECHT**	**BARRIERS IN VALENCIA**	**BARRIERS IN UTRECHT**	**BARRIERS IN VALENCIA**
		SOCIO-CULTURAL CONTEXT		
Environmental awareness	Limited awareness on benefits and opportunities of ECMs in own household	Limited awareness on benefits and opportunities of ECMs in own household	Limited awareness on potential benefits of ECMs for own enterprise	Limited awareness on potential benefits of ECMs for own enterprise
Environmental values and attitudes	Energy conservation has no priority within the household	Energy conservation has no priority within the household	Energy conservation has no strategic priority as a result of small percentage of energy costs of total operating costs	Energy conservation has no strategic priority as a result of small percentage of energy costs of total operating costs
Resource capacity	Households lack expertise and information on ECMs	Households lack expertise on ECMs; Households experience limited financial capacity	No information and/or expertise on energy consumption patterns and opportunities for energy conservation; Lack of (internal access to) financial resources as a result of short-term investment horizons	No information and/or expertise on energy consumption patterns and opportunities for energy conservation; Lack of (internal access to) financial resources as a result of short-term investment horizons and financial capacity
		MARKET CONTEXT		
Capital and instalment costs	High upfront and instalment costs	High upfront and instalment costs	High upfront and instalment costs; Hidden production costs	High upfront and instalment costs; Hidden production costs
Credit availability	—	Limited opportunities to access credit at low costs	—	Limited public or private financing opportunities
Skills and expertise of supply actors	Limited collaboration between supply-side actors	Limited experience and training of, and collaboration between, supply-side actors	Insufficient collaboration between supply and maintenance actors	Insufficient experience and skills of, and collaboration between, supply-side and maintenance actors

Table 3.2 Continued

	RESIDENTIAL BUILDINGS		COMMERCIAL BUILDINGS	
CONDITION	**BARRIERS IN UTRECHT**	**BARRIERS IN VALENCIA**	**BARRIERS IN UTRECHT**	**BARRIERS IN VALENCIA**
		MARKET CONTEXT		
Information availability	Information asymmetry; Difficulty of finding reliable and customized information on ECMs	Information asymmetry; Difficulty of finding reliable and customized information on ECMs	Information asymmetry; Difficult to find reliable and customized information	Information asymmetry; Difficult to find reliable and customized information
Energy price	—	—	Low energy tax for enterprises	Low energy tax for enterprises
		POLICY CONTEXT		
Political leadership	—	Instability of the political and policy framework	—	Instability of the policy framework
Policy instruments	No regulatory requirements regarding the energy efficiency of existing buildings	Lack of, and dispersion of, public funds or subsidies; administrative complexity No regulatory requirements for energy efficiency of existing buildings	Environmental regulation on energy efficiency standards for enterprises not ambitious enough	No regulations or energy efficiency standards for enterprises
		BUILT AND GEOGRAPHICAL CONTEXT		
Built environment	Fragmented property ownership in certain neighborhoods	High percentage of fragmented property ownership; Lack in owners' associations and governance structures to discuss energy conservation	Split-incentives; Fragmented property ownership in office buildings; Landlord-tenant dilemma	Split-incentives; Fragmented property ownership in office buildings; Landlord-tenant dilemma
Geographical environment	—	Mediterranean climatic conditions (moderate winters)	—	Mediterranean climate (moderate winters)

Table 3.3 Local strategies to scaling-up EIs. Applied and suggested strategies to scaling-up EIs in residential and commercial buildings by the majority of respondents in Utrecht and Valencia.

CATEGORY	LOCAL STRATEGY	RESIDENTIAL		COMMERCIAL		BARRIER ADDRESSED
		UTRECHT	VALENCIA	UTRECHT	VALENCIA	
Informative	Customized, face-to-face communication regarding the financial and co-benefits (such as health and enhanced comfort) of ECMs	Applied	Applied	Applied	Applied	– *Socio-cultural context:* lack of awareness on the benefits and opportunities for ECMs; Energy conservation has no priority within the household or enterprise
	Showcasing the impact of successful EIs	Applied	Applied	Applied	Applied	– *Socio-cultural context:* lack of awareness on the benefits and opportunities of ECMs; energy conservation has no priority within the household or enterprise
	Dissemination of experiences and lessons learnt from EIs to peers and professionals	Applied	Applied	Applied	Applied	– *Market context:* insufficient skills and expertise among supply-side actors
	Development of online and offline information points for customized and independent information provision and assistance	Suggested	Suggested	Suggested	Suggested	– *Socio-cultural context:* limited information and expertise on ECMs – *Market context:* information asymmetry
Cooperative	Process assistance from A to Z, including selecting suitable ECMs, financing, and finding of contractors	Applied	Applied	Applied	Applied	– *Socio-cultural context:* limited information and expertise on ECMs – *Market context:* information asymmetry; high production costs – *Policy context:* dispersion of public funds; administrative complexity – *Built and geographical context:* fragmented property ownership, landlord-tenant dilemma; lack in owners' associations and governance structures to discuss energy conservation
	Training of, and collaboration between, supply-side actors regarding ECMs	Suggested	Suggested	Suggested	Suggested	– *Market context:* insufficient skills and expertise of, and collaboration between, supply-side actors

Table 3.3 Continued

CATEGORY	LOCAL STRATEGY	RESIDENTIAL		COMMERCIAL		BARRIER ADDRESSED
		UTRECHT	VALENCIA	UTRECHT	VALENCIA	
Cooperative	Activation of owners' organization and development of support structures for EIs in shared buildings	Suggested	Suggested	—	—	– *Built and geographical context:* fragmented property ownership; lack in owners' associations and governance structures to discuss energy conservation
Financial	Collective purchasing	Applied	Applied	—	—	– *Socio-cultural context:* limited financial resources among households – *Market context:* high upfront purchase and installment costs of ECMs
	Valorizing the co-benefits of ECMs and EIs	—	—	Applied	Applied	– *Socio-cultural context:* lack awareness on the benefits of ECMs; Energy conservation has no priority within the household or enterprise
	Development of public and private financing mechanisms (e.g. revolving fund)	Suggested	Suggested	Suggest	Suggested	– *Market context:* high upfront purchase and installment costs; limited opportunities to access credit at low-costs
Regulative	Development and enforcement regulatory structures to establish owners' associations in collective buildings	—	Suggested	—	—	– *Built and geographical context:* Fragmented property ownership; lack in owners' associations and governance structures to discuss energy conservation

Market context

Respondents in both cities consider 'information asymmetry' and 'lack of customized information provision' to be barriers. Information provision is online oriented, dispersed, and the quotations offered can be abstract and not tailored to the personal needs of the customers. *"It is for interested consumers very difficult to obtain reliable and clear information"* (respondent V2). *"Many consumers have doubts on the objectivity of the information and advice provided by supply actors"* (respondent U13). Due to the high upfront investment and instalment costs of many ECMs, access to capital at relatively low costs is an important condition. 'Insufficient credit availability' is, however, considered a significant barrier in the city of Valencia. At present, there are limited opportunities for residents to access credit over the long-term at low costs (respondent V2, see also Tragopoulos & Sweatman, 2012). Moreover, especially for low-income households it can be challenging to access credit as they are often not 'credit-worthy'. In all, *"the financing of energy efficiency in the existing building stock remains one of the key barriers in the city of Valencia"* (respondent V1). The successful EIs in Valencia were realized due to public funding. Yet, *"these resources are difficult to reproduce and such financing mechanisms are not viable on a long-term basis"* (respondent V2). Accordingly, alternative financing mechanisms need to be created in order to offer households different funding possibilities. 'Insufficient credit availability' is not perceived to be a barrier by the majority of respondents in Utrecht. Households can apply for long-term and low-interest energy saving loans, financed by the National Energy Saving Fund, and various financiers allow for the extension of mortgages for ECMs. The majority of respondents also perceive 'limited experience and training of, and collaboration between, supply-side actors' to be a barrier to scaling-up EIs. This factor is especially prominent in Valencia where "*the energy refurbishment sector has not yet found momentum [and] limited skills and know-how on energy efficiency can be found by professionals at all levels of the supply chain, from contractors to architects"* (respondent V9). In Utrecht, the level of expertise and skills regarding the instalment of ECMs can also vary greatly between contractors and installers. While there are certification schemes available and a national website to find certified and skilled supply-side actors, households are not always capable of finding this information and thus need assistance with this process.

Policy context

Respondents from both cities maintain that many households do not invest in energy conservation because of a lack in regulatory incentives. In accordance with the EU Energy Performance of Buildings Directive, the national buildings codes in Netherlands and Spain contain only requirements on energy efficiency levels for new buildings and major renovations. Respondents in Valencia also identify a lack of public funding opportunities to be a barrier to scaling-up EIs in the residential building stock. Budget cuts have been significant since the 2008 financial crisis, resulting in limited availability of public funds or subsidies. The few public grants that are available for ECMs at the national and regional level can be difficult to access due to slow and complex administrative procedures and dispersion of funds (respondent V2; AviTem & Government of Catalonia, 2014). Another barrier specific to the case of Valencia is perceived 'uncertainty of the policy framework'. Respondents in Valencia note that there is little confidence in the policy framework and the stability of public schemes regarding energy conservation and generation, as a result of amongst others retroactive changes to the national feed-in-tariff in 2013 (see Real Decreto Ley/2013) and a fee for self-consumption ('sun tax').

Built and geographical context

The cases indicate that fragmented property ownership can impede the scaling-up of EIs in residential buildings, and this is especially a challenge in Valencia. The residential building stock is characterized by a high percentage of shared building blocks with a condominium ownership structure (70 to 86%), in which it can be very difficult to carry out EIs due to the need for at least 50% of shares and challenges of coordinating the decision-making processes (Atanasiu et al., 2011; Conefrey & Fitz Gerald, 2010; Kranzl et al., 2014). In many cases, there are no (active) owners' associations who could manage such a process (respondent V8). In Utrecht, it is for households in collective buildings mandatory to become a member of the owners' association, and thus there should be a governance structure in place to address issues related to energy conservation.

Respondents in Valencia consider the moderate Mediterranean climatic to be a barrier as it negatively influences the payback period of ECMs (see Tragopoulos & Sweatman 2012). *"Because of the moderate Mediterranean climate there is a lower potential in energy conservation – particularly regarding heating – and thus the payback period of investing in energy conservation measures is longer compared to Northern European countries"* (respondent V3). Nevertheless, they argue that there is a great potential for energy savings because the Mediterranean climate has led to a low emphasis on insulation of the housing stock and an increase in the use of air conditioning (see AViTem & Government of Catalonia, 2014).

3.4.1.2 *Local strategies*

Applied strategies by initiators of EIs

Respondents stress the significance of *informative strategies* in order to address barriers such as lack of awareness, priority, information, and expertise on ECMs among households, and information asymmetry. EIs in both cities have been realized due to personal and customized information provision by independent and trusted, local actors. The EIs in Utrecht were led by community actors and the EIs in Valencia were initiated by the Valencia Institute of Building. An important advantage of customized communication by local actors is that communication can be tailored to the specific motivations and needs of the audience. Communication by peers is also used and advocated by EIs in Utrecht as it can encourage sustainable conduct through social norms and because people more are likely to adopt ECMs *"because the neighbors do it too"* (respondent U17). *Cooperative strategies* have also been applied by EIs in Utrecht and Valencia in order to address barriers including households' lack in time and expertise, information asymmetry, the dispersion of funds and administrative complexity, and fragmented property ownership. Respondents emphasize the importance of offering households support – from A to Z- by independent and trusted actors who can act as mediators. Successful initiatives in Valencia demonstrate that coordination and organizational barriers, inherent to shared building blocks with fragmented property ownership, can be diminished through participatory management and process guidance. Due to intermediation by experts, successful initiatives have been carried out in shared apartment blocks with more than 30 individual owners. Finally, the majority of EIs applied *financial strategies*, namely collective purchasing arrangements -to reduce capital and instalment costs- and the valorization of co-benefits.

Suggested strategies for local government

While private actors can apply the above-mentioned strategies, the majority of respondents also underline the important role of local governments in supporting and institutionalizing such strategies. Local government can apply *informative strategies* in order to raise awareness and creating demand for EIs. This can be done through information platforms, campaigns, and demonstrating the impact of successful EIs. When doing this, "*local government should act as an example"* and initiate EIs in their own buildings and demonstrate what can be done and what the benefits of EIs are (V2). Respondents also highlight that as local and legitimate actors, local government could initiate and support *cooperative strategies*, such as the development of training programs and establishment of local offices where households can receive assistance and get connected with supply-side actors. *"Local government should focus on management and intermediation"* (V3) and can *"play an important role in linking supply and demand"* (respondent U7). Programs aimed at the training of, and collaboration between, local supply-side actors can be applied by local governments to encourage supply-side actors to work collectively in developing products or business models for EIs (e.g. packages of ECMs), thereby improving their quality and price (U5).

It is noted by some that whether local government should take the lead in developing and implementing informative and cooperative strategies is context-dependent. *"If there is a lot of 'energy' and expertise in a community, the local government does not have to take the lead but can rather mobilize and enable – through financial, technical, information, or political resources- other actors in their endeavor to realize and scale-up EIs"* (U4). *"This will enhance the chance that EIs will have a bottom-up character"* (U2). In communities with no or limited actors working on this issue, local government can take on a more directing role in which it initiates EIs and mobilizes, enthuses, and supports actors to cooperate.

As many local governments experience limitations in terms of public funding opportunities, they should pro-actively search for *financial strategies*. Financing arrangements, that are viable on a long-term basis and not susceptible to changes in the political context, can be developed in collaboration with local banks or investors (e.g. ESCOs, guarantees). If public funds are available they should be used systemically and incite a multiplying effect of public resources (e.g. creating a revolving fund for households with a low credit risk). There is no consensus among respondents as to whether *regulative strategies* should be applied by local governments (e.g. energy performance standards). Some believe that, without financial and technical support, this will be a burden that many households cannot bear. Respondents in Valencia do reflect on the need for local government to apply regulative strategies to establish owners' associations and governance structures in buildings with a condominium ownership structure in order to address barriers concerning the complexity of decision-making about energy conservation.

3.4.2 Scaling-up energy conservation initiatives in commercial buildings

3.4.2.1 *Barriers*

Socio-cultural context

Energy conservation often has low strategic priority for commercial enterprises because *"energy costs are generally relatively small for commercial enterprises"* (2–4%) (respondent U7). Accordingly, the issue tends to receive less (strategic) attention in commercial buildings compared to energy-intensive industry sectors. Respondents note that there is a general lack of awareness about the long-term financial advantage and the various economic co-benefits of energy conservation, such as enhanced productivity, comfort, and wellbeing of employees. Also, *"a great majority is motivated and willing to save energy, but does not do it"* because they do not have, or do not want to discharge, capacity (such as financial and human resources). *"If business is going well, they don't have time, and if they do have time- business is likely not going well- they don't have the financial resources to make the investment"* (respondent U7). Moreover, it can be a challenge to gain internal access to capital due to investment criteria, such as the expected rate of return or payback period of investments. The application of relatively short payback periods can lead to the fact that investments in ECMs are not made regardless of the financial benefits in the long run. Finally, many small enterprises lack the information on individual levels of energy consumption and the expertise to develop effective responses.

Market context

The respondents indicate that there is a high-risk perception toward investments in ECMs because of their high upfront purchase and instalment costs. The long payback period of ECMs is indirectly influenced by the price paid for energy by companies. Various respondents in both cities note that the burden of energy taxes is generally relatively low for enterprises in order to improve their international competitiveness, and that accordingly enterprises can lack a financial incentive to conserve energy. For those enterprises that are interested in conserving energy, it can be difficult to obtain reliable and customized information due to information asymmetry and complexity of the issue. Under such circumstances, gathering information on energy consumption patterns and suitable ECMs consumes much time and human resources, leading to high production costs. *"It takes too much precious time to start a search process and obtain clear and reliable information"* (respondent U8). Thus, there are hidden production costs related to investing in ECMs. Enterprises can also experience barriers related to external access to capital, such as lack in appropriate loan conditions. As for households, it can also be a challenge for enterprises in Valencia to access capital with low-interest rates over a long-term. Respondents in Utrecht do not report this barrier as enterprises there can make use of various local loan schemes and national tax deduction schemes concerning investments in ECMs (see RVO, 2015). Finally, respondents in both cities argue that supply-side and maintenance actors do not always have sufficient experience or skills in ECMs and that there is generally limited collaboration and integration between the different actors involved in the maintenance of a building. To illustrate, *"if an installer has to replace a boiler, he will only be looking at this aspect of the building"* (respondent U7), thereby missing the identification of other potential energy conservation opportunities.

Policy context

Respondents indicate that regulations can be an important driver to persuade enterprises to invest in ECMs. The Dutch national Environmental Protection Law and Activity Decree sets standards for energy efficiency improvements and obliges enterprises to invest in ECMs that have a payback period of five years. Yet, respondents and previous studies indicate that this law is enforced peacemeal by authorities in the Netherlands, leading to the fact that many enterprises are unaware of this regulatory obligation (Vringer, van Middelkoop, & Hoogervorst, 2014). Moreover, respondents argue that this regulation is not ambitious enough in order to achieve national and international goals on energy conservation and climate mitigation. Enterprises operating in Valencia do not have the obligation to invest in ECMs. While national legislation has set rules and procedures to fulfil energy saving requirements for new buildings and major renovations, there is no specific legislation to limit energy consumption of buildings in use. Similar to the case of residential buildings, instability in the national policy framework concerning energy conservation and generation creates uncertainty and prevents enterprises from making investments with long-term payback periods (Cuchí & Sweatman, 2013).

Built and geographical context

Respondents in both cities note that in commercial buildings with fragmented property ownership or leased spaces, the 'landlord/tenant dilemma' can occur. Depending on the structure of the commercial leases, either the landlord or tenant might not have sufficient incentives to engage in EIs because respectively the landlord pays the investment and instalment costs whereas the tenant is the sole beneficiary, or the tenant is not motivated to collaborate because he pays an all-in price and thus has no incentive to reduce energy consumption. While these barriers can be overcome through effective communication and contracts on sharing costs and savings between the tenant and landlord, the costs for verifying cost-savings and contractual arrangements are often prohibitive. Also, it can be a challenge for a single tenant to get in contact with the landlord because many commercial buildings are owned by large (foreign) investment funds. *"Sometimes the contact between landlord and the enterprises leasing the buildings is almost inexistent"* (expert U7). Like the residential sector, the Mediterranean climate conditions (moderate winters) can negatively influence the payback period of ECMs in commercial buildings. Nevertheless, respondents emphasize that improved insulation, shading, and HVAC systems can enhance indoor quality levels, thereby improving work engagement, employees' wellbeing, and other aspects linked to business productivity.

3.4.2.2 Local strategies

Applied strategies by initiators of EIs

EIs in both cities have been developed using *informative* and *cooperative* strategies. EIs in Utrecht, run by private actors in cooperation with the local government, applied customized information provision and process assistance. When enterprises were interested and motivated to engage in EIs, they were guided throughout the entire process and assisted with selecting ECMs, finding installers, and arranging the financing. *"You have to take them by the hand throughout the entire process, from A to Z. By assisting and unburdening companies, they can invest in energy conservation without having to spent much time or resources. They only have to sign the contract"* (respondent U7). The EI in Valencia, run by the Valencia Institute of Building, focused on information provision, energy monitoring, process

assistance and intermediation between all stakeholders in the building to identify appropriate solutions. Collaborative processes, guided by intermediaries, allow owners, tenants, and managers to identify and plan for cost-effectives ECMs at suitable moments (such as a tenant turnover). When applying cooperative strategies, collaboration between supply and maintenance actors should also be encouraged so that they stop working in silos and learn to apply an integrative perspective. *"The 'ecosystem' of a company – suppliers, service providers, accountants, maintenance workers – have to cooperate to ensure that energy conservation opportunities are identified"* (respondent U7). It is noted by respondents that the actors applying informative and cooperative strategies should have a position of trust and should offer companies assistance throughout the entire process (energy scan, finding installers, financing, arranging contracts, monitoring). *Financial strategies* have also been applied by EIs. As commercial enterprises will be likely attuned to the economic rationale of engaging in EIs, respondents highlight the need to communicate and valorize the co-benefits such as enhanced indoor quality, which leads to improved employee wellbeing and work engagement. The valorization of co-benefits is especially important in the Mediterranean context, where the moderate winters and hot and dry summers lead to higher payback periods. Also, showcasing the experiences and financial benefits of peers is recommended as it can lead to a reduction in risk-perception among enterprises.

Suggested strategies for implementation by local government

Respondents argue that local governments can support private actors in the application of *informative* and *cooperative* strategies through the provision of financial, human, or organizational resources. The rationale for working through 'intermediaries', rather than directly through local government, is that enterprises are more likely to engage in EIs if they are informed and assisted by businesses within the same sector, or an actor with business experience *"who can speak the language of business"* (respondent U8). Local government can also proactively initiate *cooperative* and *financial* strategies, such as training programs and the creation of public and private mechanisms. Whether local governments can apply *regulatory strategies* is greatly influenced by their capacity and autonomy. EIs in Utrecht, realized in collaboration with the Municipality, indicate that national regulatory obligation to invest in energy can be strategically used to accelerate the scaling-up of EIs. The Municipality aims to encourage enterprises to cooperate in established EIs in commercial districts by using a facilitative approach, but simultaneously threatens to use more regulative top-down instruments if these voluntary approaches are not successful.

3.5 COMPARATIVE ANALYSIS AND REFLECTION

We applied a comparative embedded multi-case study design to learn more about differences and similarities in barriers and local strategies to scaling-up EIs in residential and commercial buildings in different urban contextual environments: Utrecht and Valencia.

As for barriers, we assumed we would encounter differences in barriers related to the socio-cultural context between EIs in residential and commercial buildings as these two building types have different purposes and because the demand-side actors -households and commercial enterprises- who have

to make the decision to adopt ECMs and engage in EIs differ in terms of their needs, attitudes, and capacity. While this assumption is partly supported by our results, we also find various important similarities in barriers. Commercial buildings differ from residential buildings in their patterns of energy use and management. Energy costs only constitute a small percentage of businesses' operating costs and consequently the issue often has low strategic priority. Moreover, as commercial enterprises often apply short-term investment horizons and short payback periods, internal access to financial resources to invest in ECMs can be impeded regardless of the significant financial benefits that the investment will generate in the long run (see Fleiter, Schleich, & Ravivanpong, 2012; Schleich, 2009). An important similarity is that both households and commercial enterprises often lack awareness, urgency, and capacity to invest in ECMs (see below).

The second sub-unit of analysis relates to the contextual environment in which the EIs reside. We have chosen to compare cities in different European regions as it allows us to analyze similarities and differences in barriers related to the contextual conditions of the EIs. In both Utrecht and Valencia, barriers related to the *socio-cultural context* were identified, such a lack of awareness and expertise among demand-side actors. These findings align with previous studies stating that there is still limited awareness and expertise regarding opportunities of ECMs and that, in consequence, the issue has limited urgency among demand-side actors (see Kranzl et al., 2014; Schleich, 2009; Steg, 2008; Tuominen et al., 2012). As for the *market context*, important similarities between Utrecht and Valencia include the high capital and instalment costs of ECMs, information asymmetry, and lack of collaboration between supply-side actors. Due to the technical aspect of the issue and information asymmetry, it can be difficult for demand-side actors to find reliable and customized information and advice and accordingly investing in ECMs is associated with high production costs (see Baek & Park, 2012; Emmert et al., 2011; Kranzl et al., 2014; Reddy & Painuly, 2004; Schleich, 2009; Sherriff, 2013; Tuominen et al., 2012). Moreover, both cases reflect that that due to the high upfront costs of ECMs, credit availability is an important condition for scaling-up (see Emmert et at., 2011; Beck & Martinot, 2004; Reddy & Painuly, 2004). Yet, the financial attractiveness of investing in ECMs is also indirectly influenced by energy prices. Due to energy subsidies, enterprises can pay a low price for energy, and this price distortion negatively influences the payback period of ECMs (see Emmert et al., 2011; IEA, 2008; Sullivan et al., 2011). Our findings indicate that a stable and facilitative *policy context* is also an important condition for scaling-up EIs (see Sherriff, 2013; Sullivan, Gouldson, & Webber, 2013). In Valencia, the instability of the national policy framework and limited funding public opportunities are considered important barriers as these conditions obstruct households and enterprises from making investments with long-payback periods. Finally, the findings indicate that conditions related to *the built and geographical context* influence the scaling-up potential of EIs. The Mediterranean climate and building ownership structure present challenges specific to Valencia. The Valencia case reveals that a high percentage of shared buildings and a lack in decision-making structures (e.g. owners' associations) can lead to inaction (i.a. Kranzl et al., 2014; Tuominen et al., 2012). In all, the findings suggest that Mediterranean environment of Valencia presents some specific contextual conditions that require special attention. Due to the limited 'financial capacity' of households and enterprises (as a result of the 2008 economic crisis), 'insufficient credit availability', 'lack of public funds', and the longer 'payback period of ECMs' due to the Mediterranean climate, the financing of energy conservation constitutes a key barrier to the scaling-up of EIs in the city of Valencia. Yet, while barriers can be context-specific, the results of this study underline the importance of applying an integrative perspective when examining barriers to

scaling-up as such processes require facilitative conditions related to the socio-cultural, market, policy, *and* built and geographical context.

This paper also explored local strategies that can be implemented at the local scale in furtherance of addressing barriers to scaling-up. The outcomes suggest that various barriers to scaling-up can be reduced at the local level. In line with previous studies, the outcomes indicate that EIs are often initiated by enthusiastic 'frontrunners' who, due to their level of environmental concern and intrinsic enthusiasm in the process, are willing to combat many hurdles and apply strategies to expand the initiative and reach a greater audience (see Chmutina et al., 2014; Klein et al., 2012; Loorbach & Rotmans, 2010; Seyfang, 2010). In both cases, initiator of EIs used informative and cooperative strategies to address barriers regarding the socio-cultural and market context. Socio-cultural barriers (e.g. lack of awareness, priority, and capacity of demand-side actors) and market barriers (e.g. information asymmetry) can be diminished through customized information provision and assistance by local, trusted, and independent actors. Information provision and assistance by local experts and peers (e.g. neighbors or other businesses) can have significant advantages because they enjoy communal trust, can tailor communication to the specific needs and interest of the audience, and make use of the power of peer review (see Dieperink, Brand, & Vermeulen, 2004; Stoknes, 2014). While the above signifies that many barriers can be addressed by private and local actors, it is important that such 'frontrunners' are supported in their endeavors and that the strategies they apply are implemented at a structural basis. Local government can play an important role in providing assistance and institutionalizing successful strategies in order to ensure their continuity. Support can be offered by local government through the provision of financial, technical, political, and even mental resources (e.g. acknowledgement). This implies a need for collaborative governance structures that combine the capacity of local, private actors (communal trust, local knowledge) with the structural resources and strength of local government (independent, resource capacity).

Yet, there are also limitations as to what private actors can do to address barriers. Market-related barriers, such as lack of training and expertise of supply-side actors, information asymmetry, and credit availability can only structurally be removed if major stakeholders (such as local supply-side actors, financing institutions, and local government) collaborate in the development of cooperative and financial strategies. Accordingly, there lies an important role for local government in initiating and supporting long-term strategies aimed at developing such long-term strategies.

In all, the findings indicate that the local environment appears to be a suitable scale to address numerous barriers to scaling-up. However, it must be acknowledged that there are also constraints as to what can be done at the local level. Local governments differ in their capacity (e.g. human, financial, political, and regulatory resources) required to initiate and enable the implementation local strategies, and this capacity is significantly influenced by the national policy context (Betsill, 2001; Bulkeley & Kern, 2006). Moreover, barriers that have national or international sources, like energy pricing schemes, regulations concerning shared buildings, and European legislation regarding the energy performance of buildings, can only be effectively addressed at the national and international level.

3.6 CONCLUSION

Successful energy conservation initiatives have been realized that demonstrate the environmental, financial, and social benefits of energy conservation in buildings. However, in order to accomplish international goals on climate mitigation, the scaling-up -i.e. the increase in uptake, growth or replication – of such initiatives is needed well beyond what it happening today (EEFIG, 2014; Levine et al., 2007; UNEP, 2009). This paper started with the notion that in order to accelerate the scaling-up of EIs, there is a need to deepen the knowledge base on barriers that demand-side actors, such as households and enterprises, experience in terms of adopting ECMs and strategies that can be applied at the local scale to address these barriers. The focus on local strategies is deemed relevant because whereas the local context is generally considered an appropriate scale for promoting the transition to low-carbon societies (Betsill & Bulkeley, 2006; Schreurs, 2008; Selman, 1998), there is need for a greater understanding of how local strategies can address barriers to mitigating the global problem of climate change (Betsill & Bulkeley 2007; Burch, 2010; Rutherford & Jaglin, 2015). This paper aims to contribute to an improved understanding of barriers and local strategies to scaling-up energy conservation initiatives and has three general findings that can enrich literature and practice on urban climate governance. First, it has sketched the context-specificity of barriers to scaling-up EIs and has reflected on similarities and differences in barriers to energy conservation in residential and commercial buildings. The findings indicate that conditions related to the socio-cultural, market, policy, and built and geographical context can inhibit the scaling-up of initiatives and that such conditions can significantly differ between cities. Second, this paper has discussed several local strategies to overcome barriers, thereby improving our understanding of the relation between barriers and solutions. Finally, our findings indicate that while many barriers have national or international causes or dimensions, the local environment appears to be a suitable scale to address barriers. Initiators of EIs and other actors with an interest in scaling-up EIs can address important barriers, such as lack of awareness, priority, and resource capacity of demand-side actors, and information asymmetry through the application of informative and cooperative strategies. The findings suggest that local government can play an important role in supporting informative and cooperative strategies and pro-actively searching for financial and regulative strategies. In all, this paper contributes to an improved understanding of how low-carbon urban development can be promoted at the local scale. We suggest that additional work can be done to explore the extent to which the findings presented in this study are unique to the cities under study and to further develop an evidence-based repertoires of local strategies to accelerate the scaling of EIs. Because our findings also suggest that local governments can play an important role in addressing barriers, we propose that further research should explore the capacities required of local governments in order to initiate and facilitate the development of local strategies. As cities are at the forefront of climate action, the study and implementation of urban governance arrangements for addressing barriers to energy conservation is greatly needed.

4 EXPLAINING STRATEGIES OF INSTITUTIONAL ENTREPRENEURSHIP FOR SUSTAINABILITY TRANSITIONS: LESSONS FROM DECARBONIZING THE DUTCH BUILDING STOCK

Abstract | While literature on sustainability transitions advocates the institutionalization of niche innovations, and assigns an important role for institutional entrepreneurship in this respect, a knowledge gap exists regarding the strategies used in such a process. In particular, little is known about why and how institutional entrepreneurs opt for certain strategies. This paper contributes to theory on sustainability transitions by presenting a framework for the exploration of factors informing strategy choice. To do this, theory on sustainability transitions is combined with theory on institutional entrepreneurship and institutional work, two bodies of literature that examine agential processes of institutional change and study how actors can transform their institutional environment. An embedded case study design regarding the institutionalization of innovations contributing to a low-carbon building stock in the Netherlands is adopted to refine and illustrate the framework. The paper has two key findings that enrich literature and practice concerning the governance of sustainability transitions. First, it offers an overview of the arsenal of strategies that can be applied to promote the institutionalization of low-carbon innovations. Second, this paper contributes to an improved understanding of factors informing actors' strategy choice and shows that both actor characteristics and field-level conditions explain strategy choices.

Submitted as | Van Doren, D., Runhaar H.A.C., Raven, R., M. Giezen & P.P.J. Driessen (2017). Explaining strategies of institutional entrepreneurship for sustainability transitions: Lessons from decarbonizing the Dutch building stock.

4.1 INTRODUCTION

A growing body of research claims that fundamental changes in societal systems of production and consumption are needed in order to address climate change and realize a low-carbon society (Elzen et al., 2004; Hoogma et al., 2002). This low-carbon transition requires a process of institutional change, as it involves shifts in dominant 'rules of the game' and a process where established technologies and societal practices have to be replaced or decarbonized (Meadowcroft, 2009). Pioneers worldwide aim to contribute to this process of societal transformation by experimenting with low-carbon innovations – technologies or practices- that demonstrate that climate mitigation and the provision of societal functions, such as housing, mobility or energy, can go hand in hand (Sengers et al., 2016). However, a key challenge experienced by such pioneers is to 'move from innovation to institutionalization', while at the same time resisting pressures to conform to mainstream practices (Smith et al., 2013).

Although scholars in the field of sustainability transitions advocate the institutionalization of niche innovations, much uncertainty still exists on how this process can be governed (Geels, 2004; Smith et al., 2005; Smith, 2007; Smith & Raven, 2012). This paper aims to contribute to theory on sustainability transitions by exploring strategies for the institutionalization of low-carbon innovations. Previous studies in the field indicate that institutional theory can provide valuable lessons for developing theory about how institutional change for low-carbon transitions can be promoted (Fuenfschilling & Truffer, 2014; 2016; Jolly & Raven, 2015; Klein Woolthuis et al., 2013). Literature on institutional entrepreneurship and institutional work are deemed particularly relevant as they examine agential processes of institutional change and study the strategies that institutional entrepreneurs adopt to transform their institutional environment (DiMaggio, 1988; Lawrence & Suddaby, 2006; Lawrence, Suddaby, & Luca, 2009). Institutional entrepreneurs can be described as the individuals or collectives of actors who purposefully aim to transform existing or create new institutions (DiMaggio, 1988; Eisenstadt, 1980; Fligstein, 1997; Garud, Jain, & Kumaraswamy, 2002). However, while theory on institutional entrepreneurship and institutional work provide valuable perspectives concerning strategies that can be applied for the institutionalization of innovations, much uncertainty still exists about why institutional entrepreneurs opt for certain strategies (Battilana, Leca, & Boxenbaum, 2009; Lawrence & Suddaby 2006; Perkmann & Spicer 2008). The goal of this paper is to understand differences in strategies applied by institutional entrepreneurs and to examine how both actor characteristics and field-level conditions influence strategy choices.

In view of the above, the research question that is addressed in this paper is the following: *What strategies can institutional entrepreneurs adopt to promote the institutionalization of low-carbon innovations and what factors inform their strategy choice?* Combining theory on sustainability transitions and institutional theory, a framework is developed for the exploration of strategies and factors informing strategy choice in the context of sustainability transitions. An exploratory embedded case study is used to reflect on the research question and to refine and illustrate the framework. Through desk research and interviews, the strategies are examined of institutional entrepreneurs who are actively promoting the institutionalization of innovations contributing to a low-carbon building stock in the Netherlands. The decarbonization of the building sector represents an interesting case because energy conservation and renewable energy generation in existing buildings are considered key strategies for accelerating

the low-carbon transition, but require fundamental changes in the provision of housing (Levine et al., 2007; UNEP, 2009).

The paper will continue with an introduction to the analytical framework in section 4.2. Subsequently, section 4.3 will elaborate on the research design. Section 4 offers the results of the empirical case study. We end the paper with conclusions in section 4.5.

4.2 ANALYTICAL FRAMEWORK

4.2.1 The institutionalization of low-carbon innovations: insights from theory on sustainability transitions

Theory on sustainability transition maintains that sustainability transitions can come about through processes at three levels: (1) the development of niches in which innovations are developed, (2) the transformation of the socio-technical regime; and (3) landscape events that create pressures on the socio-technical regime (Geels & Schot, 2007). The socio-technical regime (henceforth: regime) constitutes a central notion in theory on sustainability transitions and can be described as the highly institutionalized structures which have evolved in alignment with dominant, high-carbon technologies (Fuenfschilling & Truffer, 2014; Geels, 2004). While landscape level developments are beyond the control of individuals, actors can theoretically play a role in the governance of sustainability transitions through niche development and regime transformation.

Niche development involves a process where low-carbon innovations are 'shielded' from mainstream regime pressures and 'nurtured' so that they can further develop (Geels & Raven, 2006; Raven, Kemp, Verhees, & Smith, 2016; Smith & Raven, 2012). Innovations developed in niches can be analytically characterized as social or technical innovations and can encompass both market- or community-based approaches (Seyfang & Smith, 2007; Smith et al., 2013). Market-based approaches, developed by industry and market actors, aim to decarbonize the production-side of the economy by virtue of technological innovation and sectorial change. Community-based innovations, such as community energy cooperatives, are governed by civil society and encompass practices for the provision of societal functions that correspond to local needs, possibilities, and values (Seyfang & Smith, 2007; Seyfang & Haxeltine, 2012; Seyfang, 2010). Either way, niche development can be regarded as a dynamic process during which a small number of actors develop an innovation that encompasses alternative practices and institutional arrangements. Studies in the field of strategic niche management have identified three important activities that can contribute to niche development: assisting learning processes, articulating expectations, and networking (Schot & Geels, 2008). Yet, these activities have not been examined through an institutional lens and it is not clear why and how such practices are chosen in furtherance of promoting the institutionalization of innovations.

Although niche development is critical for the development of innovations, the institutionalization of low-carbon innovation also requires regime transformation. Regime transformation involves a process

where the institutional environment of the regime is changed so that it aligns with the practices and principles promoted by the innovation (Smith & Raven, 2012). During this stage, actors try to shape their institutional environment in order to create institutional conditions that are favorable to the niche innovation. Yet, strategies to accelerate such a process are underexplored and it remains unclear how niche actors aim to transform the institutions of the regime (Smith et al., 2005; Smith, 2007; Smith & Raven, 2012).

This paper conceptualizes the institutionalization of niche innovation to occur through two stages (see Jacobssen & Bergek, 2004). The first stage of niche development involves a process in which new innovations and institutional structures are created. This is followed by a stage of regime transformation in which actors seek to broaden social consensus regarding the legitimacy of the innovation and strive to transform institutions to support its diffusion (Meyer & Rowan, 1997; Strang & Meyer, 1993; Tolbert & Zucker, 1996). Both stages are expected to be critical for the governance of sustainability transitions; niche development contributes to enhancing the capacity of innovations to address societal functions, whereas regime transformation favorably affects the ability of innovations to diffuse throughout society. The following section will demonstrate that work in institutional theory provides helpful insights for exploring and concretizing strategies for the creation and transformation of institutions.

4.2.2 The institutionalization of low-carbon innovations: insights from institutional theory

The field of institutional theory has long been concerned with the question how institutions exert stabilizing influence on social life (DiMaggio & Powell, 1982). Institutions can be described as the more-or-less taken-for-granted repetitive and enduring patterns of social practice (Greenwood et al., 2008; Lawrence, 1999). Institutions determine the legitimacy of actions and - though socially constructed – have a reality-like status (Berger & Luckmann; Tolbert & Zucker, 1996). Entities, organizations, and actors conform to institutions to safeguard their legitimacy – a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate with some socially constructed system of norms, values, beliefs, and definitions (Suchman, 1995) – and thus their chances of (organizational) survival (Meyer & Rowan, 1977; Suddaby & Greenwood, 2005). Institutions are carried by regulative, normative, and cognitive pillars, which differ in their characteristics and bases of legitimacy (Scott, 2001).

Whereas institutional theory has traditionally accounted exogenous shocks as sources of institutional change, recent streams within the field – theory on 'institutional entrepreneurship' and 'institutional work' – have started to explore agential processes of institutional change (DiMaggio, 1988; Lawrence & Suddaby, 2006; Lawrence et al., 2009). This literature subscribes to the view that both structure and agency can exert influence on institutions. Theory on institutional work focuses on day-to-day practices and processes aimed at the creation, maintenance, and disruption of institutions (Lawrence & Suddaby, 2006). Rather than focusing on the activities of one institutional entrepreneur, this work is interested in distributed agency and studies how the coordinated and uncoordinated efforts of various actors can influence institutions. While these two streams of literature have different focal points, they

have in common that they highlight agential processes of institutional change and examine strategies that can be employed by institutional entrepreneurs to transform their institutional environment.

A distinction can be made between political, technical, and cultural strategies of institutional entrepreneurship (Lawrence & Suddaby, 2006; Perkmann & Spicer, 2008) (see Table 4.1). Political strategies are directed at transforming the regulative pillar of institutions, such as legal systems and regulatory structures. Such strategies have the objective to develop a political constituency behind an innovation and to construct a policy environment that is favorable to its diffusion. Technical strategies target the cognitive pillar of institutions, namely frames through which meaning is made such as common beliefs, understandings, and routines. The goal of technical strategies is to generate predictable and credible results pertaining to an innovation. Cultural strategies encompass the development of narratives and use of discourse about what is appropriate or wrong, thereby primarily targeting the normative pillar of institutions, such as values and duties.

Table 4.1 Political, technical, and cultural strategies of institutional entrepreneurship. Classification based on: Lawrence & Suddaby, 2006; Perkmann & Spicer, 2008.

CATEGORY	STRATEGY	OPERATIONAL DEFINITION
Political	Visioning	Creating a vision for change by defining problems, related to the dominant regime, and justifying how the innovation, can solve these problems
	Coalition building	The development of coalitions composed of actors, with different skills and knowledge, to mobilize collective action
	Lobbying	To gather political and regulatory support for an innovation through direct and deliberate techniques of political suasion
	Vesting	The creation of new rule structures and policies that support the innovation
Technical	Theorizing	The development of abstract categories, models, frameworks, and cause-effect relations regarding innovations, institutions, and events
	Demonstrating	The demonstration of the workability of an innovation and corresponding institutional arrangements
	Standardizing	The development of products, business models, market mechanisms, or valuation techniques for the innovation
	Educating	The educating of actors in skills and knowledge necessary to support the diffusion of the innovation
	Construction of learning communities	The construction of networks through which practices become normatively sanctioned and which form the relevant peer group with respect to compliance, monitoring, evaluating, and learning regarding an innovation
Cultural	Changing normative associations	Awareness raising activities to shape the beliefs and perceptions of different stakeholders and to re-make the connections between sets of practices and the moral and cultural foundations of those practices
	Creation of new identities	Enhancing the attractiveness of innovations by linking it to identities, roles, or values

4.2.3 Factors informing strategy choice

Battilana et al. (2009) propose that both actor characteristics and field-level conditions can be conducive to institutional entrepreneurship. Yet, their framework remains conceptual and it remains to be proven whether these factors influence institutional entrepreneurship in the context of sustainability transitions. Furthermore, it is not clear how such factors inform actors' choice in political, technical, or cultural strategies.

4.2.3.1 *Actor characteristics*

We assume that differences in strategy choices can be explained by actors' problem perception of a field and their capacity to implement change. Actors perceive different field conditions and accordingly may have different problem perceptions, leading them to explore different solutions (Geels & Schot, 2007). Problem perception is likely influenced by an actor's social position as this mediates their relation with the environment and affects their perception of a field (Battilana et al., 2009). In the context of this research, problem perception can relate to the niche innovation itself or involve concerns regarding the compatibility between the innovation and the regime. Regarding the latter, niche innovations can be incompatible with the regulative, cognitive, or normative pillars of the institutional structures of the industry, market, science, policy, or socio-cultural dimension of the regime (Geels, 2004).

In addition, it is expected that actors' capacity, determined by resources and skills, also inform strategy choices. Previous studies point out that successful institutional change is influenced by actors' control over, and skills to mobilize, resources (Battilana et al., 2009; DiMaggio 1988; Kukk, Moors, & Hekkert, 2016; Lawrence & Suddaby 2006; Perkmann & Spicer, 2008). Resources that can play a role in the context of sustainability transition include human, mental, monetary, natural, and artefactual resources (Avelino & Rotmans, 2009). Perkmann and Spicer (2008) argue that actors need to possess political, analytical, and cultural skills for the deployment of political, technical, and cultural strategies respectively. Political skills include the capability to inspire and mobilize others and to invoke common interests, analytical skills relate to the ability to develop abstract models and theories concerning the innovation, and cultural skills involve the competence to influence wider societal norms and values through the use communication and persuasion (Fligstein, 1997; Perkmann & Spicer, 2008). Yet, while previous studies indicate that capacity matters, robust theory linking resources and skills with the different strategies for institutional entrepreneurship for sustainability transitions is lacking. Of course, when examining capacity, it must be acknowledged that institutional entrepreneurs are not 'disembedded agents' and that their conduct is also influenced by field-level conditions. Incumbent institutions pre-configure institutional entrepreneurs' possibilities and constraints in mobilizing required resources, and, in consequence, shape the strategies that they apply.

4.2.3.2 *Field-level conditions*

Strategy choices for the institutionalization of low-carbon innovation are likely also influenced by field-level conditions. First, as indicated previously, incumbent institutions, such as political opportunity

structure, determine what and how resources may be used and whether actors have access to political decision-making processes (McAdam, John, McCarthy, Mayer, & Zald, 1996; Tarow, 1998). Such dimensions can enable or prevent institutional entrepreneurship as they affect actors' access to resources and expectations for success in adopting strategies. Second, jolts or crises are expected to inform strategy choices as they can lead uncertainty in a field (Hardy & Maguire, 2008). Jolts or crises at the landscape level can be lead to 'windows of opportunity' that enable institutional entrepreneurs to strategically propose alternative institutional arrangements (Meyer, 1982). Third, the actions of other actors can also foster opportunities for institutional entrepreneurship and inform strategy choices (Battilana et al., 2009).

4.3 RESEARCH DESIGN

To explore strategy choices and refine the analytical framework, an embedded case study design was adopted. A qualitative approach was deemed appropriate given the exploratory nature of the research (Gerring, 2004). It allows deeper insight into what strategies institutional entrepreneurs employ and how actor characteristics and field-level conditions influence strategy choices. We employed a so-called embedded case study involving multiple sub-units of analysis (Yin, 2014). The main case study is institutional entrepreneurship for promoting the institutionalization of innovations contributing to the decarbonization of the exiting building stock in the Netherlands. Sub-units are institutional entrepreneurs within this field: organizations or networks that aim at decarbonizing the building stock by advocating institutional change, amongst other things. Using web search, thirteen identifiable networks or organizations were selected that – in accordance with the definition of institutional entrepreneurship described in section 4.2: (1) advocate innovations that offer a solution to reducing the carbon footprint of the building stock; and (2) leverage resources to create and transform institutions. Another selection criterion was that the institutional entrepreneurs fulfilled an intermediary position and had been, directly or indirectly, involved in various local initiatives where the innovations were applied. Appendix B provides an overview of the institutional entrepreneurs and respondents, who have been anonymized in order to maintain respondent confidentiality.

Internal validity and richness of the data was achieved through triangulation of data sources. Desk research was conducted to learn about the innovations promoted, institutional entrepreneurs' strategy choices, and capacity. Data sources included organizational records, reports, newspaper articles, and direct communications via social media and internet (such as blogs, tweets, and YouTube videos). Subsequently, fifteen semi-structured interviews were held with key representatives of the institutional entrepreneurs that could offer a holistic perspective ('helicopter view') on the strategies applied (such as directors and program managers). The interviews followed a basic script that contained questions about the following themes: the innovations, the strategies applied to promote its institutionalization, and explanations for strategy choices. Semi-structured interviews were conducted to systematically identify strategy choices, but to also allow for flexibility and exploration of the strategies and factors informing strategy choice not previously discussed in literature. All interviews were transcribed and summarized. Appendix C provides an overview of the questionnaire and indicates how data from

the interviews was coded. Conclusions concerning the function of strategies and factors informing strategy choice are based on the inter-subjectivity of responses (Scheff, 2006). Yet, diverging views concerning these issues are also reported. Because presenting detailed case information would develop at significant length, we present the results at aggregation level. Empirical examples and quotes of the respondents are used to illustrate the occurrence of strategies and to discuss factors informing strategy choice.

The results will be presented in line with our analytical framework. As a point of departure, the case and the individual institutional entrepreneurs will be introduced. This is followed by a description of the strategies applied in section 4.2, an overview of factors informing strategy choice in section 4.3, and a critical reflection on the results in section 4.4.

4.4 RESULTS

4.4.1 Introduction to the case

4.4.1.1 *Decarbonizing the Dutch building stock*

The decarbonization of the building stock constitutes a highly cost-effective measure for climate mitigation and accelerating the low-carbon transition (Levine et al. 2007; UNEP, 2009). In the European Union, the building stock is the greatest contributor to carbon emissions: buildings are responsible for 40% of energy consumption and 36% of corresponding GHG emissions (EU, 2016). The energy retrofitting of existing building is regarded a critical means for reducing Europe's energy consumption (BPIE, 2016; Bresaer, 2015). In addition to the climate mitigation impact, the energy retrofitting of buildings can generate a variety of environmental economic and social benefits, such as job creation, business opportunities, higher value of buildings, and enhanced comfort and health of residents (Immendoerfer et al., 2014; Levine et al., 2007; UNEP, 2009). However, while the drivers are numerous, studies emphasize the need for a rapid increase in energy retrofitting of buildings in order to achieve Europe's climate mitigation targets (EEFIG 2014; UNEP, 2009).

As a member of the European Union, the Netherlands is facing the challenge to reduce its GHG emissions with 80 percent in 2050 compared to 1990 levels (EU, 2011). As the built environment is a significant source of the country's GHG emissions, the Dutch government has set the objective to have an energy neutral built environment in 2050 (Ministry of Economic Affairs, 2016; SER, 2013). This transition demands deep energy retrofits and involves fundamental changes in the way households heat and cook. In the Netherlands, natural gas forms 70% of all energy provision in households. Yet, as all 7 million households must have an energy-neutral household in 2050, the use of natural gas for energy provision of buildings will need to decrease significantly (Ministry of Economic Affairs, 2016). Niche innovations promoted by institutional entrepreneurs offer solutions to the high level of energy consumption of buildings.

4.4.1.2 *Institutional entrepreneurs*

The institutional entrepreneurs studied in this research advocate different types of innovations as a solution for decarbonizing the Dutch building stock. Six embrace market-based social and technical innovations, namely zero-energy building concepts and energy performance contracts. A zero-energy building is a building that has a net annual energy bill of zero. To achieve such a standard, a variety of technical measures can be used. Standard measures including thermal isolation of the housing shell, triple glazing, heat pumps, mechanical ventilation, and solar panels. Energy performance contracting is an innovative financial model stipulating that an energy service company (ESCO) organizes and finances the energy retrofit and that the owner use the monthly cost savings, resulting from the energy conservation, to repay the energy retrofit. The other institutional entrepreneurs promote community-based, social innovations for decarbonizing the building stock, such as energy cooperatives and community-based purchasing and retrofit schemes. They maintain that community-based innovations can be important carriers of low-carbon transitions because they can develop local solutions to the global problem of climate change, while at the same time contributing to public education, the creation of social capital, community resilience, and public acceptability for climate policy. However, while the innovations advocated by institutional entrepreneurs have the potential to generate wider societal transformation, they experience internal barriers and are underpinned by a set of practices and institutional configurations that demonstrate little regime compatibility, which limits their institutionalization and diffusion throughout society (see Table 4.2).

4.4.2 Strategies for promoting the institutionalization of low-carbon innovations

The review of the data suggests that overall different strategies are adopted for niche development or regime transformation, but that also some strategies can be directed at both goals. Furthermore, institutional entrepreneurs have different underlying rationales for their strategy choice. Hence, strategies can have several functions in terms of furthering the institutionalization of low-carbon innovations.

4.4.2.1 *Strategies for niche development*

The political strategies 'visioning' and 'coalition-building' are applied for niche development. All institutional entrepreneurs engage in coalition-building to facilitate stakeholder interactions, enhance trust, and mobilize resources, thereby increasing the niche's problem-solving capacity for developing and strengthening the innovation. Moreover, *"coalition building is important for developing institutional configurations around the innovation"* (R10), such as business models and partnerships. To develop and continuously activate the coalition, institutional entrepreneurs engage in *visioning* to articulate goals and to develop a common direction for all actors working on the innovation ('point on the horizon').

Table 4.2 Summary of barriers to the institutionalization of low-carbon innovations contributing to the decarbonization of the Dutch building stock, as mentioned by the majority of respondents.

INTERNAL BARRIERS		
		– Insufficient resource availability to develop and improve the innovation – Insufficient collaboration and learning between niche actors – High price of zero energy building concepts; need to develop financially feasible zero-energy building concepts that can be developed at industrial scale (MB) – Guarantee of performance of zero-energy building concepts (MB) – Level of professionalization of community energy initiatives to organize retrofits (CB)
BARRIERS RELATED TO REGIME INCOMPATABILITY		
Regime Dimension	**Actors**	
Industry	Contractors; suppliers; R&D; maintenance actors	*Cognitive pillar* – Sector fragmentation and lack in collaboration in organizing energy retrofits; Information asymmetry and great diversity in offers and products for energy retrofits; No actors that offer integrated, all-in-one zero-energy retrofit concepts and guarantee the energy performance of products (MB)
Market	Intermediaries; consultants; financers; architects; developers	*Cognitive pillar* – Lack in financing arrangements for energy retrofits – Property valorization practices and routines by banks and appraisers; Insufficient economic valorization of energy efficient buildings and no instruments for the economic valorization of energy efficient buildings – Risk aversion; High risk perception to zero energy buildings and retrofits or Uncertainty concerning the performance of zero energy building concepts or, performance contracts (MB) – Financing practices by banks; high risk perception for financing small-scale community-based initiatives (CB)
Science	Academic and private research institutes	*Cognitive pillar* – No scientific consensus on how to achieve zero energy buildings and a low-carbon building stock
Policy	Policy-makers; planners	*Cognitive pillar* – Insufficient political leadership and long-term political goals; insufficient political urgency; political short-termism – Community energy initiatives not sufficiently involved in policy implementation; risk aversion of policy-makers (CB) *Regulatory pillar* – Legislation concerning mortgages for energy retrofits – Legislation concerning property valorization; insufficient valorization of energy efficient buildings (until 2016) – Legal obligation to be connected to the gas grid – Legislation concerning the use of energy performance contract; landlords legally not allowed to change an energy performance fee (until 2016) (MB) – Tax schemes for community energy (until 2016) (CB)
Socio-cultural	End-users, building owners	*Cognitive pillar* – Insufficient awareness about the possibilities and benefits of energy conservation among building owners; risk aversion *Normative pillar* – Insufficient sense of urgency for energy conservation (short-termism); insufficient sustainability values

MB means that the barrier only applies to market-based innovations; CB means that the barrier only applies to community-based innovations. Regime dimensions based on Geels (2004)[3].

Following the formation of coalitions, technical strategies are applied. *Theorization* is used to legitimize how an innovation offers a solution to problems in the regime, such as climate mitigation, energy dependence, or energy poverty, and learn about regime dimensions that need to be transformed for further diffusion. The development of theory about the innovation generally occurs through experiments and projects and has a rather pragmatic nature. *"Through experimentation you learn about necessary conditions in terms of demand, supply, policy, and financing required for scaling-up"* (R1). Questions such as *'what institutional conditions need to be worked on in order to make the business model feasible?'* (R3) need to be answered in order to inform strategies for regime transformation. *The construction of learning communities* is employed to generate and disseminate knowledge and skills concerning the innovation among niche actors. Respondents highlight the practical nature of learning activities related to the energy retrofitting of buildings ('learning by doing'). *"Learning occurs through projects and knowledge should be linked to projects"* (R2). *Standardizing* has the objective to develop a common language among actors applying the innovation, to monitor the performance, and to enhance the efficiency and effectiveness of innovations. Standardization occurs through the development of, amongst others, standardized contracts, certification schemes, guidelines, and procedures. Standardization and the construction of learning networks *"are important to prevent actors from reinventing the wheel"* (R6).

Finally, some of the institutional entrepreneurs also apply a cultural strategy for niche development, namely the *creation of new identities* in order to establish a distinct and common identity among the distinct niche actors. In particular institutional entrepreneurs advocating community-based innovations use this strategy to enhance a feeling of belonging and to make initiatives feel part of a bigger political movement. *"Some initiatives feel as if they have to fight the rest of the world. It is important that they feel that they are part of a greater movement"* (R12).

4.4.2.2 *Strategies for regime transformation*

Political, technical, and cultural strategies are oriented to actors outside the niche and are employed to transform institutional structures of the regime. To broaden the political coalition around the innovation and gain political support, all institutional entrepreneurs engage in *visioning* and develop discursive framings to illustrate how their innovation offers a solution to societal problems and connects to the interests of actors. To illustrate, the zero-energy building concept developed by Energy Leap was initially described as an 'energy product', but framing has been broadened over the years so that it could be linked to various social challenges, such as climate adaptation, energy poverty, and security (R3). On the other hand, institutional entrepreneurs promoting community-based innovations draw on local culture, interests, and opportunities in their narratives. Innovations are framed as appropriate solutions for climate mitigation, but also as a vehicle for, amongst others, local regeneration, social cohesion, affordable energy, the democratization of the energy market, and the avoidance of peak oil and related geopolitical risks. Institutional entrepreneurs promoting market-based innovations highlight the importance of *coalition-building* for engaging more market and industry actors in the development of financially feasible zero-energy building concepts. They maintain that the transition to a low-carbon building stock requires market and industry actors to work together in developing integrated propositions with a high performance. Yet, there is often a vicious circle; actors only move

when others do (for instance there are no financing arrangements, because there is no demand; there is no demand because households cannot finance the product). *"Coalitions can break this circle"* (R3). Institutional entrepreneurs endorsing community-based innovations maintain that *coalition-building* is also important to enhance the visibility of the movement. In order to counter resistance from dominant actors who value the status quo, it is important that all actors endorsing the innovation unite and have a 'collective voice' to actors outside the niche. *"We often hear small groups working on this issue saying 'we will take care of this at the Parliament. But it won't be a successful lobby if they all do it on their own. That's why we developed a coalition"* (R9).

Only few institutional entrepreneurs engage in *lobbying* and *vesting* to create a facilitative policy environment. Institutional entrepreneurs supporting market-based innovations, such as Energy Leap, mobilize resources to change regulations concerning property valorization, mortgages rules, and the use energy performance contracts. This is deemed critical since insufficient economic valorization of energy efficient buildings and inability to finance energy retrofits through mortgages discourages the diffusion of zero-energy buildings. On the other hand, institutional entrepreneurs endorsing community-based innovations lobby to influence tax schemes regarding community energy and to persuade policy-makers to involve local energy cooperatives in the implementation of local climate policy. Respondents note that lobbying and vesting become relevant after experiments have been conducted that provide the 'burden of proof' for the innovation and yield valuable lessons about policy conditions that are required for diffusion.

Technical strategies, namely education and demonstrating, are employed to enhance the legitimacy of the innovation and to enable actors – outside the niche – in applying the innovation. *Education* occurs both online (databases, booklets) and offline (workshops, support centers) and is required for the diffusion of knowledge and skills that are needed to sustain the innovation. Institutional entrepreneurs promoting market-based innovations organize educational activities to address barriers related to the cognitive pillar of the industry and market dimension of the regime, such as lack in collaboration between actors to realize zero-energy buildings and inadequate in property valorization practices among banks and appraisers. Educational activities to actors outside the niche are relevant at a later stage, when the innovations have strengthened sufficiently and niche actors have reached consensus on required institutional conditions required for diffusion. As noted by a respondent from Energy Leap: *"developments went so quickly and in consequence the lessons were always one step behind"* (R1). *Now that major successes have been achieved in terms of performance and institutional configurations around the innovation have been optimized, such as business models and contracts, education becomes more important* (R3). All employ the strategy *demonstrating* to reduce risk perception among other demand and supply-side actors. Successful projects play an important role for conceptualizing how 'the old ways of doing things are wrong' and how the innovation supported by the institutional entrepreneurs provides a solution thereto. *"People only believe your assumptions and theories once they are demonstrated with physical, visible projects"* (R2). Therefore, booklets are developed and site visits are organized to demonstrate the practical viability and impact of innovations.

Institutional entrepreneurs adopting community-based innovations also mobilize resources to *change normative associations,* a cultural strategy. Awareness raising programs and engagement programs are developed to influence values and norms concerning sustainability and to address barriers related to the socio-cultural dimension of the regime. Respondents highlight that information provision alone is not sufficient for changing peoples' attitudes and behavior; people should also be given concrete instruments and instructions. Furthermore, they maintain that changing people's conduct does not necessarily have to result from a change in attitudes, but can also occur the other way around. By enabling people to reduce their energy consumption through behavioral or single energy conservation measures, they can incrementally change their sustainability attitudes and values and be more susceptible to deep energy retrofits. Cultural strategies are also applied to create a sense of urgency for political action among the public, so that barriers related to the policy dimension of the regime can be addressed. An example hereof is the education and awareness program developed by the project team of the Energy Accord of Gelderland. Aware that the policy agenda is typically dominated by the short-term, they initiated an educational program in cooperation with local schools that encourages politicians to introduce long-term considerations into their politics. By engaging local schools in developing solutions for their community, *"we create problem ownership among both politicians and the community"* […] *We want to build this new institutional model [social enterprise ESCO for organizing retrofits], but this is not a 'hot political topic' as it requires a lot of resources, time and includes taking risks"* (R10). Accordingly, for our model to succeed, *"we need to create context in which there is a strong sense of urgency for political action"* (R10).

4.4.3 Factors informing strategy choice

4.4.3.1 *Actor characteristics*

Problem perception

The results indicate that strategy choice is influenced by institutional entrepreneurs' problem perception, namely their view on barriers to the institutionalization of low-carbon innovations. Strategies for niche development are applied to address internal barriers, thereby enhancing the capacity of niche innovation to offer alternative ways for the provision of societal functions. Strategies for regime transformation are applied to tackle barriers related to the institutions of the regime, thereby enhancing the compatibility between the innovation and regime dimensions. Strategy choices for regime transformation are informed by barrier perceptions concerning the institutional pillar and regime dimension that must be transformed in order for the innovation to be able to diffuse throughout society. Overall, political strategies are applied to address barriers related to the regulatory pillars of the policy dimension; technical strategies to influence cognitive pillars of the industry and market dimension; and cultural strategies to influence the socio-cultural dimension.

As reflected in section 4.2, a difference can be observed in the rationales behind strategies of institutional entrepreneurs promoting market-based innovations and institutional entrepreneurs endorsing community-based innovations. While the former group primarily employs strategies to tackle institutional barriers related to the industry, market, and policy dimensions of the regime,

the former addresses barriers related to policy and socio-cultural regime dimensions. Institutional entrepreneurs promoting market-based innovations maintain that the creation and broadening of a strong coalition around the niche is critical because the transition to a low-carbon building stock encompasses a complex process in which a wide-ranging group of stakeholders need to collaborate. It is argued that *"the building sector is a very traditional, non-innovating sector"* (R1), that is characterized by fragmentation, lack of collaboration, and stacked margins. The transition to a low-carbon building stock requires market and industry actors to take on a different role and work together in developing integrated propositions with a high performance. *"We need to develop better products for lower prices, so that we can offer building owners an attractive alternative to their energy bill"* (R1). Accordingly, sector collaboration is encouraged and coalitions with frontrunners are set up to work on projects, improve the performance of innovations, and address policy conditions to enhance the business-case of the innovations.

On the other hand, groups supporting community-based innovations perceive that the greatest challenge – and opportunity -for the low-carbon transition relates to increasing public awareness, political leadership, and creating a more sophisticated role of local energy initiatives. Whereas actors supporting community-based innovations recognize the importance of market-based solutions, they subscribe to the view that such top-down approaches might not suffice if citizens experience a weak sense of personal agency and have lack of faith in the (information offered by) the organizations offering the solution. Accordingly, they maintain that the transition to a low-carbon building stock can only be achieved from the bottom-up, through community-based approaches. As one interviewee commented: *"If you do no start from the bottom up, and involve citizens, there will be no public acceptance for technological solutions. […] The transition to an energy-neutral building stock demands substantial interventions. For instance, we have to remove all gas boilers in peoples' houses and convince them to invest in energy conservation. This requires a social transition that can only be realized through local energy initiatives, which act transparently and in harmony with local values"* (R9).

Capacity

The institutional entrepreneurs that are studied differ to a large extent in terms of capacity. Some, such as government- and industry initiated innovation networks such as Energiesprong and Stroomversnelling, involve networks with extensive human, monetary, and mental resources, whereas others, such as ODE Decentraal and Transitions Towns, supporting community-based approaches, are dependent on time, efforts and donations by volunteers and members. Resource capacity influences the amount and intensity of strategies that can be applied. As different strategies require different resources and skills (Table 4.3) it can be said that they 'compete' for capacity and that institutional entrepreneurs thus have to decide how their capacity is best served. Accordingly, institutional entrepreneurs with restricted resources note that they direct their efforts towards strategies with which they have experience and with which they expect to have a higher chance of success. Experience at the organizational level can inform strategy choices (such as experience in lobby or public campaigns), but experience, skills, or personalities of the individuals in high-level positions can also significantly exert an influence in strategy choices, especially in smaller organizations. *"Strategy choices are very person driven. Some leading figures of other organizations have much experience in political lobby and know how to play that game. We, on the other hand, are much grounded in communities and thus focus on hands-on activities to support and strengthen local energy initiatives"* (R13).

To engage in political strategies for niche development, institutional entrepreneurs must have a broad network and have a comprehensive overview of the field they are working in. Key categories of resources required for the creation of a coalition of frontrunners and experimentation with innovations concern human and monetary resources, as these can be used to mobilize other resource types. Human resources include both tangible aspects, such as the number of employees available, but particularly refer to intangible resources, such as leadership and perceived reliability and legitimacy. Coalition members must recognize that the institutional entrepreneur serves in their interests and must remain motivated to contribute resources for the accomplishment of the niche's goals and vision. The importance of clear leadership is illustrated by the quote below: *"Without us, the movement would have stopped. We are continuously pushing and pulling to ensure that all stakeholders remain having a perspective and motivation*" (R3). For technical strategies aimed at niche development, an arsenal of mental, natural, and artefactual resources must also be mobilized, such as expertise of various kinds, technologies, and buildings. The deployment of technical strategies requires analytical skills, including the ability to monitor and analyze the impact of interventions, design templates and models, codify learning experiences, and study institutional conditions required for wide-scale diffusion. Furthermore, in order to coordinate niche actors and implement experiments, institutional entrepreneurs must also possess strong hands-on, organizational skills.

Political skills required for regime transformation differ from political skills required for niche development described above, with the former involving actors to be able to create political attention, mobilize support, engage in political bargaining, and link the innovation to the interests of broader, external audiences. Institutional entrepreneurs must therefore be cognizant of the values and needs of regime actors and frame the innovation as a solution to their needs and interests. Institutional entrepreneurs engaging in lobbying note that they are able to do this because they have strong links in political arenas and enjoy the legitimacy to constructively engage in political decision-making processes. Lobbying also requires institutional entrepreneurs to be recalcitrant. *"You must fight your space. As a small actor, you are easily put aside; "the big players will take care of it". I often had to insist: 'we will remain at the table!'"* (R8). At the same time, flexibility and patience are required as political processes can take a long time and can involve instances where other, bigger parties will claim your success. The deployment of technical and cultural strategies for regime transformation requires institutional entrepreneurs to have analytical and cultural skills, such as the ability to develop teaching materials, generate publicity, and frame an innovation so that it aligns with specific norms and values.

4.4.3.2 *Field-level conditions*

The results suggest various field-level conditions that enable institutional entrepreneurship for decarbonizing the Dutch building stock, but it was difficult to establish to establish a clear link between field-level conditions and specific strategy choices. Yet, it is noted by some that the use of the strategies *lobbying* and *vesting* was enhanced through formal and informal access to political decision-making processes (*political opportunity structure*). As noted in the previous section, the institutional entrepreneurs that opt for these strategies tend to have much experience, and a broad network, in policy circles and are perceived as legitimate actors to access such processes.

The results also support the assumption that *jolts and crises* can be conducive for the institutionalization of low-carbon innovations. Such occurrences generate public and political attention, thereby serving in particular as policy windows for the use of political and cultural strategies for regime transformation. Several empirical examples exist of how institutional entrepreneurs exploited policy windows. For instance, earthquakes in the province of Groningen – caused by gas extraction – have been strategically framed by Energiesprong to promote political support for zero-energy buildings. Likewise, Transition Towns Netherlands maintains that weather extremes and records also offer opportunities for the use of cultural strategies because the public will be more susceptible alternative framings as a result of such events. *"It demonstrates that the current way in which we organize society is not the right way [..] and that structural change is required"* (R11). In addition to jolts and crises, international political developments can also result in policy windows. To illustrate, the signing of the Paris Agreement in 2015 was used by Klimaatverbond to lobby for a facilitative national policy framework and to address regulatory barriers that hinder the transition to a low-carbon building stock, such as the obligation to be connected to the gas grid. All in all, the above signifies that institutional entrepreneurs anticipate policy windows and use such occasions strategically to highlight the weaknesses related to the ways in which societal functions are organized and to stress the need for institutional reform.

The findings suggest that institutional entrepreneurs also strategically make use of societal dynamics, trends, and discourses within the organizational fields in which they operate. The building sector is faced with various challenges, including low margins, higher material costs, lack in manpower, and the demand to respond to societal trends, such as urbanization and climate adaptation. Such developments enhance other actors' susceptibility to alternative practices and willingness to collaborate in the development of innovations that can offer solutions to these challenges. Institutional entrepreneurs endorsing community-based innovations acknowledge that they are the product of – but also make use of- the rise of an ethic of self-reliance among citizens. This trend, which has been termed 'the energetic society' (Hajer, 2001), refers to an increase in associational activity and civic engagement. Motivated by a range of drivers, including the desire to become independent from incumbent organizations or the wish to enhance social capital within the community, citizens and local businesses want to change the ways in which societal functions are organized and increasingly take matters into their own hands.

In sum, the above indicates that the occurrence of institutional entrepreneurship can be ascribed to the influence of broader societal dynamics that create structural opportunities for actors to advance institutional reform. Furthermore, the results suggest that strategy choice of institutional entrepreneurs is also influenced by *the conduct of other actors* and that change may result from the coalescence agency of various actors. This is especially the case for organizations that experience scarcity in terms of human and financial resources. *"We are constantly looking around; what are other doing, and how can we contribute?"* (R12). Yet, while institutional entrepreneurs take the strategies of others into consideration, there is no formal coordination of strategies between them.

Table 4.3 Summary of results. The table provides an overview of the functions of strategies and the factors informing strategy choices.

	STRATEGY	# OF INSTANCES IN DATA	FUNCTION	FACTORS INFORMING STRATEGY CHOICE ACTOR CHARACTERISTICS			FIELD-LEVEL CONDITIONS	
				Problem perception (regime dimension and institutional pillar)	Capacity		*Political opportunity structure*	*Jolts, crises, political developments, sector trends*
					Resources	*Skills*		
	POLITICAL							
NICHE DEVELOPMENT	Visioning	13	– Articulate goals and develop a common direction for all actors working on the innovation	*Internal* – Resource availability to develop and improve the performance of innovations – Insufficient collaboration and learning between niche actors	*Human* – Leadership – Perceived reliability and legitimacy – Coalition of front running actors *Mental* – Interdisciplinary project team with general and specialized knowledge and expertise *Monetary* – Budget to mobilize coalitions	*Organizational* – Being able to set up experiments and expectations; mobilize and coordinate niche actors	n/a	Societal dynamics and sector development and trends. Examples include the challenges experienced by the building sector and the rise of 'the energetic society'
	Coalition-building	13	– Enhance the problem solving capacity of the coalition and make niche actors feel big of a bigger movement – Reflect on institutional configurations around the innovation – Enhance the visibility of the movement and create a constituency on whose behalf can be lobbied for institutional reform					
	TECHNICAL							
	Theorizing	8	– Legitimize how an innovation offers a solution to problems in the regime – Learn about institutional conditions of the regime that need to be transformed	*Internal* – Insufficient collaboration and learning between niche actors – High price of zero-energy building concepts (MB) – Level of professionalization of community energy initiatives to organize retrofits (CB)	*Human* – Coalition of front running actors *Mental* – Interdisciplinary project team with general and specialized knowledge and expertise *Monetary* – Budget to finance experiments and research *Natural* – Space, land *Artefactual* – Buildings; technologies	*Analytical* – The ability to develop abstract models and representations of an institution (mental models, cause-and-effect schemata, projections) *Organizational* – Being able to set up experiments and expectations; mobilize and coordinate niche actors		
	Standardizing	10	– Develop a common language among actors applying the innovation – Enhance the efficiency and effectiveness of innovations					
	Construction of a learning community	6	– Generate and disseminate experiences, knowledge and skills concerning the innovation					

Table 4.3 Continued

	STRATEGY	# OF INSTANCES IN DATA	FUNCTION	FACTORS INFORMING STRATEGY CHOICE ACTOR CHARACTERISTICS			FIELD-LEVEL CONDITIONS	
				Problem perception (regime dimension and institutional pillar)	Capacity		*Political opportunity structure*	*Jolts, crises, political developments, sector trends*
					Resources	*Skills*		
REGIME TRANSFORMATION	**POLITICAL**							
	Visioning	13	– Gain political support and broaden the coalition around the innovation	*Policy, cognitive pillar* – Insufficient political leadership *Market, cognitive pillar* – Risk aversion/ High risk perception *Socio-cultural, cognitive pillar* – Insufficient sense of urgency for energy conservation	*Human* – Perceived legitimacy – Connections in policy networks *Mental* – Expertise on policy and regulatory conditions and developments *Monetary* – Budget to finance strategies	*Political* – The ability to communicate a clear vision for change and connect the innovation to different interests and needs *Cultural* – Ability to represent the innovation so that it appeals to a broader audience	Access to political decision-making procedures	Events and crises, such as climate change, earthquakes caused by gas extractions and international policy developments
	Coalition-building	13	– Broaden the niche and political constituency behind an innovation	*Industry, cognitive pillar* – Sector fragmentation and lack in collaboration in organizing energy retrofits				
	Lobbying	6	– Creating policy conditions facilitative for diffusion; address barriers related to the policy dimension of the regime	*Policy, regulative pillar* – Legislation concerning mortgages for energy retrofits – Legislation concerning property valorization; insufficient valorization of energy efficient buildings – Legislation concerning use of energy performance contract; landlords legally not allowed to change an energy performance fee – Insufficient economic valorization of energy efficient buildings and no instruments for the economic valorization of energy efficient buildings – Insufficient political leadership – Regulatory obligation to be connected to the gas grid – Tax schemes for community energy				
	Vesting	4	– Creating policy conditions facilitative for diffusion; address barriers related to the policy dimension of the regime					

Table 4.3 Continued

STRATEGY	# OF INSTANCES IN DATA	FUNCTION	FACTORS INFORMING STRATEGY CHOICE ACTOR CHARACTERISTICS			FIELD-LEVEL CONDITIONS	
			Problem perception (regime dimension and institutional pillar)	Capacity		*Political opportunity structure*	*Jolts, crises, political developments, sector trends*
				Resources	*Skills*		
TECHNICAL							
Educating	9	– Encouraging and enabling actors outside the niche to apply the innovation by providing them with skills and know-how	*Market, cognitive pillar* – Risk aversion; High risk perception to zero energy buildings and retrofits; uncertainty concerning the performance of zero energy building concepts *Science, cognitive pillar* – No scientific consensus on how to achieve zero energy buildings and a low-carbon building stock *Socio-cultural, cognitive pillar* – Insufficient awareness about the benefits and possibilities of energy conservation among building owners; risk aversion	*Human* – Team members who are effective in communication and instructing *Mental* – Interdisciplinary project team with general and specialized knowledge and expertise *Monetary* – Budget to finance strategies	*Analytical* – The ability to develop abstract models and representations of an institution *Cultural* – The ability to represent an innovation so that is appeals to a broader audience; ability to instruct other actors about the benefits and impacts of an innovation	N/a	
Demonstrating	13	– Reducing risk perception concerning the innovation among supply- and demand-side actors – Enhancing the legitimacy of an innovation as a solution to a problem					
CULTURAL							
Awareness raising activities directed at changing normative associations	8	– Change people's perceptions concerning an innovation or dominant ways of organizing societal functions – Create a sense of political urgency among the public	*Socio-cultural, cognitive pillar* – Insufficient awareness concerning the possibilities and benefits of energy conservation among building owners. *Socio-cultural, normative pillar* – Insufficient sense of energy for energy conservation	*Human* – Local operating team who have access to, and are trusted by, households – Perceived legitimacy and credibility *Mental* – Interdisciplinary project team with knowledge on values and needs of different target audiences. *Monetary* – Budget to finance strategies	*Cultural* – The ability to represent an innovation so that is appeals to a broader audience; ability to instruct other actors about the benefits and impacts of an innovation	N/a	

4.4.4 Reflection on the results

Table 4.3 offers a summary of the functions of strategies and factors informing strategy choices. The empirical insights suggest that actor characteristics and certain field-level conditions are conducive to institutional entrepreneurship and the use of specific strategies for the institutionalization of low carbon innovations. As important differences have been observed in terms of strategies for niche development and regime transformation and the rationales behind strategies employed by actors endorsing market-based and actors promoting community-based innovations, we propose that a typology of approaches can be developed based on these two characteristics (see Figure 4.1). Shared goals and a combination of strategies to achieve such goals characterize the different approaches. Of course, it must be emphasized that the typology illustrated in Figure 4.1 is an analytical classification. The empirical reality is more messy and dynamic. Institutional entrepreneurs generally fall within more than one category, or change from classification over time.

Approaches for niche development involve the deployment of political, technical, or cultural strategies with the objective to cultivate innovations and to create novel institutional arrangements around it. Institutional entrepreneurs engage in political strategies, such as visioning and coalition-building, to develop a common vision for how the innovation can contribute to a low-carbon future and to strengthen the capacity and visibility of the niche. Technical strategies, including standardization, theorization, and the construction of learning communities, are used to improve the efficiency, effectiveness, and legitimacy of innovations in fulfilling societal functions.

Actors promoting community-based innovations also actively strive to create new identities, a cultural strategy, so as to develop a sense of belonging and community among distinct local niche actors. The strategies 'construction of learning communities', 'visioning', and 'coalition-building' align with activities that have been identified within theory on strategic niche management, namely 'assisting learning processes', 'articulating expectations', and 'networking' (Schot & Geels, 2008). Institutional entrepreneurs apply strategies for niche development to address internal barriers related to resource availability, the performance of the innovation, and lack in collaboration and learning among niche actors. While actors endorsing market-based innovations primarily focus on barriers related to the price-performance ratio of zero-energy building concepts, actors promoting community-based innovations concentrate on improving the professional capacity of community energy initiatives.

INSTITUTIONAL FIELD CONDITIONS:

- *Jolts or crises:* Weather extremes caused by climate change; Earthquakes caused by gas extractions; International policy developments, such as the Paris Agreement
- *Societal dynamics and sector trends:* 'The energetic society'; Challenges faced by the building sector
- *Political opportunity structure:* Ability to access decision-making structures required for regime transformation strategies
- *Activities of other actors:* Actors take the strategies of other actors into account and react to each other

REGIME TRANSFORMATION

STRATEGIES

Political: Visioning; Coalition-building; Vesting; Lobbying

Technical: Demonstrating; Educating

ACTOR CHARACTERISTICS

Problem perception

Innovation incompatible with cognitive and regulative pillars of industry, market, and policy regime dimension.

Capacity

Resources: Human; Monetary; Mental.

Skills: Political

EXAMPLES

Lobbying for, and drafting, new regulations concerning the valorization of energy efficient buildings; organizing training sessions and workshops for industry and market actors

STRATEGIES

Political: Visioning; Coalition-building; Vesting; Lobbying

Technical: Demonstrating; Educating

Cultural: Awareness raising activities directed at changing normative associations

ACTOR CHARACTERISTICS

Problem perception

Innovation incompatible with regulative, cognitive, and normative pillars of policy and socio-cultural regime dimension

Capacity

Resources: Human; Monetary; Mental.

Skills: Political; Cultural

EXAMPLES

Public engagement and awareness programs in neighbourhoods and schools; lobbying for a greater role for community energy initiatives in the implementation of local climate policy

MARKET-BASED INNOVATION

STRATEGIES

Political: Visioning; Coalition-building

Technical: Standardizing; Theorizing; Constructing learning communities

ACTOR CHARACTERISTICS

Problem perception: Internal barriers: lack in collaboration and learning among niche actors; high price and uncertainty of performance of retrofit concepts

Capacity

Resources: Human; Mental; Monetary; Natural; Artifactual

Skills: Analytical; Organizational

EXAMPLES

Creation of a community of practice to develop and improve the performance of zero-energy building concepts ; development of a certification scheme for zero-energy building concepts

COMMUNITY-BASED INNOVATION

STRATEGIES

Political: Visioning; Coalition-building

Technical: Standardizing; Theorizing; Constructing learning communities

Cultural: Creation of new identities

ACTOR CHARACTERISTICS

Problem perception: Internal barriers: lack in collaboration and learning among niche actors; insufficient capacity and professionalization of community energy initiatives

Capacity

Resources: Human; Mental; Monetary; Natural; Artifactual

Skills: Analytical; Organizational

EXAMPLES

Creation of a community identity; Organizing events and creating a community of practice to share experiences and best practices

NICHE DEVELOPMENT

Figure 4.1 Typology of approaches for promoting the institutionalization of low-carbon innovations.

Institutional entrepreneurs can also mobilize their resources for strategies directed at transforming the regulative, cognitive, and normal pillars of regime dimensions. Political strategies are used to broaden support for the innovation and to create a supportive policy environment. Technical strategies, such as educating and demonstrating, are used to spread skills and know-how required for diffusion and to reduce risk perceptions concerning the innovation. Political and technical strategies for niche development differ from political and technical strategies for regime transformation. While the former are targeted at niche actors and have the objective to strengthen the niche, the latter are directed towards regime actors with the aim to create external, institutional conditions that are favorable for diffusion of the innovation. Institutional entrepreneurs promoting community-based innovations also apply cultural strategies to activate public values for sustainability. Institutional entrepreneurs' problem perception influences the underlying rationale and function of the strategies for regime transformation. Actors endorsing market-based innovations use these strategies to address cognitive and regulatory pillars of industry, market, and policy dimension of the regime. Actors supporting community-based innovations apply these strategies to address cognitive, regulatory, and normative pillars of the policy and socio-cultural dimension of the regime.

Figure 4.1 depicts that field-level conditions are conducive to institutional entrepreneurship and can inform strategy choices. As suggested by previous studies, jolts and crises lead to uncertainty and criticism concerning dominant ways of organizing societal functions and thus offer opportunities for the introduction of alternative practices and technologies (see Battilana et al., 2009; Hardy & Maguire, 2008). Due to the political and public attention generated during such 'policy windows', political and cultural strategies for regime transformation are considered especially promising (see Meyer, 1982). Additionally, societal dynamics, trends, and discourses influence the way in which institutional entrepreneurs frame their innovation and strive to achieve goals. Other field-level conditions that can influence strategy choices include the activities of others and political opportunity structure. The latter is in particular important for the deployment of political strategies for regime transformation, as these require formal and informal connections to political decision-making procedures.

While certain approaches demand particular resources and skills, there is also substantial overlap in capacity required for strategies. Contrary to expectations, this study did not find a one-to-one relationship between political, technical, and cultural strategies and political, analytical, and cultural skills respectively (Perkmann & Spicer, 2008). Moreover, to coordinate niche actors and implement experiments for niche development, institutional entrepreneurs must also possess organizational skills -a category of skills not previously identified in literature (see Perkmann & Spicer, 2008). In all, the results suggest that institutional entrepreneurs must be multi-skilled and possess a plurality of resources. In fact, as strategies 'compete' for resources and skills, it could be argued that institutional entrepreneurs should carefully consider how their capacity is best served to accomplish their goals. Yet, the results imply that strategy choices often result from experiences or personalities of individuals in high-level positions in field and are therefore often more emergent than intended.

As the institutionalization of low-carbon innovations encapsulates a process of creating new institutions and transforming existing ones, we propose that greatest success is achieved when institutional entrepreneurs apply strategies for both niche development and regime transformation. The case study suggests that institutional entrepreneurs first mobilize resources to develop the niche,

and subsequently take actions aimed at creating institutional conditions favorable for its diffusion. Particularly institutional entrepreneurs that experience limitations in terms of capacity and those promoting community-based approaches, mobilize the bulk of resources for niche development. As illustrated by a respondent from Transition Towns Netherlands: *"Initiatives are generally set-up by enthusiastic individuals who wish to work on concrete, local projects"* However, *"while such local initiatives are a visible manifestation of our vision for low-carbon development, they are not the final goal"* (R11). Accordingly, it is critical that institutional entrepreneurs combine niche development with strategies for regime transformation. Also, it is deemed valuable to strengthen the relationship between strategies for niche development and regime transformation because experiences from 'the ground' can be used to legitimize and demonstrate the need for institutional change. Yet, to do this, institutional entrepreneurs with limited capacity should excel in certain strategies for regime transformation, rather than risking failing at all, or co-ordinate their strategies with other institutional entrepreneurs in the field in order to achieve maximum effect (see Dorado, 2005).

4.5 CONCLUSION

Literature on sustainability transitions advocates the institutionalization of niche innovations and assigns an important role for institutional entrepreneurship in this respect. Underexplored and under-theorized, however, are the strategies used in such a process. This paper has three findings that enrich literature and practice concerning the governance of sustainability transitions. First, it has presented an arsenal of strategies that can be applied to promote the institutionalization of low-carbon innovations through niche development and regime transformation. Insights are provided into the activities and everyday strategies that institutional entrepreneurs employ for accomplishing their vision for a low-carbon future. Second, this paper contributes to an improved understanding of factors informing actors' strategy choice and shows that both actor characteristics and field-level conditions explain strategy choices. In particular, actors' problem perceptions with respect to barriers hampering the institutionalization of their innovation influences the type and function of strategies applied. Third, a new typology of approaches has been proposed based on whether actors focus on niche development or regime transformation, and support market-based or community-based innovations. The typology illuminates the different pathways for accelerating the low-carbon transition. An embedded case study design of institutional entrepreneurship for a low-carbon building stock in the Netherlands served to illustrate how actors transform their institutional environment and why and how they opt for certain strategy choices. As an explorative case study, the findings have limitations in terms of generalizability. Yet, our findings suggest that the analytical framework allows for a systemic understanding of how the institutionalization of low-carbon innovations can be governed and how this can be explained. It can be a useful tool for assessing and comparing institutional entrepreneurs' goals and strategies. Moreover, it can be used *ex ante* to examine capacity required for the different strategies and to help predict actors' likelihood in success. We suggest that the analytical framework and typology of approaches are applied to more cases in order to enhance their applicability and to determine whether our observations are applicable in other sectors and contexts. Examining how and why institutional entrepreneurs try to decarbonize other sectors in different countries can further improve

our understanding about the relationships between context and strategies. In addition, longitudinal studies should be conducted to assess the impact of institutional entrepreneurs' endeavors in transforming their institutional environment. We believe that theory and empirical findings regarding these issues are critical for academics and practitioners in understanding and advancing the transition to low-carbon societies.

5 LEARNING WITHIN LOCAL GOVERNMENT TO PROMOTE THE SCALING-UP OF LOW-CARBON INITIATIVES: A CASE STUDY IN THE CITY OF COPENHAGEN

Abstract | Local governments are experimenting with low-carbon initiatives (LCIs) to learn how the transition to low-carbon cities can be advanced. However, while there may be a significant amount of learning within such initiatives, little is known about how local governments can capitalize lessons and use it to accelerate scaling-up processes, e.g. by sharing lessons among actors involved in other LCIs or by removing institutional obstacles identified by actors experimenting with LCIs. This paper contributes to theory on climate governance and sustainability transitions by exploring the complex relationship between low-carbon initiatives and learning processes at the level of the local government. The issue is examined through an explorative embedded case study in the City of Copenhagen, a sustainability frontrunner. The paper has three contributions that can enrich literature and practice concerning climate governance for sustainability transitions. First, it offers an overview of the type of knowledge that can be derived from low-carbon initiatives and reflects on how such knowledge can be used to accelerate scaling-up processes. Second, the paper provides a concrete overview of learning practices for governing learning processes within local government. Finally, the paper offers an overview of explanatory factors, which can act as barrier or drivers, for learning.

Submitted as | Van Doren. D., Driessen, P.P.J., Runhaar, H.A.C., & M. Giezen (2017). Learning within local government to promote the scaling-up of low-carbon initiatives: A case study in the City of Copenhagen.

5.1 INTRODUCTION

Theory on urban climate governance and sustainability transitions highlight the important role of experimentation with low-carbon, socio-technical innovations in order to learn how low-carbon transitions can be advanced (e.g. Brown & Vergragt, 2008; Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013; Geels & Deuten, 2006; Geels & Raven, 2006; Hoffman, 2011; Kivimaa et al., 2017; Schot & Geels, 2008 Sengers et al., 2016). In particular local governments play a prominent role in experimentation for sustainability transitions as cities represent a significant part of global GHG emissions and local governments show farsighted leadership in addressing climate change (Bulkeley, 2010; Castán Broto & Bulkeley 2013; Covenant of Mayors, C40, 2017; ICLEI, 2016; McGuirk et al., 2015; Schreurs, 2008; Selman, 1998). In their endeavor to foster low-carbon urban development, local governments are increasingly leading and enabling the implementation of low-carbon initiatives (henceforth: LCIs or initiatives), such as the retrofitting of building districts or creation of eco-districts, in which they experiment with low-carbon, socio-technical innovations that have the potential to contribute to sustainable societal change (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013).

Theory on sustainability transitions suggests that all forms of experimentation with LCIs occur in protected spaces called 'niches', that offer resources and conditions (e.g. through public support structures or specific market segments), that shield the innovation from the selection pressures of the dominant institutional structure of the regime and allow it to develop (Geels & Raven, 2006; Smith & Raven, 2012). However, it is important that the community of practitioners learns from LCIs, implemented in a temporary space and scale, so that scaling-up processes can be encouraged (Brown & Vergragt, 2008; Bulkeley, 2006; Castán Broto & Bulkeley, 2013; Hoffman, 2011; Kemp et al. 2007; Kivimaa et al., 2017; Sengers et al., 2016). The concept of 'scaling-up' means that LCIs increase their impact in terms of low-carbon development and can result from horizontal and vertical scaling-up (van Doren et al., 2017). Horizontal scaling-up refers to the spatial growth of an initiative or parts thereof as a result of internal growth, replication or the uptake of similar initiatives. Vertical scaling-up occurs when the knowledge generated by LCIs leads to institutional change favorable to the low-carbon innovations implemented in LCIs (related to the concept of 'regime transformation', Smith & Raven, 2012).

While experimentation -and learning from LCIs is considered an important way in which urban climate governance is conducted (Bulkeley, 2006; Castán Broto & Bulkeley, 2013; Kivimaa et al., 2017) the role of local government – a critical actor in low-carbon transitions – in governing learning processes remains underexplored. Previous scholars argue that knowledge and experiences from initiatives often remain stuck within the local project team, resulting in the fact that others have to 'reinvent the wheel' (Geels & Deuten, 2006). Knowledge loss at the end of LCIs can lead to an increase in costs, redundant work, the repetition of mistakes, and loss of relevant knowledge, thereby hampering the scaling-up of LCIs. Moreover, when local governments fail to learn from LCIs, the initiatives can be criticized for being isolated, fragmented, or stand-alone initiatives that do not contribute systematically to climate governance (Hoffman, 2011; Kivimaa et al., 2017; McGuirk et al., 2015). Therefore, to be at the forefront of climate governance, local governments need to learn from previous experiences and embed relevant knowledge from LCIs into local decision-making structures so that it can be used for scaling-

up processes. This paper will explore the complex relationship between LCIs and learning processes at the level of the local government. The questions that are addressed in this paper is the following: *How can local governments learn from low-carbon initiatives to contribute to their scaling-up?* To reflect on this question, insights from theory on urban climate governance and sustainability transitions are complemented with theory on organizational learning. The research question is empirically investigated through an exploratory embedded case study of six LCIs focused on decarbonizing the building stock in the city of Copenhagen. The city of Copenhagen represents a relevant case as it has set the ambition to become the first carbon-neutral capital in the world and implements LCIs to learn how it can achieve this objective (City of Copenhagen, 2009).

Section 5.2 will start with an introduction of the key concepts and analytical framework guiding this paper. Section 5.3 will elaborate on the research design, followed by an overview of the results in section four. The paper will conclude with a reflection and discussion about the policy implications of the findings.

5.2 ANALYTICAL FRAMEWORK

To reflect on the research question addressed in this paper, use has been made of theory on urban climate governance (Bulkeley, 2006, 2010; Bulkeley & Castán Broto & Bulkeley, 2013; Bulkeley & Kern, 2006; Klein Woolthuis et al., 2013; Schreurs, 2008; Yohe, 2001), theory on sustainability transitions (Geels, 2004; Geels & Deuten, 2006; Schot & Geels, 2008; Smith & Raven, 2012), and theory on organizational learning (Hansen, Nohria & Tierney, 1999; Lam, 2010; Moorman & Miner, 1998; Prencipe & Tell, 2001; Senge, 1993; van der Vegt, & Bunderson 2005; Zollo & Winter, 2002).[3] However, as these bodies of literature are large and as various comprehensive overviews of the literature exist (see Betsill & Bulkeley, 2007; Rashman, Withers, & Hartley, 2009; Schot & Geels, 2008; Wang et al., 2003), we will not try to replicate such work here but rather give a synthesis of key findings regarding the following themes: learning outcome, learning output, learning practices, and explanatory factors for learning[4].

5.2.1 Learning outcome

Building on insights from organizational learning, it is suggested that local government has learned from LCIs when inferences from previous LCIs are used to guide future conduct and decision-making on scaling-up processes (Levitt & March, 1988; Scarbrough et al., 2004). It is important to emphasize that *"learning need not result in observable changes in behavior. An entity learns if, through its processing of*

[3] Within sustainability transitions theory, various studies have been conducted that reflect on learning practices in furtherance of niche development that are helpful for understanding how local government can learn from LCIs. Theory on climate governance has, to our knowledge, not yet explicitly addressed the issue of learning, but offers insights on factors that influence cities' ability to act on climate change, which we consider to be a relevant for realizing initiatives and using lessons for the promotion of scaling-up processes. Because processes of knowledge creation and knowledge transfer within organizations are central themes in theory on organizational learning, it offers valuable insights on how local governments can promote learning from LCIs.

[4] A more detailed overview of the literature review is available on request.

information, the range of its potential behavior is changed" (Huber, 1991, p. 89). Accordingly, we maintain that learning does not always result in observable scaling-up processes (i.e. 'impact'), but can also occur when the knowledge from previous LCIs is used *as a reference* for future scaling-up processes, i.e. for the implementation of new initiatives (horizontal scaling-up) or for addressing hampering institutional conditions (vertical scaling-up) (Huber, 1991; Mastop & Faludi, 1997).

5.2.2 Learning output

Based on theory organizational learning and sustainability transitions, we maintain that LCIs generate tacit knowledge, that tends to be locally applicable, in specific geographical places. It can relate to, amongst others, local problems, possibilities, needs, resource capacity, and skills. While local knowledge is highly context- and project-specific, the experiences of individual LCIs can, through learning practices (see section 5.2.3), be aggregated into abstract 'global' knowledge, which has more formal and abstract features (Geels & Deuten, 2006; Rip, 1997).

Moreover, building on Argyris and Schön's (1978) well-known framework on single-and double loop learning in organizations, a distinction can be made between 'instrumental' and 'transformative' global knowledge. Instrumental knowledge refers to practical skills, strategies, and insights on cause-and-effect relationships between interventions and outcomes, that is related to single-loop learning. This type of knowledge has a practical nature and is related to issues of effectiveness and goal-attainment (Argyris & Schön, 1978). It can lead to insights as to the 'what works and why?' of LCIs. For instance, LCIs can generate knowledge related to technical aspects, design specifications of innovations, user preferences, and by demonstrating the evidence-base for innovations ('proof of concept'). In addition, LCIs offer insights into successful approaches or strategies contributing to project success. However, whereas instrumental knowledge can be used to strengthen the innovations experimented with in LCIs and can contribute to horizontal scaling-up processes, the interpretation of the policy problem and dominant institutional structures remain intact.

Transformative knowledge, on the other hand, includes insights concerning the underlying assumptions, values, structures, problem perceptions or goals underlying LCIs, which leads to double-loop learning (Argyris & Schon, 1978). It may comprise reflections on the institutional structures of the industry, market, policy, or socio-cultural context that need to be in place in order for large-scale application of the innovation to be possible. Double-loop learning is linked to institutional change because it deals with altering cognitive frames and perceptions on established, 'taken-for-granted' rules and systems related to a policy issue. Transformative knowledge can be used for vertical scaling-up processes directed at transforming the institutional environment in favor of the innovations experimented with in the LCIs.

5.2.3 Learning practices

Theory on sustainability transitions maintains that the creation of explicit, global knowledge requires dedicated aggregation work, during which tacit, local knowledge is 'delocalized' and transformed

into general rules (Geels & Deuten, 2006). Examples of such activities include model building, standardization, writing of handbooks, and the formulation of best practices. Through systemic knowledge aggregation from local projects, global knowledge becomes more articulated, stable and specific (Schot & Geels, 2008).

Scholars in the field of organizational learning argue that the process of organizational learning occurs through various (not necessarily succeeding) practices: knowledge accumulation; knowledge articulation; knowledge codification and knowledge distribution (Dixon, 1994; Hansen et al., 1999; Nonaka, 1994; Zollo & Winter, 2002). 'Knowledge accumulation' encompasses the relatively passive process of learning through experiences. 'Knowledge articulation' involves a more deliberative process through which individuals and groups learn by reflecting on what works and what doesn't in the execution of projects or tasks (Zollo & Winter, 2002). Knowledge articulation leads to an improved understanding of causal relationships and can promote double-loop learning through collective reflections (Argyris & Schön, 1974). After knowledge has been articulated, organizations can initiate a phase of 'knowledge codification', during which the articulated knowledge is codified in written tools, such as best practices or case study guides, and stored in databases or libraries where others can access it. Finally, knowledge can be distributed using a codification or personification strategy (Hansen et al., 1999). While a codification strategy builds on the sharing of codified knowledge through impersonal tools, such as (online) databases, a personification strategy encapsulates practices to share knowledge through direct person-to-person contact (Hansen et al., 1999).

5.2.4 Explanatory factors for learning

The different bodies of literature also offer insights on factors conducive for learning from LCIs. From the literature analysis, three key groups of factors emerge, namely: motivation, resources, and skills. 'Motivation' includes climate leadership and a willingness among politicians or persons on strategic positions to accelerate the low-carbon transition (Bulkeley, 2010; Bulkeley & Kern, 2006; Kingdon, 1995). Political leadership is expected to influence the resources available for experimentation with low-carbon innovations (Betsill, 2001; Granberg & Elander, 2007; Kasioumi, 2011; Romero-Lankao, 2012; Schreurs, 2008). Furthermore, commitment on behalf of employees (Senge, 1993), and 'a co-operative organizational culture' (Zollo & Winter, 2002) are expected to foster learning processes. Second, it is expected that a local government's resource capacity can influence its ability to learn from LCIs (Bulkeley & Kern, 2006; Fichman & Kemerer, 1997; Geels & Deuten, 2006; Holgate, 2007; van der Vegt & Bunderson, 2005; Yohe, 2001). Finally, it is suggested that a local government's capacity to learn from LCIs is influenced by the skills of project leaders and program coordinators to encourage discursive processes and critical reflections, such as intermediation and cooperation skills (Bulkeley & Kern, 2006; Geels & Deuten, 2006, 2007; Klein Woolthuis et al., 2013; van der Vegt & Bundeson, 2005).

5.2.5 A conceptual model to examine how local governments can learn from low-carbon initiatives

Building on our findings from the literature review, a conceptual model is proposed that can be used to study how local governments can learn from LCIs to promote their scaling-up (see Figure 5.1). The empirical case study will be used to explore and concretize practices related to the learning practices and explanatory factors, acting as driver or barrier, to learning. It is important to note that the empirical analysis will be used study how factors and learning processes influence learning *outcomes*, and not focus on the *impact* of learning, i.e. scaling-up processes.

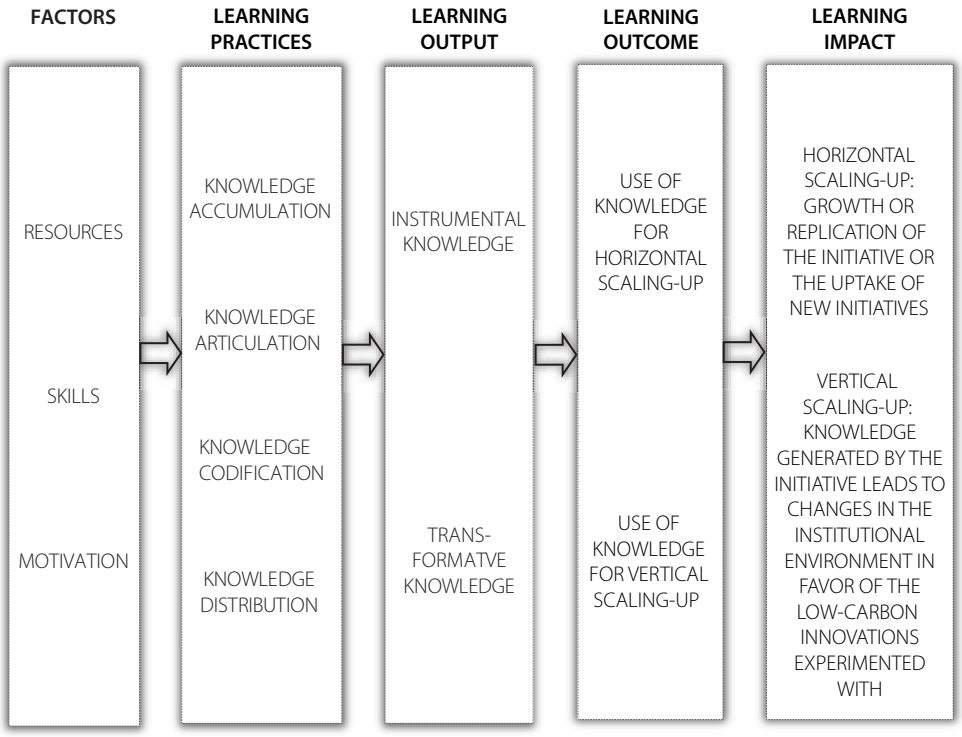

Figure 5.1 Ideal typical model representing the process of learning from low-carbon initiatives.

5.3 RESEARCH DESIGN

To explore how local government can learn from LCIs to promote scaling-up processes, an embedded case study design was adopted. This means that we have selected one city as a case study, and studied various LCIs within that city as sub-units of analysis (Yin, 2014). We have chosen the city of Copenhagen as our general case. The City of Copenhagen constitutes an interesting case as it has set the goal to become the first carbon neutral capital of the world by 2025 (City of Copenhagen, 2012, 2016)

and is actively supporting the implementation of LCIs to learn how the transition to a low-carbon Copenhagen can be achieved. Through desk research and four informant interviews, a selection was made of seven LCIs focused on energy conservation in the existing building stock. A selection of LCIs representing different types of building stocks was made to allow for diversity in knowledge generated and actors involved. Case selection has also been based on pragmatic reasons, such as the availability and willingness of stakeholders involved in the LCIs to participate in an interview. Table 2 offers an overview of the key characteristics of the LCIs studied.

To answer the questions guiding this paper, four key research steps were conducted. The first step was to identify the instrumental and transformative knowledge generated by the LCIs. The second step was to assess whether local government has learned from the LCIs by examining to what extent the instrumental and transformative knowledge generated by LCIs had been used for respectively horizontal and vertical scaling-up. Third, learning practices applied by the project team and department were identified. Finally, it was explored how the (lack of) learning could be explained, by identifying factors – related to motivation, resources, or skills - that enabled or hampered learning. Desk research and 19 semi-structured interviews have been conducted to collect the necessary data. First, 13 semi-structured interviews with key actors involved in the LCIs (such as project managers) were held. Interviews followed a basic script during which respondents were asked to reflect on the following themes: key instrumental and transformative knowledge derived from the LCI, the influence of the knowledge on scaling-up processes, and learning practices and factors that had hampered or enabled learning. Semi-structured interviews were deemed suitable as it allowed us to systematically address all research themes, but to also allow for flexibility and exploration of learning practices and explanatory factors for learning that had not been previously discussed in literature. In addition, six policy-makers were interviewed to reflect on the results and to discuss general learning practices within the organization. All interviews were transcribed and summarized. An overview of the interviewees, who have been anonymized in order to maintain respondent confidentiality, can be found in Appendix D. Appendix E provides an overview of the questionnaire and indicates how the data was coded.

Conclusions concerning practices and factors explaining (the lack of) learning are based on the inter-subjectivity of responses (Scheff, 2006). Empirical examples and quotes of the respondents are used to illustrate the findings. The result section will start with an introduction to the case and LCIs. This is followed by an overview of the types of knowledge generated by the LCIs, as assessment of learning, and an overview of practices and factors enabling and hampering learning. Due to space constraints, the results are presented at aggregation level. It is important to note that the cases are illustrative, rather than representative, as the key goal is to explore how local governments can learn from LCIs, thereby promoting the scaling-up of LCIs.

5.4 RESULTS

5.4.1 Introduction to the case

5.4.1.1 *Towards a carbon neutral Copenhagen*

The City of Copenhagen has the political ambition to become the first carbon neutral capital of the world in 2025. In 2009, the City Council adopted the Climate Plan for Copenhagen. This plan sets out the policy for achieving a 20% CO2 in 2015 and a vision for becoming carbon neutral in 2025. Copenhagen's Climate Plan reflects that both economic and normative rationales underlie the City's ambition to become carbon neutral. *"Copenhagen as a Metropolis and capital must assume responsibility for the climate and show that it is possible to generate growth while also reducing CO2 emissions"* (City of Copenhagen, 2012, p. 8). Because Denmark has traditionally experienced a strong energy dependency, investing in energy conservation and renewable energy sources is considered financially rational, particularly in light of the rising price of fossil fuels. Moreover, by acting as frontrunner in the field of low-carbon urban development, the City can attract pioneering companies with green ambitions, which will in turn leverage innovation, new jobs, and investments (ibid, p. 8). The notion that becoming a carbon neutral city acts as a leverage for green growth is illustrated by the following reference from the Climate plan: *"The transition is one of the key elements to increasing increased economic growth in Copenhagen. The city must attract more foreign businesses within the green sector and must establish an innovation and entrepreneurial environment able to support the development of new solutions"* (ibid, p. 26). Carbon neutrality implies a net zero carbon footprint and means that unavoidable carbon emissions may be compensated through carbon sequestration initiatives or investments in renewable energy. Carbon neutrality is to be achieved through a variety of measures in different sectors. The majority of CO2 reductions – 74% – will be in the area of energy production through an increase in renewable energy and switching from coal to biomass in the CHP plants for district heating. The remaining reductions are to be achieved from initiatives in transport (11%), energy consumption (7%), city administration (2%), and other areas (6%) (City of Copenhagen, 2012).

5.4.1.2 *Decarbonizing Copenhagen's building stock*

Reducing the energy consumption of buildings is a great opportunity and challenge for decarbonizing Copenhagen. *"The building stock is responsible for the major part of the city's energy consumption"* (City of Copenhagen, 2016, p. 29). As energy consumption requirements for new buildings are tightened regularly in accordance with the European Directive on the Energy Performance of Buildings, the greatest challenge lies in reducing the carbon footprint of existing buildings. Studies show that there is a great potential to make existing buildings more energy efficient as the great majority (70%) of buildings were built before the first building regulations were in place (ibid). Reducing the energy consumption of the existing building stock generates economic and social benefits; it is expected to lead to lower energy costs and an improved indoor climate, resulting in increased productivity and health for building users. Reducing energy consumption in buildings is also imperative for minimizing investments in renewable energy production. This is reflected by a quote of the Mayor of Technical and

Environmental Affairs of the City of Copenhagen: *"We must develop methods to jump-start large-scale retrofitting of our buildings. Failure to do so will greatly increase the costs of our transition to a low-carbon future, as it will mean a greater need for energy production capacity"* (ibid). The City aims to systematically improve the energy performance of its buildings. Goals regarding energy consumption include a 20% reduction in heat consumption, a 20% reduction of electricity consumption in commercial and service companies and a 10% reduction of electricity consumption in households compared to 2010 (ibid). Yet, practice shows that achieving these goals is challenging. *"The rate of retrofitting in Copenhagen remains slow, despite the enormous potential for energy savings"* (ibid, p. 22). Fortunately, various successful LCIs have been implemented that can offer valuable knowledge on how the City can accelerate the decarbonization of the building stock.

5.4.1.3 *Key characteristics of the low-carbon initiatives*

The LCIs studied vary in size, scope, objectives, and type of building stock (see Table 5.1). Four of the LCIs are sustainable urban renewal projects in residential buildings: 'Ryesgade', 'Klimakarre', 'Sydhavnen', and 'Hedebygade'. Each year various urban renewal projects are carried out in Copenhagen, which present opportunities for deep retrofitting. These LCIs demonstrate how buildings with an architectural value can be retrofitted and how building users can be involved to promote optimal use of the buildings. The objective of the LCI 'Carbon 20' was to reduce the GHG emissions of small and medium enterprises in the city with 20% through improvements in energy efficiency. The LCI 'Energy Leap' ('Energispring') is a growing partnership program between the City of Copenhagen and major building owners, landlords, housing associations, and administrators committed to reducing energy consumption in their buildings. The final LCI relates to pilot projects with energy management and refurbishment of technical installations in the City's own building mass, such as municipal offices, libraries, sport arenas, and day-care centers.

5.4.2 Learning from low-carbon initiatives

5.4.2.1 *Learning output*

Tables 5.2 and 5.3 summarize the findings on knowledge derived from the LCI. Themes regarding instrumental knowledge -what and how of LCIs- relate to the importance of taking user behavior into consideration and promoting user involvement for achieving predicted energy savings. Also, the findings show that it is important that there is continuous monitoring of innovations and that optimal energy use can be promoted through energy management. Transformative knowledge includes critical reflections on institutional barriers that need to be addressed to promote the large-scale applications of the innovations experimented with in the LCIs. Key issues that emerge from the data include the need to increase awareness and priority regarding energy conservation among building

Table 5.1 Summary of characteristics of the LCIs studied in this paper.

CASE	RYESGADE 30	KLIMAKARRÉ	URBAN RENEWAL SYDHAVNEN	HEDEBYGADE	CARBON 20	ENERGY LEAP	ENERGY PILOT PROJECTS
Building type	Residential buildings	Residential buildings	Residential buildings	Residential buildings	Commercial building (SMEs)	Buildings owned by big building owners, administrators, and housing associations	Municipal buildings
Goals	Deep retrofitting of a historical multistory building; 32 homes built in 1896 and creation of penthouses on the roof of building	Urban renewal of building district to create a climate resilient city district; Development of cost-effective solutions for energy conservation with a high technical and architectural value	Sustainable urban renewal project with the aim to improve the quality of the district's buildings. Other goals include improvement of quality of urban spaces and improve neighborhood viability and cultural life	Sustainable urban renewal project in the Vesterbro district. In addition to urban renewal of 19 5-story blocks, 12 demonstration projects were carried out to demonstrate urban ecology solutions	Reducing energy consumption of SMEs by 20% through technical and behavioral measures	Reducing energy consumption in the buildings of Copenhagen's major building owners, landlords, housing associations, and administrators.	In-house pilot projects focusing on energy monitoring and energy management and BMS systems
Time period	**2012**	**2013–2018**	**2014–2019**	**1995–2004**	**2011–2013**	**2015–present**	**2015–2018**
Initiator and financer	Initiator: private developer (Drost Fonden). Co-financers: urban renewal department City of Copenhagen; Krydsrum architects	Initiator and financer: urban renewal department of the City of Copenhagen; Henning Larsen Architects	Initiator and financer: urban renewal department City of Copenhagen	Initiator: urban renewal department, City of Copenhagen; co-financer: Ministry of Housing and Urban Affairs of the National government	Initiator and financer: LIFE+; project manager: Gate21; partners: 7 municipalities; 2 universities (Aalborg University and DTU)	Initiator and financer: City of Copenhagen; co-financer and organizer: HOFOR	Initiator and financer: Copenhagen City Properties, City of Copenhagen

Table 5.1 Continued

CASE	RYESGADE 30	KLIMAKARRÉ	URBAN RENEWAL SYDHAVNEN	HEDEBYGADE	CARBON 20	ENERGY LEAP	ENERGY PILOT PROJECTS
Low-carbon innovations applied (technical or social)	*Technical innovations:* Interior insulation; class A windows; centralized and decentralized partially solar powered ventilation system; internal insulation facade; behavioral measures.	*Technical innovations:* façade that can be placed at the rear of the building and that can be developed in an industrialized fashion; new wall shafts for ventilation and new technical installations *Social innovation:* innovation platform where market and industry actors can work together on developing integrated solutions	*Social innovations:* community-based approach for developing energy conservation measures. Each household gets customized advice and assistance with reducing their energy consumption bill.	*Technical innovations:* urban renewal in accordance with Danish building regulations; urban ecology solutions included energy efficient facades, sun walls with solar cells, heat exchangers, energy saving facades *Social innovations:* Low-tech solutions focusing on user involvement and behavior	*Social innovations:* 100 Partnership agreements between Municipality and participating SMEs to reduce energy consumption. SMEs in the capital region are offered the opportunity to develop a green business model to enhance energy efficiency and resource efficiency. Companies are offered a structured process with potential analysis support in order to develop green business models.	*Technical innovations:* data monitoring and benchmarking tool to identify opportunities for energy savings *Social innovation:* partnership agreement with which the partners commit to 7 principles, including participation in workshops, data and experience sharing, and training for technical personnel	*Technical innovations:* energy monitoring and management; surveillance and renovation of the BMS system (system to control ventilation, temperature, lightening)
Energy saving or carbon reduction (potential)	Primary energy consumption reduced by 73% from 162.5 to 43. kWh/m^2 /year. The initiative received the Danish retrofitting award ('Renoverprisen') in 2013.	50% reduction in energy consumption	Not quantified	Reduction in 20% of energy consumption	Goal of the project is to reduce the footprint of at least 100 businesses. Reduce material consumption of 2,5000 tons and CO2 emissions by approximately 13,000 tons.	6.000 tons of CO2 reduction by 2025	15–20% reduction in energy consumption can be attained through refurbishments of technical installations and energy management

Table 5.2 Summary of instrumental knowledge derived from the LCIs.

	GENERAL THEMES RELATED TO THE INSTRUMENTAL KNOWLEDGE DERIVED FROM THE ICIs	LCIs
Innovation (what)	Having data on energy consumption and user behavior is critical for developing customized solutions and business models	Ryesgade, Klimakarré, Sydhavn; Carbon 20; Energy Leap; Energy pilot projects
	Need for continuous monitoring of technologies applied, also after project completion, to see how different technologies interact and to understand the influence of building use on energy performance	Ryesgade; Klimakarré; Energy Leap; Energy pilot projects
	Uphold an integrative approach when developing solutions for reducing the energy consumption of buildings, businesses, and districts and connect the goal of energy conservation to other (policy) goals, societal challenges, and urban development needs	Sydhavn; Carbon 20
	Novel approach for retrofitting heritage buildings; heritage buildings can be energy retrofitted without destroying their architectural value by leaving the old façade towards the street intact	Ryesgade; Hedebygade
	Low-tech solutions demanding user maintenance (e.g. green façade) demand ownership and commitment among users to ensure their optimal performance	Hedebygade
	Great potential for energy savings using energy management and surveillance and renovation of BMS systems (ventilation systems)	Carbon 20, Energy pilot projects
Strategies (how)	Create an open innovation platform to promote the continuous development of technologies and to develop integrated, rather than stand-alone, solutions	Klimakarré
	Create a platform where participants (with a common denominator) can share data and experiences and can benchmark their performance	Carbon 20; Energy Leap
	Promote user involvement and co-creation to ensure optimal use and ownership of the innovations applied	Ryesgade, Klimakarré, Sydhavn; Carbon 20; Energy Leap
	Assist households and businesses with implementing energy conservation measures from beginning to end (one-stop-shop)	Sydhavn; Carbon 20
	Work together with local actors who are trusted and known by building owners and users and that can tailor communication to their needs	Sydhavn; Energy Leap
	Communicate co-benefits of energy saving to building owners and users	Sydhavn; Hedebygade, Carbon 20; Energy Leap

owners and tenants, fragmentation and lack in collaboration among industry actors, insufficient capacity and training in energy retrofits among building companies and maintenance actors, lack in financing opportunities, hampering regulations pertaining to energy taxation schemes and lack in regulatory powers among municipalities to incentivize building owners to improve the energy performance of their buildings.

5.4.2.2 *Learning outcomes*

Use of instrumental knowledge for horizontal scaling-up processes

Respondents are generally positive about the local government's ability to use the instrumental knowledge generated by the LCIs for new initiatives, i.e. horizontal scaling-up (see Table 5.4). Respondents note that instrumental lessons are embedded within decision-making processes and are, or will be used, as a reference for future initiatives. It is noted that knowledge distribution within project teams and departments is quite good, and that links between lessons learned and subsequent initiatives are accordingly more direct when the same project team or department works on similar initiatives. As illustrated by one of the respondents: *"We oversee a lot of projects, and we try to promote all the good aspects of previous projects"* (R2). When initiatives follow each other closely and are implemented by the same project team the influences of lessons learned on project design are evident. For example, the project team of the municipality that worked on Ryesgade 30 also worked on Ryesgade 25, for which a similar innovations and approach was adopted. However, respondents note that assessment of learning becomes more challenging when there is a long time-span between initiatives and when other project teams or departments work on initiatives. Respondents note that this is because learning occurs through an indirect aggregation process during which the experiences from different initiatives are cumulated. Accordingly, it can be difficult to establish one-to-one causal relationships between lessons learned and scaling-up of processes.

While respondents are generally positive on the local government's ability to generate instrumental knowledge, and learn from LCIs, it is suggested that there is a greater potential for learning between actors involved in different types of initiatives (e.g. different focus areas or sectors). Lesson sharing often occurs within departments or groups working on similar issues (e.g. retrofitting of heritage buildings), but there are valuable lessons that are 'transferrable' and relevant for a broader array of initiatives. Examples include lessons and practical guidelines on stakeholder involvement, communication, and financing that are not specific to a certain sector.

Respondents also argue that, because many LCIs are implemented in partnerships with other local governments, community or private actors, it is important that learning does not remain within the local project team and local government but that lessons are distributed across the wider policy network. Decision-makers note that the City of Copenhagen aims to strengthen its function as an intermediary actor in demonstrating low-carbon innovations and distributing lessons learned among actors within the policy network (see section 5.4.2.3). Yet, it is challenging to assess how knowledge generated by the LCIs has been used by other actors in the field.

Use of transformative knowledge for vertical scaling-up processes

Successful LCIs provide the evidence base for alternative institutional arrangements and generate transformative knowledge on institutional barriers that need to be addressed (see Table 5.3) and can through vertical scaling-up processes influence their institutional context. *"In this area, you can really move forward. But it is the difficult part"* (R18). It is important to note that there is a general consensus among respondents that local government does not only learn about institutional conditions that need to be addressed (i.e. acquires transformative knowledge) through the implementation of LCIs, but also by learning from the experiences of other cities, discussions with stakeholders in the field, and experiences with failed experiments. Examples of institutional barriers that are being addressed include the Municipality's lack in regulatory powers to promote energy savings in buildings and lack in training and expertise in energy conservation among building operators. The City of Copenhagen tries to address these institutional barriers, at different political scales and related to different context conditions, through different practices, such as awareness raising activities, lobbying, writing of policy briefs, educating, advancing media debates, membership to issue networks, the creation of partnerships with sector actors and municipalities. National networks (such as the association for municipalities) or transnational networks (such as C40) can be used to creating momentum for policy issues and getting ideas spread out. Successful LCIs are used to underline the need for institutional reform. Partnerships are also considered an important tool as they can be used as an advocacy coalition for lobbying. *"Some of the structural barriers you cannot address by your own"* (R19). *"Some of the partners have connections at a higher level. They have political entrance and if there are obstacles they can address them. Of course, we have our own politicians too. But when we are all together, we are stronger"* (R3). When writing policy briefs or engaging in lobbying or media debates, one must strategically make use of 'policy windows', occurrences and events that generate public and political attention for institutional reform. For example, the development of the Energy Agreement at the national level will be used to lobby for more regulatory power to promote energy savings in buildings. Partnerships and sector collaborations are important means for addressing non-regulatory barriers. Examples include training courses set-up together with the labor union for technical personnel in buildings so that they learn how to save energy through optimization of technical installations and energy management.

The findings suggest that vertical scaling-up processes aimed at transforming the institutional conditions of the regime occur an ad-hoc basis, influenced by the likelihood of success and resource capacity. *"It is also a matter of how much we should prioritize resources for that. We do it when we think we have a good case. When we see possibilities in the political landscape we bring in facts, figures and arguments"* (R16).

5.4.2.3 *Learning practices*

The following section will offer a concretization of practices related to the different phases of the learning process.

Table 5.3 Summary of the transformative knowledge derived from the LCIs. The lessons have been categorized in accordance with the different dimensions of the institutional context in which an LCI is implemented: the policy, market, industry, and socio-cultural institutional context (see van Doren et al., 2017).

	GENERAL THEMES AND LESSONS RELATED TO TRANSFORMATIVE KNOWLEDGE DERIVED FROM LCIs	LCIs
Policy context	National energy pricing schemes; Low energy price discourages investments in energy efficiency	Ryesgade, Klimakarré, Urban renewal Sydhavn, Hedebygade, Carbon 20, Energy Leap
	No regulatory requirements for the energy performance of existing buildings makes it difficult to incentivize building owners to invest in energy efficiency; Local government lacks regulatory capacity to set regulatory requirements regarding the energy performance of buildings	Klimakarré
	Frictions between energy retrofitting of buildings and local regulations regarding the aesthetics of buildings; complexity in permit procedures	Ryesgade, Sydhavn ,Hedebygade
	No regulatory structures to address the split-incentives problem in shared buildings	Klimakarré, Sydhavn, Energy Leap
	Regulations regarding the energy labelling scheme needs to be further developed to make it possible to upgrade energy labels without additional costs and to address the performance gap of buildings	Ryesgade, Energy Leap
Market context	Difficulty in financing deep retrofits or small-scale energy retrofit projects ('credit worthiness); creditors are sceptical of the potential of energy savings and long payback measures	Ryesgade, Klimakarré; Carbon 20
Industry context	Limited collaboration between supply-side actors; sector fragmentation and limited collaboration between market actors in developing integrated solutions	Ryesgade, Klimakarré
	Low level of expertise among building operators and technical personnel on how to optimize building operations through energy management and refurbishments of technical installations; many companies renovating or maintaining buildings are not aware of energy saving possibilities or do not have the expertise to carry them out	Energy Leap; Energy pilot projects
	High upfront and instalment costs of (deep) retrofits	Ryesgade, Klimakarré; Urban renewal Sudhavn; Hedebygade,
Socio-cultural context	Lack in awareness about the benefits and opportunities of energy savings in buildings among building owners and users	Ryesgade, Klimakarré, Sydhavn, Hedebygade, Cabon 20; Energy Leap; Municial pilot projects
	Lack in sense of urgency among building owners and users to save energy and willingness to invest in energy efficiency due to short-term investment horizons	Ryesgade, Sydhavnen; Klimakarré, Sydhavn, Carbon 20; Energy Leap

Knowledge accumulation

Piloting and prototyping within LCIs, and the ***monitoring and follow-up*** thereof, are important activities for accumulating knowledge about the success and potential of low-carbon socio-technical innovations. *"We are in a transition period. Despite that there we already have a lot of technologies on the shelf, there is a need for innovation and testing of new products and processes in different types of contexts"* (R17). The City has set the goals to become carbon neutral, but pathways to achieving this are still not set out in stone. Therefore, LCIs play an important function in acquiring knowledge on successful solutions. Strategies and solutions set out in the City's Climate Plan are therefore accompanied by demonstration projects *"which, on a small scale will provide Copenhagen with knowledge and experience relating to the strengths and challenges of each individual solution model"* (CHP, 2012, p. 15). Continuous monitoring on key indicators, including indoor climate and energy consumption on a yearly, and monthly or even daily basis, is critical for demonstrating and developing the business case for LCIs, which is necessary for horizontal scaling-up. Respondents emphasize that monitoring must take place over a long period of time, until several years after project completion, to learn how different technologies interact and to learn about the impact of user behavior on the performance of measures.

Knowledge articulation

Respondents identify three practices for knowledge articulation at the project level: ***project evaluations, project team meetings***, and ***dialogues with stakeholders***. These practices offer a context for reflecting on past actions and for identifying what could be improved in the next phase or future LCIs. During such occasions, project managers have the opportunity to reflect on their actions and to articulate causal relations between actions and outcomes. *"It is important for monitoring success, achievements and identifying problems"* (R17). There are no formal project evaluation mechanisms and accordingly evaluations can differ per initiative. Project evaluations often focus on generating instrumental knowledge, related to innovation features and strategies contributing to success, relevant for horizontal scaling-up processes. However, to identify lessons for vertical scaling-up processes, project teams should also reflect on broader institutional barriers that need to be addressed. Some respondents note that it is challenging to acquire this type of information from project leaders, as they are primarily concerned with project implementation. *"The project leaders of project are working on a daily basis with project implementation. They are aware of the problem [institutional barriers], but maybe not of the entire political situation. But is it also important to get this kind of information from the project leader"* (R17). Given this, various organizational structures, such as the creation of ***program coordinators*** and ***program evaluations*** of the City's Climate plan, are set-up that aim to stimulate the articulation of both instrumental and transformative knowledge. There are various program coordinators that function as intermediaries between LCIs, implemented by project teams in different municipal departments, and the Climate Unit, responsible for implementing and monitoring the implementation of the City's Climate Plan. They coordinate initiatives regarding specific policy domains, such as such as energy conservation in buildings or renewable energy generation, and encourage the aggregation of global instrumental and transformative knowledge. In addition, general evaluations of the Climate plan are used to articulate transformative knowledge. In the period up to 2025, when the City of Copenhagen must be carbon neutral, three general evaluations of the CHP2025 will be conducted. For such evaluations, an overview is made of the current status, initiatives, and national institutional framework conditions that can help the City achieve its targets.

Table 5.4 Assessment of learning, i.e. whether instrumental and transformative knowledge generated by the LCIs has been used for horizontal and vertical scaling-up (yes; no; likely (in the future))

CASE	USE OF INSTRUMENTAL KNOWLEDGE FOR HORIZONTAL SCALING-UP	INDICATORS	USE OF TRANSFORMATIVE KNOWLEDGE FOR VERTICAL SCALING-UP	INDICATORS
Ryesgade 30	Yes	Initiatives 'Ryesgade 25', application of similar technologies	Yes	National awareness raising activities and collaboration within the building sector
Klimakarré	Likely in the future	Ambition to continue with the platform for further development of the façade so that more initiatives can be realized	Likely in the future	Local awareness raising activities and collaboration within the building sector
Urban renewal Sudhavn	Likely in the future	Ambition to grow and replicate the community-based approach for promoting energy conservation through urban renewal in other districts of the City of Copenhagen	Yes	Development of local policy programs for promoting energy conservation through urban renewal
Hedebygade	Yes	Some of the urban ecology solutions have been used in other initiatives in Fredericksberg and Copenhagen	Yes	Development of national standards for urban renewal projects; demonstration activities to enhance awareness on the concept of urban ecology among policy-makers and planners
Carbon 20	Yes	New partnerships realized within the commercial and Service Companies Policy Initiative; Energy Leap	Yes	Development of local policy initiative 'Commercial and Service Companies' for reducing energy consumption in commercial and service companies
Energy Leap	Likely in the future	Ambition to grow the partnership and involve more stakeholders	Yes	Lobbying activities to influence national regulation on energy efficiency of heating installations
Energy pilot projects	Likely in the future	Ambition to apply the energy monitoring and management approach in other municipal buildings	Yes	Development of educational material for technical personnel in collaboration with labor union; awareness raising activities in the building sector

Knowledge codification

Knowledge articulation processes can promote learning within individuals and teams, but this knowledge remains within the heads of the individuals. Knowledge codification practices, such as ***the writing of project reports and project evaluations***, guarantee that internal, tacit knowledge is externalized and available to others outside the project team. Other ways to codify knowledge include the ***development of prototypes*** or the ***writing of issue papers or articles***. In addition to project-specific evaluations, general ***program evaluations*** and ***annual reports*** published by the Climate Department to evaluate actions and monitor progress, also constitutes a way to codify knowledge. Knowledge codification practices occur at an ad-hoc basis. Yet, respondents note that codification of lessons learnt is deemed valuable for sharing knowledge with external audiences and for promoting learning across LCIs and aggregating global knowledge.

Knowledge distribution

Knowledge distribution can occur using a codification strategy (distribution of codified knowledge) or personification strategy (distribution through people-to-people communication). While project reports are in principle available to everyone, actors outside the project team often do not read them in practice due to lack in awareness about their availability or lack in time. *"Project reports often end up on the shelf"* (R19). Knowledge distribution about LCIs is encouraged via weekly or monthly ***department- or team meetings***. In some cases, projects ***workshops*** or ***training events*** are organized at the end of a project during which the results of the project evaluation are presented to key stakeholders. Organizational structures, such as ***interdepartmental meetings*** for experts working on similar policy domains, are set up to promote collaboration and sharing between different departments. ***Dissemination of program or project evaluations and reports, publication of articles in professional journals,*** and organizing ***project visits*** or ***workshops*** are ways to promote awareness and share knowledge about a project to a wider audience. ***Conferences, partnerships,*** and ***membership of issue networks*** are also deemed effective practices for the distribution of knowledge about LCIs and best practices for reducing energy consumption in buildings to external actors. Annually, the City organizes a conference during which national and international stakeholders meet for dialogue on experiences and future opportunities. Partnerships are not only useful for accumulating resources and knowledge, but can also promote the dissemination of knowledge within the sector.

5.4.2.4 *Explanatory factors for learning*

The following section will reflect on explanatory factors, acting as barrier or driver, to learning. In accordance with the analytical framework, factors relate to the following categories: 'motivation', 'resources', or 'skills'.

Motivation

The Mayor of Copenhagen and department leaders recognize the importance of low-carbon development and understand how they can increase the city's attractiveness and competitiveness through experimentation with LCIs. ***Political leadership*** is therefore identified as an important factor enabling experimentation with, and learning from, LCIs. *"An important factor is the motivation to push things forward. […] It is key that you have strong political commitment and that there is an overall target*

[…] Because if there was uncertainty about the City's Climate goals, then it would be really difficult for our CEO to prioritize the resources for this" (R17). Respondents note that ***a clear mandate for project evaluations and conducting general evaluations of the Climate Plan*** is important for embedding learning practices within the local government organization. If there is no mandate, project teams are quickly dissolved and actors will jump into the next project without critical reflection on lessons learnt. *"If there is no requirement for evaluation you will skip it and start with a new project, because that is what you are being assessed on"* (R19). The ***availability of ambitious leaders (i.e. institutional entrepreneurs)*** at the municipal and department level is also important for promoting sustainability among project leaders and staff and ensuring that knowledge is used for vertical scaling-up processes. Respondents note that knowledge distribution occurs primarily through people-to-people communication and informal channels, facilitated by a ***co-operative and open culture*** and ***ownership of the City's Climate plan among employees***. Nevertheless, as transfer of knowledge or sparring about projects is more likely to occur between actors working in same units or working groups that work 'in walking distance' of each other, it is challenging to prevent the creation of knowledge siloes.

Resources

As noted above, political leadership fosters the mobilization of ***human and financial resources*** required experimentation with LCIs and conducting project and program evaluations. In addition, ***team diversity*** – having project team members with different professional backgrounds- can promote knowledge accumulation and articulation as it allows the team to be confronted with diverse perspectives and promotes the sharing of experiences. Challenges to learning relate to the ***availability of sufficient structural human and financial resources*** for the accumulation, articulation, codification, and distribution of knowledge. Annual budgets for experimentation are influenced by the political climate and can differ per year and external sources often only offer financing sufficient for project implementation, but not evaluation. To illustrate, while long-term monitoring of innovations is regarded an important practice for learning (see section 4.2.3), there are many projects that receive short-term financing (1–2 years) so that at the end of the project (e.g. when a building is retrofitted) there are no financial resources left for long-term monitoring and follow-up. As for the availability of structural human resources, respondents note that for certain projects, primarily projects financed by external funding (e.g. support offered by the EU), temporal staff is hired and that these people often get a new job before project completion, thereby hampering knowledge articulation and distribution processes. When people have to leave after project completion, *"how do you secure that the knowledge in their brain is transferred to new people? […] And how can you bring it out there in the organization?"* (R17). Moreover, while there may be a great amount of learning within departments or teams, there are not always sufficient resources available for knowledge distribution practices. As illustrated by the following quote: *"within their department they have been very good at learning about specific technologies. However, one thing that is a challenge for them- when you are talking about scaling-up – is that they don't always have the resources to communicate the results"* (R15). Changing team compositions can also hamper knowledge distribution. Reasonably, when the same people work on similar types of projects, knowledge from former LCIs can be used as reference for the design of future initiatives. However, it is noted that sometimes team compositions and project leaders are assigned on availability rather than experience, which may increase the barriers to learning from previous projects (R5). Yet, some argue that at while continuity in staff can be valuable for use of knowledge for horizontal scaling-up, in practice it is neither always possible nor desirable because there is a risk of groupthink and the team becoming less creative due to lack of outside, critical perspectives.

Skills

Learning practices at project level are highly influenced by the competences of the project and program leader. Project leaders must be good at ***communication, intermediation, and collaboration*** as such skills can encourage discursive processes directed at generating instrumental and transformative knowledge. The perspective and questions of external stakeholders can stimulate discussions and 'outside the box thinking'. As illustrated by a respondent: *"When you are from the outside you are allowed to ask any kind of questions. Why don't you do it like this? If you are working within the municipal organization you cannot ask these questions because you know what the answer is. We know what the struggles and challenges and why we do things a certain way"* (R19). Program coordinators working at the department level, acting as institutional entrepreneurs, must be effective in intermediation and working cross-sectorial to use transformative knowledge for addressing institutional barriers.

5.5 REFLECTION

5.5.1 CONTRIBUTIONS TO THE LITERATURE

The City of Copenhagen aims to be a frontrunner in the field of sustainability and actively aims to foster the low-carbon transition by experimenting with LCIs. The explorative case study offered helpful insights into how local government can learn from LCIs to promote scaling-up processes. The findings underline the importance of experimenting with LCIs to learn how low-carbon technical (e.g. insulation material, BMS systems) or social innovations (platform, partnership agreements) can offer a solution to societal problems concerning sustainability (e.g. Castán Broto & Bulkeley 2013; Sengers et al., 2016). The case study also showed that different types of knowledge – instrumental and transformative- can be derived from LCIs. Instrumental knowledge is used to foster the development of low-carbon innovations and successful approaches for realizing initiatives. This knowledge is relevant for the growth and uptake of new initiatives, i.e. horizontal scaling-up. LCIs also generate transformative knowledge regarding institutional barriers that need to be addressed. Transformative knowledge can be used by local governments to promote institutional reform favorable to the low-carbon innovations experimented with, i.e. vertical scaling-up.

The findings indicate that assessment of learning can be difficult due to the long-time scale or indirect relation between projects. While respondents are generally positive and maintain that learning from LCIs takes place it is challenging to establish what and how lessons are re-used. This finding aligns with previous studies in the field of sustainability transitions that maintain that learning from experimentation with innovations occurs through the accumulation and aggregation of various experiences (Geels & Deuten, 2006; Schot & Geels, 2008).

The case study also functioned to concretize practices and to identify factors that can foster learning from LCIs. Learning from experimentation within LCIs requires local governments to engage in practices related to knowledge accumulation, articulation, codification, and/or distribution (Zollo & Winter, 2002). With regards to factors promoting learning, the case confirmed that learning results

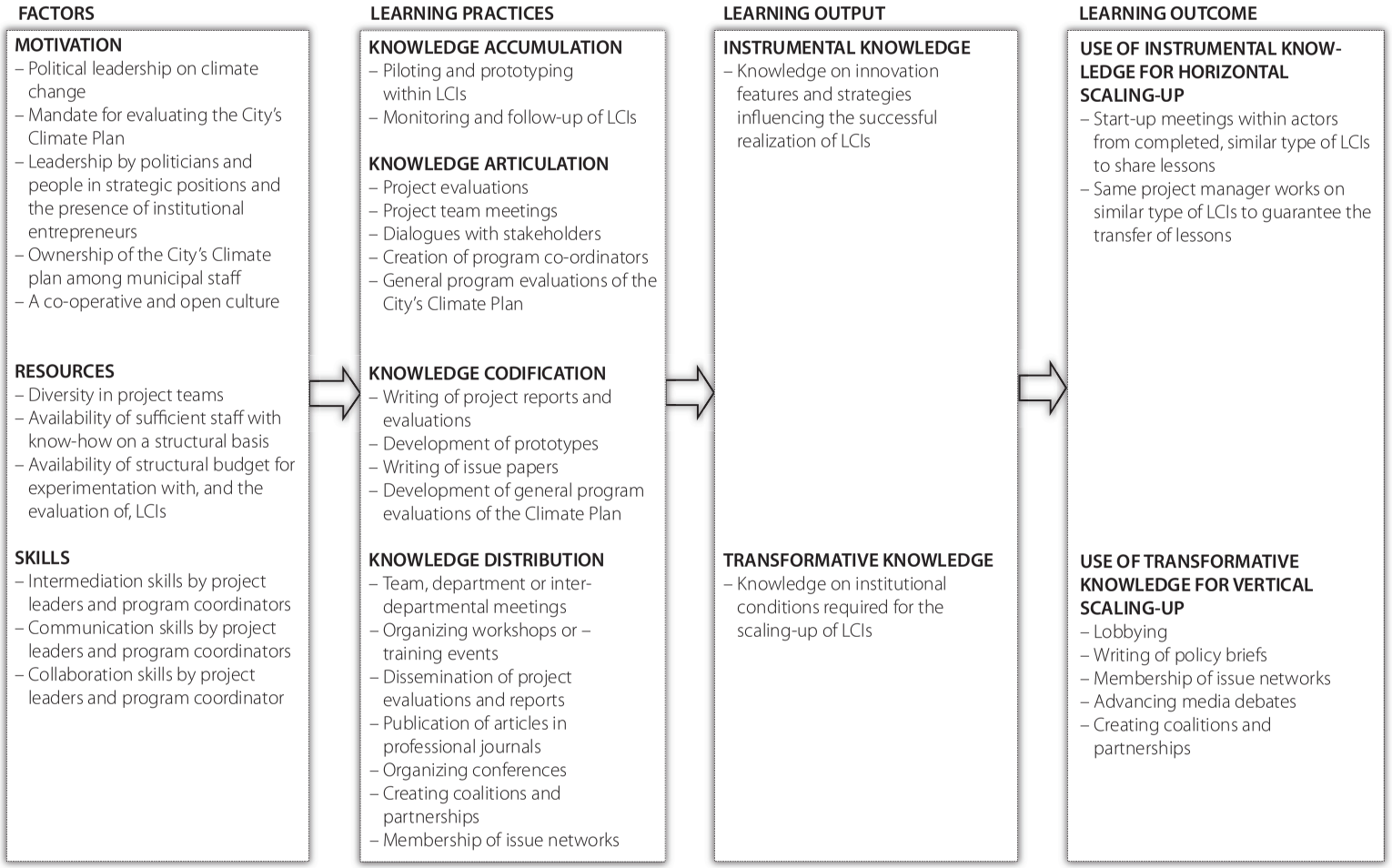

Figure 5.2 Further operationalization of factors and practices influencing learning from LCIs within local government to promote their scaling-up

from interplay of factors related to motivation, resources, and skills on the part of the local government organization. As for motivation, political leadership on climate change, a mandate for evaluation of the Climate plan, and the presence of institutional entrepreneurs willing to accelerate the low-carbon transition are critical for prioritizing resources for experimentation with LCIs. These findings underline the importance of leadership for learning and accelerating the low-carbon transition (e.g. Bulkeley, 2010; Bulkeley & Kern, 2006; Kingdon, 1995; Senge, 1990; Zollo & Winter, 2002). Second, the findings underline that a local governments' resource capacity facilitates learning processes as a local government is better positioned to amortize the costs of learning and acquire novel knowledge when it has sufficient budget and staff with know-how (Bulkeley & Kern, 2006; Fichman et al., 1997; Geels & Deuten, 2006; Holgate, 2007; van der Vegt & Bunderson, 2005; Yohe, 2001). Finally, the case study highlights that project managers and program coordinators working at local government must possess strong negotiating, communication, and cooperation skills in order to get initiatives off the ground, govern learning practices, and to ensure that knowledge derived from LCIs are used for scaling-up processes (e.g. Bulkeley and Kern, 2006; Geels and Deuten, 2006; Klein Woolthuis et al., 2013).

In all, based on the results, the analytical framework can be further operationalized (see Figure 5.2). It is important to note that while Figure 5.2 suggests a linearity and rationality of the learning process, in practice learning processes are generally more complex and non-linear.

5.5.2 LIMITATIONS

Because – as an explorative case study – this paper has limitations in terms of generalizability, we propose that future studies are conducted to examine whether and how learning practices differ between local governments that demonstrate climate leadership. We believe that learning more about how local governments learn from experimentation with LCIs is critical for understanding and accelerating the transition to low-carbon cities.

5.6 CONCLUSIONS AND POLICY IMPLICATIONS

Theory on climate governance and sustainability transitions recognize the important role of experimentation with – and learning from – LCIs to learn how the transition to low-carbon cities can be advanced (Bulkeley et al., 2011; Castán Broto & Bulkeley 2013; Kivimaa et al., 2017; Sengers et al., 2016). While local governments play an important role in leading and enabling LCIs (Bulkeley, 2010; Castán Broto & Bulkeley 2013), the issue of how local governments learn from low-carbon initiatives to promote scaling-up processes had received little attention up to now. Using the City of Copenhagen – regarded a sustainability frontrunner- as a case study, this paper explored the complex relationships between LCIs, learning processes within local government, and scaling-up processes. The paper has three key contributions that not only enrich literature but that can also assist local governments worldwide in enhancing their capacity to learn from LCIs, thereby promoting scaling-up processes.

First, the paper discussed the types of knowledge that can be derived from initiatives and showed how such knowledge can be used for scaling-up. LCIs can generate instrumental knowledge related to innovations and approaches influencing project success is, which is relevant for expanding the initiative or realizing new initiatives, i.e. horizontal scaling-up. In addition, LCIs should also generate transformative knowledge so that vertical scaling-up processes aimed at addressing institutional barriers can be encouraged. Therefore, we advise local governments to ensure that learning practices are oriented to the capitalization of both instrumental and transformative knowledge.

Second, the paper provided a concrete overview of learning practices and an overview of explanatory factors for learning that can help local governments in optimizing learning practices and creating organizational frameworks fostering the capitalization of knowledge from LCIs. The paper offered an overview of learning practices that can encourage the accumulation, articulation, codification, and distribution of knowledge. Experimentation with LCIs – and continuous monitoring and follow-up – is critical for generating instrumental knowledge and transformative knowledge. Local governments can enhance the articulation of knowledge through, amongst others, structural project and program evaluations, stakeholder dialogues, and creating program coordinators that act as intermediaries between 'projects on the ground' and a City's broader climate plan. Through organizing workshops and conferences and membership to national and international issue networks local government can distribute knowledge with a broader, external audience, thereby promoting the construction of a learning community fostering niche development and creating advocacy coalitions to address institutional barriers hampering the scaling-up of LCIs.

Third, the paper reflected on resources and skills that can influence a local government's capacity to learn from LCIs. First and foremost, the findings point to the importance of local political leadership on climate change and a mandate for experimentation. The City of Copenhagen has developed an ambitious climate plan and experimentation with LCIs is an important means to achieve the City's Climate goals. Such climate leadership has enabled the Climate Department to develop – and structurally evaluate- collective efforts towards carbon neutrality. Leadership by politicians and persons in strategic positions incite a shared vision and ownership on carbon neutrality among civil servants and local stakeholders, thereby promoting lesson sharing and the creation of sense of urgency to scale-up LCIs. Political leadership on climate change also creates a context in which resources can be mobilized for experimentation and practices aimed at the articulation, codification, and distribution of knowledge. Yet, as a policy implication, it is important that resources required for experimentation and learning are required on a structural basis because, as noted, even a frontrunners city like Copenhagen can experience internal struggles to secure structural resources, such as funding and permanent staff. All in all, it is expected that the findings of this paper can assist local governments in optimizing learning from LCIs, which is greatly needed in order to accelerate the transition to low-carbon cities.

6 CONCLUSION

6.1 INTRODUCTION

Cities are at the frontline of the fight against climate change and demonstrate farsighted leadership in accelerating the low-carbon transition. In fact, mayors and governors of the world's cities argue that *"the future of our globe will be won or lost in cities of the world"* (Copenhagen Climate Communique, December 2009). In their endeavor to foster low-carbon urban development, pioneering local governments and private actors are involved in the implementation of low-carbon initiatives (LCIs) in which they experiment with low-carbon, socio-technical innovations that have the potential to contribute to sustainable societal change (Castán Broto & Bulkeley 2013; McGuirk et al., 2015; Sengers et al., 2016). In particular, LCIs that focus on energy conservation in the existing building stock can greatly contribute to the decarbonization of cities, as the building stock is responsible for 40% of energy consumption and 36% of GHG emissions (EC, 2015; 2016; Levine et al., 2007; UNEP, 2009; UNEP, 2011). Examples of LCIs promoting energy conservation in buildings include community-led energy retrofitting initiatives and the creation of zero-energy building districts.

At present, these LCIs, developed by different actors and for different purposes, jointly constitute a patchwork of manifestations of what low-carbon development implies in practice. While LCIs are proliferating, scholars and practitioners underline the need to scale-up LCIs beyond local and isolated initiatives so that they can contribute to systemic, societal change fostering sustainable, low-carbon development (e.g. Bulkeley & Castán Broto 2013; Deloitte, 2013; Hoffman, 2011; McGuirk et al. 2015; UNEP, 2016). Yet due to the relative immaturity of the field of urban climate governance, there is still limited knowledge of factors and strategies that can influence such a process (Angeluelovsky & Carmin, 2011; Bulkeley & Castán Broto, 2013; Burch, 2010; Castán Broto & Bulkeley, 2013; Rutherford & Jaglin, 2015).

The objective of this dissertation was to analyze and explore factors and strategies influencing the scaling-up of LCIs focused on energy conservation in the existing building stock. The different empirical chapters analyzed drivers and barriers to the uptake and scaling-up of LCIs within this domain and explored how, via strategies, barriers can be addressed and drivers can be created, with the ultimate aim of accelerating the transition to low-carbon cities. In doing so, this PhD dissertation aims to contribute to the scientific debate within urban climate governance on how LCIs – which can be subsumed under the scope of climate experimentation (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley 2013; Evans & Karvonen, 2014; Evans et al., 2016; Kivimaa et al., 2017; McGuirk, 2014)- can contribute to the low-carbon transition.

This final chapter summarizes and reflects upon the main findings presented in the dissertation. It is structured as follows: section 6.2 presents the conclusions on the sub-questions presented in chapter 1. Section 6.3 provides reflections on the research design, case selection, and methods and examines the findings of this dissertation in the light of the different bodies of literature applied. Recommendations for future research and practice are discussed in section 6.4. Finally, section 6.5 offers some final thoughts on how the scaling-up of LCIs can be advanced to accelerate the transition to low-carbon cities.

6.2 CONCLUSIONS

This section presents a concluding synthesis of the key findings from the analyses contained in the separate chapters. The synthesis of findings over the different research projects is structured around the research questions posed in the introduction chapter.

6.2.1 RQ1 | What does the concept of scaling-up entail and how can the scaling-up of low-carbon initiatives contribute to the transition to low-carbon cities?

In chapter 2, LCIs were operationalized as interrelated systems of low-carbon social and/or technical innovations and operational arrangements that are implemented in a wider contextual environment. While technical innovations are centered on physical, technical artifacts (e.g., singular technologies, such as thermal insulation and heat pumps, or integrated zero-energy building concepts), social innovations relate to novel behavioral practices or financial and organizational models that can directly or indirectly contribute to energy conservation (e.g. behavioral measures for reducing one's energy consumption or an ESCO financing model).

The concept of LCI is a broad overarching term to describe forms of experimentation with innovations and is linked to a variety of terms described in literature, including: 'niche experiments' (Geels & Raven, 2006; Hoogma et al., 2002; Kemp et al., 1998; Schot & Geels, 2008), 'socio-technical experiments' (Brown and Vergragt, 2008), 'transition experiment' (van den Bosch & Rotmans, 2008), 'grassroots experiments' (Seyfang & Smith, 2007; Seyfang, 2010), 'sustainability experiments' (Berkhout et al., 2009), 'urban climate experiments' (Castán Broto & Bulkeley 2013) and 'urban living labs' (Voyotenko et al., 2015). While the different terms may have specific focus points, they share important commonalities (see Sengers et al., 2016 for an overview). For instance, they all constitute arrangements of socio-technical innovations that can offer a solution to persistent societal problems related to sustainability; they are inclusive and engage a variety of actors; and are practice-based and tested in a real-life social context (Sengers et al., 2016). Distinct features of the term 'LCI', applied throughout this dissertation, is that LCIs are initiatives where low-carbon innovations are implemented collectively, at the level of building blocks or districts on the urban, local scale and that they are realized on a voluntary basis. LCIs can be initiated by community actors, private actors, governmental actors, or be organized in a cooperative form. Due to the voluntary nature of LCIs, they can be perceived as bottom-up approaches for sustainability transitions as they depart from the statutory, expert-led top-down central government governance

on climate mitigation (Selman & Parker, 1997). LCIs can be subsumed under climate experimentation as they can advance social learning on how to advance sustainability transitions and challenge institutional structures fostering high-carbon development (Brown & Vergragt, 2008; Geels & Deuten, 2006; Geels & Raven, 2006; Kemp et al., 2007; Kivimaa et al., 2017; Schot & Geels, 2008).
The starting point of this dissertation was that LCIs need to be 'scaled-up' and increase their impact in order for them to play a significant role in climate stabilization efforts and the low-carbon transition. An unequivocal understanding of the concept of scaling-up is required to assess whether and how scaling-up is occurring and to explore factors and strategies influencing scaling-up processes. The definition of scaling-up adopted in chapter 2 was as follows: to increase the impact of LCIs from a small to a large scale. Inspired by the frameworks of the IIRR (2001) and World Bank (20003), that focus on the impact of development interventions, and building on related concepts used by different bodies of literature (see Table 1), two overall pathways were identified to which LCIs can go to scale, thereby reaching a higher impact in terms of low-carbon development: horizontal and vertical pathways. Table 1 summarizes key features of the concepts. Horizontal pathways to scaling-up refer to the spatial growth of an initiative or parts thereof. It implies a process where an initiative increases its impact on a *spatial scale*, and can result from internal growth, replication, or the uptake of similar initiatives that make use of the lessons of the initiative ('inspiration'). Horizontal pathways to scaling-up are related to processes such as 'diffusion' (Rogers, 1995), 'organizational growth' (World Bank, 2003) and 'replication' (Rotmans & Loorbach, 2006). An example of horizontal scaling-up processes is the increase in urban communities that collectively work towards reducing their energy consumption through collective retrofitting and installment of solar panels (Seyfang, 2010; Walker, 2008).

While horizontal pathways to scaling-up LCIs are important, LCIs can also increase their impact in terms of promoting low-carbon development on an *institutional scale* through vertical pathways to scaling-up. This encapsulates a process where the knowledge generated by LCIs serves as the basis for institutional change favoring low-carbon development. Vertical pathways to scaling-up are important because the low-carbon innovations applied in LCIs are underpinned by a set of practices that are incompatible with prevailing institutional structures, which can be found at different spatial jurisdictions. Vertical scaling-up has occurred when the knowledge from LCIs has influenced its institutional environment, thereby creating an enabling environment for change and changing the structural sources of high-carbon development. The findings of Chapter 3 and 4 support the view that institutional change from experimentation within LCIs generally occurs through the accumulation and aggregation of knowledge derived from multiple LCIS (see Geels & Deuten, 2006; Schot & Geels, 2008). An empirical example of vertical pathways to scaling-up would be how the lessons from various LCIs focused on experimentation with zero-energy building concepts were used to change national regulatory structures on mortgage financing so that zero-energy buildings can be more easily financed in the Netherlands (see Chapter 4). The process of vertical scaling-up is linked to different concepts discussed by different bodies of literature, including institutionalization (North, 1990), political scaling (Uvin, 1995), regime transformation (Smith & Raven, 2012) and policy learning (Bennett & Howlett, 1992; Etheredge, 1981; Hall, 1988; Heclo, 1978; Rose, 1991; Sabatier, 1988).

It is important to note that the concepts of horizontal and vertical (pathways to) scaling-up are theoretical concepts and that the distinction is analytical. In practice, horizontal and vertical pathways to scaling-up are interlinked and there is great potential for synergy. The more horizontal scaling-up occurs, the greater the chance that LCIs will influence their (local) institutional environment. Vertical

scaling-up leads to a facilitative institutional context, thereby promoting the uptake of new and similar initiatives, i.e. horizontal pathways to scaling-up.

While horizontal and vertical pathways to scaling-up can be interlinked in practice, it is proposed that the analytical distinction is relevant for exploring and governing scaling-up processes. The analytical distinction constitutes a valuable instrument for scholars and practitioners working in the field of urban climate governance as it allows them to monitor and evaluate the different types of impact that LCIs can have in terms of promoting low-carbon development. It must be underlined that the success or impact of LCIs does not determine their ability to contribute to scaling-up processes. Even failed LCIs can contribute to these processes as they can offer valuable lessons on innovation features or institutional conditions that hampered the successful realization of the initiative.

Table 6.1 Overview of the concepts of horizontal and vertical pathways to scaling-up

PATHWAY TO SCALING-UP	HORIZONTAL	VERTICAL
Operational definition	The increase in spatial scale of LCIs, or parts thereof, as a result of their internal growth, their replication to other geographical areas, or the uptake of new LCIs where the low-carbon innovations or lessons from the LCIs are applied ('expansion', 'replication' and 'inspiration')	Knowledge derived from LCIs influences the institutional environment in favor of the low-carbon innovation applied in the LCI
Contribution to the low-carbon transition	Direct contribution to climate mitigation and urban development; Enabling the community of practitioners to develop and strengthen the low-carbon innovations applied and to learn about institutional and context conditions required for large-scale application of the low-carbon innovations applied	Creating institutional conditions required for required for large-scale application of the low-carbon innovations applied in the LCI, thereby promoting horizontal scaling-up processes
Related concepts	Diffusion (Rogers, 2003), quantitative scaling (Uvin, 1995); scaling-out (Douthwaite et al., 2003); broadening (van den Bosch & Rotmans, 2008; replication (Rotmans & Loorbach, 2006); organizational growth (World Bank, 2003)	Political scaling (Uvin, 1995); translation (Seyfang & Haxeltine, 2012); scaling-up (van den Bosch & Rotmans, 2008); institutionalization (North, 1990), policy learning (Hall, 1988; Heclo, 1978; Etheredge, 1981; Sabatier, 1988; Rose, 1991, Bennett & Howlett, 1992); regime transformation (Smith & Raven, 2012)
Indicators of processes of change	Internal growth of LCI Replication of the LCI in another context Uptake of new initiatives, where the innovations of the LCI are applied or further developed Uptake of new initiatives where lessons on low-carbon innovations are applied	Lessons from LCIs are used to change institutional structures on different political scales (local, regional, national, international) so that they align with the practices and principles of the low-carbon innovations applied in the LCIs
Scale of analysis	Geographical	Institutional

6.2.2 RQ 2 | What factors influence the uptake and scaling-up of low-carbon initiatives focused on energy conservation in the existing building stock?

In order to be able to develop strategies to accelerate scaling-up processes, an in-depth understanding and accurate diagnosis is required of factors – which can act as barrier or driver – influencing the uptake of initiatives focused on energy conservation in the existing building stock. Knowledge of factors influencing the *uptake* of LCIs can be used to develop strategies directed at *horizontal pathways to scaling-up*. Furthermore, knowledge of institutional barriers hampering the uptake of initiatives is also needed to inform strategies promoting *vertical pathways to scaling-up* (i.e. what institutional change is required?).

The section below and Table 6.2 summarize the findings on explanatory factors acting as driver or barrier – to the uptake of LCIs and horizontal pathways to scaling-up. Empirical examples from the chapters are added that illustrate their relevance. Explanatory factors can be categorized in accordance with the operationalization of an LCI and its contextual environment: (i) characteristics of the low-carbon socio-technical innovations, (ii) operational arrangements and (iii) context factors. This categorization is based on a preliminary explanatory framework proposed in chapter 2 and the further refinement thereof in succeeding chapters.

a. Innovation characteristics

Low-carbon innovations must be reliable, low in complexity, and have a financial advantage in order to be applied on a large scale. Yet, at present, the low-carbon innovations applied in LCIs are still relatively expensive and must be further developed and strengthened in terms of efficiency and effectiveness in solving societal challenges, such as the high energy consumption of buildings. This implies amongst other things that the so-called 'performance gap' of low-carbon innovations must be resolved (see Chapters 4 and 5). The performance gap implies that there is a discrepancy between predicted and actual energy use, which may result from user behavior or interaction of technologies.

b. Operational arrangements

Operational arrangements relate to conditions at the level of an initiative. Leadership, resource mobilization, effective communication and stakeholder involvement are important drivers to the uptake of LCIs. For instance, the LCIs studied in Chapter 2 (e.g., the GWL district), Chapter 3 (e.g., the Elih-Med project), Chapter 5 (e.g. Ryesgade) have been realized thanks to leaders with determination who, despite setbacks, continue to have faith in the LCIs and encourage stakeholder commitment and the mobilization of resources. Leadership is important because institutional context conditions, such as market, industry and policy conditions, are not yet supportive to the low-carbon innovations applied in the initiative (see below). To realize an initiative and to expand it and reach a greater audience, initiators of LCIs must clear many hurdles and apply strategies (see section 6.2.3) to address contextual barriers.

c. Context conditions

The context of an LCI relates to the institutional context and physical context. The institutional context can be subdivided into different dimensions: policy context, market context, industry context, and

socio-cultural context[5]. The physical context relates to features of the natural and built environment, such as weather and building conditions. The barriers discussed below and summarized in Table 6.2 are general barriers, found across cases, and thus should be taken into consideration when developing strategies for scaling-up, even though the relative importance of the factors can be context-dependent. Key factors identified which hamper scaling-up processes include a lack of long-term national policy frameworks on climate change and energy conservation, insufficient collaboration among industry and market actors in developing integrative solutions and support structures for reducing the energy consumption of buildings, the difficulty of financing energy retrofits, and insufficient urgency, awareness and capacity among building owners and users to invest in energy conservation.

C (i) Institutional context

Policy context

A facilitative local policy environment is conducive to the uptake of LCIs. The findings of chapter 2, 3 and 5 indicate that pioneering LCIs can be realized thanks to local political leadership on climate change on/or the availability of public support structures, such as subsidy schemes. However, while public support structures can be an important driver for action, these institutional structures are often temporary or only applicable within a certain spatial jurisdiction. Moreover, while local political leadership on climate change is conducive to the uptake of LCIs, it can be challenging for local governments to translate political rhetoric into action due to limited regulatory and financial capacities and the difficulty of mainstreaming climate goals into all policy domains and municipal departments.

National policy frameworks can be supportive of innovation and offer public support for LCIs (see Chapter 2, 4, 5). Yet, many respondents depicted national policy frameworks as being fragmented and characterized by short-termism. National public support structures are often available on a temporal basis and susceptible to changes in the political context and there are numerous policy conditions that make investments in energy savings unattractive or complex (see Chapter 3). For instance, national energy taxation schemes and energy prices can undermine the economics of investing in energy conservation measures for property owners and users (see Chapter 3, 5) and changing subsidy or policy schemes make it challenging to develop a business case for long-term projects (see Chapter 1). In all, when national agendas fail to reflect political urgency on climate change, it can reduce demand- and supply-side actors' trust in the policy framework and their willingness to engage in LCIs.

Market context

LCIs are implemented in a market context that is not yet supportive for horizontal pathways to scaling-up. Barriers to horizontal pathways to scaling-up relate to credit availability, information asymmetry, and the valorization of energy efficient buildings. The lack of financing opportunities at low costs and financing practices by creditors and financers, who can be skeptical of the performance of innovations and reluctant to finance small-scale energy retrofits projects, has been found to be a key barrier across cases (see Chapter 3, 4, and 5). While the high costs of deep energy retrofits require the availability of a diversity of financing arrangements for different target groups, such as financing through mortgage

[5] The industry, market, social, and policy context align with the different dimensions of the regime proposed in theory on sustainability transitions (Geels, 2002). Barriers regarding the 'scientific context', suggested as a separate category by Geels (2002), have been integrated into the other context dimensions.

or low-cost and long-term loan schemes, credit can often only be obtained at high cost. The accurate valuation of low energy or zero energy buildings by real estate agents and valuers is of importance so that property owners are assured of the value enhancement of their property. Also, the market is characterized by information asymmetry and there are still limited market actors that can support households or companies to reduce their energy consumption and that offer attractive 'one-stop-shop' packages.

Industry context

Institutional structures in the industry context are not yet supportive of horizontal pathways to scaling-up. In the current market, energy retrofits demand high capital and installment costs and there is still uncertainty about the performance of innovative technologies. This can be partly explained by the fact that the building sector is characterized by fragmentation and limited cooperation between the various stakeholders in the supply chain. LCIs demonstrate that sector collaboration between industry and market actors can lead to improved process optimalization, improved performance and price of retrofit concepts, and improved capacity among industry actors. To close the 'performance gap, i.e. the discrepancy between predicted and actual energy use, industry actors must take building usage into consideration when developing solutions, co-ordinate the design and construction phase, and disclose data on the performance of buildings during their operation.

Socio-cultural context

Many LCIs initially attract green-oriented citizens – a specific market segment – who are willing to engage in an initiative due to their levels of environmental awareness and values. However, to accomplish the low-carbon transition, LCIs need to attract a broader and greater audience. A key barrier to horizontal pathways to scaling-up include a lack of urgency to reduce energy consumption and a lack of public awareness of the possibilities and benefits of saving energy in buildings. Due to this low priority and level of awareness, owners can be reluctant to make long-term investments, regardless of the financial benefits in the long run. Moreover, if households are interested in saving energy, they can lack the financial, technical or informational capacity to do so. Nevertheless, the findings of this dissertation also underline LCIs can involve building owners and users that were not 'sustainability fanatics' at the start, but that incrementally become through customized framing and experiencing the benefits of energy conservation (see section 6.2.3).

c (ii) Physical context

Natural context

Drivers and barriers related to the natural context are always context-specific. Careful scoping is required to ensure compatibility between the innovations applied and the characteristics of the natural environment.

Built context

As for the built context, fragmented property ownership in collective buildings can impede retrofits due to different user needs and challenges related to coordinating the decision-making process (Chapter 3). In many buildings, there are no (active) building associations that have the capacity and motivation to manage such collective retrofitting processes.

Table 6.2 General drivers and barriers to the uptake and horizontal pathways to scaling-up LCIs focused on energy conservation in the existing building stock, as identified in the different empirical chapters.

CATEGORY	DRIVERS	DISCUSSED IN CHAPTER	BARRIERS	DISCUSSED IN CHAPTER
			INNOVATION FEATURES	
Financial advantage	Profitability of investing in low-carbon innovations by demand-side actors	2; 3	High upfront capital and installment costs of (deep) energy retrofits and energy conservation measures	3; 4; 5
Reliability	The reliability of low-carbon innovations in terms of environmental and economic performance		Uncertainty about the performance of innovations/ performance gap; uncertainty about the interaction of different types of technical innovations and the influence of user behavior on the energy performance of a building	4; 5
Low complexity	The degree to which low-carbon innovations are easy to use by end-users	2		
			OPERATIONAL ARRANGEMENTS	
Leadership	Presence of a leader who can motivate and coordinate stakeholders, promote commitment and mobilize resources required for the realization of an LCI	2,3,4,5	—	
Stakeholder involvement	Participation of actors that have an interest in the LCI and that contribute to the mobilization of resources	2	—	
Resource mobilization	Mobilization of human, financial, informative and technical resources required for the realization of an LCI	2	—	
Communication	Effective communication within the project team to coordinate resources and stakeholders	2	—	

Table 6.2 Continued

CATEGORY	DRIVERS	DISCUSSED IN CHAPTER	BARRIERS	DISCUSSED IN CHAPTER
	LOCAL IMPLEMENTATION CONTEXT		**BROADER INSTITUTIONAL ENVIRONMENT**	
		(A) INSTITUTIONAL CONTEXT		
Policy				
	Political leadership at the local level	2, 3, 5	Insufficient political leadership and long-term political goals on climate change at the national level; insufficient political urgency at the national level concerning climate change and/or energy conservation in buildings	3, 4, 5
	Availability of public support structures for LCIs (e.g. subsidies or other forms of public support) at the local and/or national level	2, 3, 5	Instability of the (national) policy framework	3, 4, 5
			No regulatory requirements regarding the energy efficiency of existing buildings at the national level	3, 4, 5
			Lack of, or dispersion of, public funds or subsidies; complexity in acquiring public funding	3, 5
			Regulatory structures inhibiting business models concerning low-carbon innovations (e.g. on mortgage structures, property valorization schemes; use of energy performance contracts; obligation to be connected to the gas)	4, 5
			Insufficient capacity among local governments to set regulatory requirements and/or offer financial support for energy conservation in buildings	5
			National energy taxation schemes; low energy prices	3, 4, 5
Market			Low credit availability for small-scale LCIs; Limited opportunities to access credit at low costs for different target groups; risk aversion among financers due to perceived uncertainty regarding the performance of certain low-carbon innovations (e.g. zero-energy building concepts)	3, 4, 5

Table 6.2 Continued

CATEGORY	DRIVERS	DISCUSSED IN CHAPTER	BARRIERS	DISCUSSED IN CHAPTER
Market			Property valorization practices by banks and appraisers; insufficient economic valorization or energy efficient buildings	4, 5
Industry			Sector fragmentation and limitation in collaboration between supply-side actors in developing integrated solutions for energy retrofits	3 4, 5
			Limited experience and capacity of industry actors to organize deep retrofits	3, 4, 5
			No (scientific) consensus on how to achieve zero energy buildings and a low-carbon building stock (incremental or radical)	4, 5
Socio-cultural	Specific market-segment -green-oriented building owners and users – that are willing to engage in LCIs due to their levels of environmental concern, environmental values, or willingness to pioneer	2, 3	Lack of awareness among building owners and users on the benefits and opportunities for energy conservation in buildings	3, 4, 5
			Energy conservation has limited priority among building owners and users due to discounting, short-term investment horizons and/or risk aversion	3, 4, 5
			Insufficient capacity (financial, mental) among building owners and users to identify and develop energy conservation measures	3, 4, 5
(B) PHYSICAL CONTEXT				
Built environment			Fragmented property ownership/split-incentives; no active building associations to govern LCIs	3, 4, 5
Natural environment			—	

6.2.3 **RQ3 |** What strategies can be applied to promote the scaling-up of low-carbon initiatives?

The goal of this research question was to contribute to theory and practice on urban climate governance by exploring strategies that can be applied by actors operating on the local scale to promote the scaling-up of LCIs. The different empirical chapters discussed two meta-strategies: strategies for advancing horizontal pathways to scaling-up and strategies to support vertical pathways to scaling-up. The objective of the strategies is to address the barriers to scaling-up discussed in section 6.2.2, thereby promoting the scaling-up of LCIs.

6.2.3.1 *Local strategies directed at horizontal pathways to scaling-up*

The goal of this meta-category of strategies is to directly contribute to the uptake, growth or replication of LCIs by addressing contextual barriers. These strategies were identified by exploring the strategies that are applied by initiators of LCIs in Utrecht and Valencia promoting the uptake and growth (i.e. horizontal pathways to scaling-up) of LCIs focused on energy conservation in the existing building stock and by examining how these strategies could address the various barriers discussed in section 6.1.2. Three types of local strategies were identified:

— *Informative*. Informative strategies focus on the provision of information and advice, such as informational and advice programs or centers. Information provision by local, trusted actors is beneficial as they can apply a local framing and tailor the communication to the specific local needs and interests of the audience. Barriers related to the socio-cultural (e.g. lack of awareness, priority and capacity of households) and market context (e.g. information asymmetry) can be addressed through informative strategies.
— *Cooperative*. Cooperative strategies are directed offering at process guidance and improving the quality and efficiency of realizing LCIs through partnerships and stakeholder collaborations. Cooperative strategies can address different types of context barriers that make it unattractive and/or difficult for building owners and users to conserve energy. For instance, process support by independent intermediaries, from beginning to end, can relieve building users and owners from the complexity of retrofitting projects and the challenge of dealing with the different market- and supply-side actors.
— *Financial*. Financial strategies strive to make LCIs more financially feasible and attractive. Through the valorization of co-benefits and creation of collective purchasing arrangements, socio-cultural barriers (e.g. insufficient financial capacity) and market barriers (high upfront and instalment costs) can be addressed.

Private actors, such as urban community groups, tend to direct these strategies at particular locations or housing blocks, thereby reducing barriers on a temporal and local spatial scale. Yet they can lack the capacity to develop the strategic interventions required to address contextual barriers. Therefore, as discussed in Chapter 2, local governments can play an important role in supporting and institutionalizing these strategies so that they are employed on a structural basis. Moreover, local governments can also play a role in creating actor coalitions to initiate additional strategies that can address different types

of barriers (see Table 6.3). For instance, barriers related to the market and industry context, such as the lack of training and expertise of supply-side actors, information asymmetry, and credit availability, can only be structurally removed through collaborations between different actors in the supply chain. There was no consensus among respondents on the question of whether local governments should apply regulative strategies to address barriers, as they maintained that without financial and technical support this would be a burden that many building owners and users cannot bear.

Table 6.3 Local strategies *applied* by initiators of LCIs in Utrecht and Valencia to promote the uptake and growth of their initiative (i.e. horizontal pathways to scaling-up) and strategies *suggested* for application by local government (see Chapter 3).

CATEGORY	STRATEGY	BARRIER ADDRESSED	ACTOR
informative	Customized, face-to-face communication regarding the financial, and social benefits of energy conservation	*Socio-cultural context:* insufficient awareness of the benefits and opportunities for energy conservation in buildings; Energy conservation has limited priority among building owners and users. *Market context:* information asymmetry and complexity in finding reliable and customized information on energy conservation opportunities	Private; local government
	Showcasing the impact of successful LCIs		Private; local government
	Development of online and offline information points for customized information provision		Local government
Cooperative	Process assistance throughout the entire process, from beginning to end (e.g. identifying energy conservation opportunities, selecting contractors, financing, implementation, follow-up)	*Policy context:* lack of, or dispersion of, public funds or subsidies; complexity in acquiring public funding *Market context:* information asymmetry and complexity in finding reliable and customized information on energy conservation opportunities *Socio-cultural context:* insufficient capacity among building owners and users to identify and implement energy conservation measures *Built and geographical context:* fragmented property ownership, landlord-tenant dilemma; lack in owners' associations and governance structures to discuss energy conservation	Private; local government
	Activation of owners' organizations and development of support structures for the realization of LCIs in shared buildings	*Built and geographical context:* fragmented property ownership, landlord-tenant dilemma; lack in owners' associations and governance structures to discuss energy conservation	Local government
	Organizing training of, and collaboration between supply-side actors in organizing retrofits	*Market context:* insufficient skills and expertise of, and collaboration between, supply-side actors in organizing retrofits	Local government

Table 6.3 Continued

CATEGORY	STRATEGY	BARRIER ADDRESSED	ACTOR
Financial	Collective purchasing	*Market context:* high upfront purchase and installment costs of energy conservation measures *Socio-cultural context:* insufficient financial capacity among building owners to implement energy conservation measures	Private; local government
	Valorizing the co-benefits of energy conservation in buildings	*Socio-cultural context:* insufficient awareness of the benefits and opportunities for energy conservation in buildings; Energy conservation has no priority among building owners and users.	Private; local government
	Development of public and private financing mechanisms	*Market context:* high upfront purchase and installment costs of energy conservation measures; Difficulty to access credit at low cost	Local government

6.2.3.2 *Strategies of institutional entrepreneurship directed at vertical pathways to scaling-up*

Using insights from literature on institutional entrepreneurship and institutional work (DiMaggio, 1988; Lawrence & Suddaby, 2006; Lawrence et al., 2009) (see section 6.3.4) and empirical case work in the Netherlands, chapter 4 identified three types of strategies that actors can use to transform institutional context conditions (see Table 6.4). It is important to note that these strategies were applied by intermediary actors that, directly or indirectly, were involved in multiple local LCIs where low-innovations were applied.

— *Political.* Political strategies, namely visioning, coalition building, lobbying, and vesting, are used to broaden support for low-carbon innovation and to create a supportive policy environment. They are primarily directed at transforming barriers regarding the policy context, such as legal systems and regulatory structures. Political strategies have the objective of developing a political constituency behind a low-carbon innovation and constructing a policy environment that is favourable for its large-scale application.
— *Technical.* Technical strategies, such as educating and demonstrating, are used to reduce risk perception concerning low-carbon innovations and to spread skills and know-how required for their application by demand- and supply-actors. The goal of technical strategies is to generate predictable and credible results pertaining to an innovation and to enhance its perceived legitimacy in terms of solving a societal problem.
— *Cultural.* Cultural strategies include awareness-raising activities aimed at changing building owners' and users' perceptions concerning low-carbon innovations and the energy consumption of buildings, thereby overcoming primarily socio-cultural barriers, such as lack of environmental values and lack of priority of energy conservation among households.

Table 6.4 Strategies of institutional entrepreneurship applied by actors involved in LCIs in the Netherlands to promote vertical pathways to scaling-up (Chapter 4). Strategy categories are based on the work of Lawrence & Suddaby (2006) and Perkmann & Spicer (2008).

	STRATEGY	INSTITUTIONAL BARRIER ADDRESSED
POLITICAL	*Visioning* – Creating a vision for change by defining problems related to the building stock and by justifying how the low-carbon innovations can solve these problems	*Policy* – Insufficient political leadership and/or insufficient political urgency at the national level concerning climate change and/or energy conservation in buildings *Market* – Risk aversion and high-risk perception regarding the performance of low-carbon innovations by financers *Socio-cultural* – Insufficient awareness of the benefits and opportunities for energy conservation in buildings – Energy conservation has no priority among building owners and users due to discounting or short-term investment horizons
	Coalition-building – Broaden the political constituency behind a low-carbon innovation	*Policy* – Insufficient political leadership and/or insufficient political urgency at the national level concerning climate change and/or energy conservation in building *Industry* – Sector fragmentation and limitations in collaboration between supply-side actors in developing integrated solutions for energy retrofits
	Lobbying – Gathering political support for a low-carbon innovation and facilitative policy conditions *Vesting* – Creating policy conditions that support the low-carbon innovation (writing of policy proposals or regulations)	*Policy* – No regulatory requirements regarding energy efficiency of existing buildings – Regulations hampering the business case for low-carbon innovations (e.g. regulations on mortgage funding) – Energy pricing schemes
TECHNICAL	*Educating* – Providing market and industry actors, not yet involved in LCIs, with skills and know-how to apply the low-carbon innovation *Demonstration* – Demonstrating the workability of a low-carbon innovation and its effectiveness in solving societal problems	*Market* – Risk aversion and high-risk perception regarding the performance of low-carbon innovations by financers – Insufficient valorization of energy-efficient building *Industry* – No (scientific) consensus on how to achieve zero energy buildings and a low-carbon building stock *Socio-cultural* – Insufficient awareness of the benefits and opportunities for energy conservation in buildings – Energy conservation has no priority among building owners and users due to discounting or short-term investment horizons
CULTURAL	*Awareness raising activities* – Taking actions to shape the beliefs and perceptions about an innovation or dominant ways of organizing societal functions (e.g. housing) among building owners and users	*Socio-cultural* – Insufficient awareness on the benefits and opportunities for energy conservation in buildings – Energy conservation has no priority among building owners and users due to discounting or short-term investment horizons

6.2.3.3 *Synthesis*

The overview of strategies that can be applied to promote the scaling-up of LCIs is helpful to improve our understanding about the relation between barriers and solutions. While strategies for horizontal and vertical pathways were, in accordance with the analytical distinction, explored separately in chapters 3 and 4, it is expected that in practice there could be significant overlap between the two. For instance, the strategies 'educating' and 'demonstrating' can in practice appear similar to informative strategies for horizontal scaling-up. However, differences between the two categories of strategies relate to their intent and effect. Strategies for horizontal scaling-up have the purpose of addressing barriers on the local scale, thereby promoting the growth, replication, or uptake of new initiatives. On the other hand, strategies for vertical scaling-up have the goal of addressing institutional structures on different political scales, so that horizontal pathways to scaling-up can be accelerated.

In addition to strategies directed at promoting horizontal and vertical pathways to scaling-up, chapter 4 also identified strategies directed at creating and strengthening the low-carbon innovations, applied in LCIs, and the creation of institutional arrangements around them. This category of strategies aims to address internal barriers related to the performance of an innovation (e.g. price-performance of innovations; reliability), thereby improving their capacity to solve societal challenges. Strategies falling within this category, such as visioning, standardizing and the construction of a learning community, are thus not directly aimed at promoting scaling-up processes, but can support and inform scaling-up processes. Strategies falling within this category can be regarded as being part of the processes of 'niche development', proposed sustainability transitions theory (see section 6.3.3) and processes of 'pre-institutionalization', discussed in institutional theory (see section 6.3.4).

The different types of strategies can be applied by both local government and private actors. Local governments that aim to decarbonize their cities can initiate, support and institutionalize strategies directed at horizontal pathways to scaling-up (Chapter 2), and can engage in institutional entrepreneurship to address institutional barriers (Chapter 5). Also, it is expected that there is a great potential for addressing barriers and promoting scaling-up processes by creating collaborative governance structures that combine the capacity of local, private actors (e.g. communal trust, local knowledge, creativity) with the structural resources and strength of local government (e.g. independence, legitimacy, continuity).

6.2.4 **RQ4 |** How can local government learn from low-carbon initiatives, in order to contribute to their scaling-up?

To goal of this question was to examine how local governments can learn from LCIs and use this knowledge to promote scaling-up processes. As local governments are increasingly leading and enabling experimentation with LCIs for sustainability transitions (Bulkeley, 2010; Castán Broto & Bulkeley 2013), it is relevant to examine how they can govern learning processes, which can lead to an acceleration in the scaling-up of LCIs. Using the City of Copenhagen – regarded as a sustainability frontrunner- as a case study, chapter 5 provided a concrete overview of learning practices and an overview of explanatory factors, which can act as barrier or drivers, for learning.

As a point of departure, chapter 5 proposed that there exist two types of knowledge that can be derived from LCIs: instrumental and transformative knowledge. Instrumental knowledge includes knowledge of the performance of innovations (e.g. 'proof of concept') and approaches that contributed to a project's success. Transformative knowledge comprises reflections on the institutional structures that need to be addressed for large-scale application of the innovation to be possible. It is proposed that instrumental knowledge can inform horizontal pathways to scaling-up directed at the strengthening of low-carbon innovations, while transformative knowledge can inform vertical pathways to scaling-up.

Chapter 5 illustrated that local governments can learn from LCIs through four categories of practices: experience accumulation; knowledge articulation; knowledge codification; and knowledge distribution.

— *Knowledge accumulation*. Piloting and prototyping within LCIs, and the monitoring thereof, are important activities for accumulating knowledge about the impact and potential of low-carbon socio-technical innovations. Continuous monitoring is critical for learning how different technologies interact and to learn about the impact of user behaviour on the performance of buildings.
— *Knowledge articulation*. Project and program evaluations, project team meetings, and dialogues with stakeholders can foster knowledge articulation processes as they offer a context for reflecting on past actions and for identifying lessons for scaling-up. The creation of program coordinators that act as intermediaries between LCIs 'on the ground' and a City's Climate department can foster the articulation and distribution of instrumental and transformative knowledge.
— *Knowledge codification*. Writing of project reports and issue papers and the creation of prototypes are ways to ensure that the lessons learned by a project team are codified and available to external actors.
— *Knowledge distribution*. Knowledge distribution within the municipality can be encouraged via regular department- and team meetings. Through organizing workshops, training events, and conferences and membership to national and international issue networks, local government can distribute knowledge with a broader, external audience, thereby promoting the construction of a learning community and creating an advocacy coalition to address institutional barriers.

Chapter 5 also identified three groups of factors, which can act as barrier or driver, that influence a local government's capacity to learn from LCIs: motivation, resources, and skills.

— *Motivation*. The case study in the City of Copenhagen confirms the importance of local political leadership on climate change and a mandate for experimentation – and evaluation of LCIs – in furtherance of achieving a local government's carbon targets. Furthermore, the presence of institutional entrepreneurs, a co-operative and open culture, and ownership of the local government's Climate Plan among municipal staff, can foster learning practices.
— *Resources*. A local government's resource capacity can greatly influence its ability to learn from LCIs. Political leadership, discussed above, is a key driver for mobilizing resources for experimentation. Yet even a sustainability frontrunner like Copenhagen experiences internal struggles to secure

resources on a structural basis, such as securing access to funding and ample permanent staff, required for optimizing learning practices.

— *Skills*. To encourage discursive processes aimed at generating instrumental and transformative knowledge and to promote the distribution of knowledge among municipal departments and stakeholders, project leaders and program coordinators working within local government must possess strong intermediation, communication, and collaboration skills.

To sum up, local governments can learn from LCIs in order to contribute to their scaling-up by optimizing practices directed at the accumulation, articulation, codification, and distribution of instrumental and transformative knowledge from LCIs. The capacity of local governments to effectively govern such learning processes is influenced by their motivation, resources, and skills. The findings underline the importance of local political leadership for mobilizing resources for experimentation with – and learning from – LCIs to accelerate the low-carbon transition (Bulkeley, 2010; Bulkeley & Kern, 2006; Castán Broto & Bulkeley, 2013).

6.3 REFLECTIONS

6.3.1 Reflections on the research strategy, case selection and methods

The multiple case-study design was useful for the identification of factors and strategies influencing scaling-up pathways. The LCIs studied were implemented in three European cities – Utrecht, Valencia and Copenhagen. The variation in Northern, Western and Mediterranean urban contexts in which the LCIs are implemented allowed for the exploration of similarities and differences in factors influencing the scaling-up of LCIs. The cases were also selected for pragmatic reasons, such as the EU's Climate-KIC program funding the research and providing access to interesting cases and stakeholders, such as the Valencian Institute of Buildings and the City of Copenhagen. Of course, studies applying case-study design can be criticized for the limited empirical generalizability of the findings (Sharp, 1998). Yet by confronting the findings with previous studies in the field, theoretical generalizations on factors influencing scaling-up processes could be made (see Hillebrand, Kok, & Biermand, 2001). Moreover, as noted in the different chapters, while there are context-, building- or innovation-specific barriers, it is relevant to have an overview of general barriers – found in different contexts – as it is expected that scaling-up processes can be significantly accelerated when these are removed.

Applying a case study approach was also valuable given the explorative nature of the research questions addressed in two chapters (Chapter 4 and 5). As noted in the introduction, a key advantage of the case study approach is the depth of the analysis of the research object (Gerring, 2004). The qualitative nature of these different empirical chapters allowed the exploration of strategies and the rationales underlying them.

The triangulation of data sources was beneficial for improving the internal validity of the findings because factors and strategies influencing scaling-up identified by interviewees could be supported

with data derived from desk research. Semi-structured interviews were valuable for systematically identifying factors and strategies, but to also allow for flexibility and exploration of factors and strategies not yet discussed in literature and/or not fitting the analytical frameworks applied in the respective chapters.

6.3.2 Reflections vis-à-vis urban climate governance theory

The implementation of LCIs – as a form of climate experimentation – is increasingly recognized as an important feature of urban climate governance (Bulkeley, 2013; Castán Broto & Bulkeley, 2013; Kivimaa et al., 2017; McGuirk, 2014). However, as noted in the introduction, due to the relative immaturity of the field (Angelovsky & Carmin, 2011; Rutherford & Jaglin, 2015), there are limited studies so far on strategies that can be applied to support scaling-up processes. This dissertation has used multiple perspectives (such as sustainability transitions theory, institutional theory and organizational learning theory) to develop a better understanding of strategies for scaling-up LCIs. The combination of multiple perspectives and empirical studies in different contexts has been useful for more in-depth insights into the different types of strategies that can be applied to promote the scaling-up of LCIs. Of course, due the dynamic nature of climate experimentation in the field, the theoretical developments of key themes, such as strategies to promote scaling-up, are occurring simultaneously with their practical implementation. Therefore, much more is still to be discovered about how scaling-up processes can be advanced. For instance, follow-up research applying a longer time span is needed to assess the impact of strategies on scaling-up processes and to critically reflect on how scaling-up processes contribute to the transition to low-carbon cities (see section 6.4.1).

6.3.3 Reflections vis-à-vis sustainability transitions theory

In chapters 4 and 5, scaling-up processes were examined in the light of theory on sustainability transitions. Theory on sustainability transitions is concerned with the issue of how to promote and govern a transition towards sustainability (see Markard et al., 2012 for an overview). Scholars in the field maintain that sustainability transitions can come about through processes at three levels: (1) niche development, (2) the transformation of the socio-technical regime; and (3) landscape events that create pressures on the socio-technical regime (Geels & Schot, 2007). The 'socio-technical regime' is a key concept in theory on sustainability transitions and can be described as the highly institutionalized structures and practices which have evolved in accordance with high-carbon technologies and practices (Fuenfschilling & Truffer, 2014). While landscape level developments cannot be influenced by individuals, actors can theoretically play a role in the governance of sustainability transitions through niche development and regime transformation. Niche development encompasses a process where low-carbon innovations are 'shielded' from mainstream regime pressures and 'nurtured' so that they can further develop (Geels & Raven, 2006; Raven et al., 2016; Smith & Raven, 2012). Regime transformation regards a process where the institutional environment of the regime is changed so that it aligns with the practices and principles promoted by the innovation (Smith & Raven, 2012).

The concepts of 'horizontal and vertical pathways to scaling-up' are compatible with processes of 'niche development' and 'regime transformation'. It is suggested that horizontal scaling-up processes should be oriented towards niche development so that the capacity of low-carbon socio-technical innovations to address societal challenges is improved and that the actors working with these innovations can learn from each other and do not have to reinvent the wheel. At the same, actors working with LCIs should also foster vertical scaling-up processes oriented towards regime transformation. Regime transformation is deemed relevant for promoting sustainability transitions because without changing the institutional structures, LCIs remain little more than 'islands of excellence' in a wider institutional environment that is not favorable to low-carbon development.

The findings of this dissertation contribute to theory on sustainability transitions by discussing and concretizing strategies directed at vertical pathways to scaling-up (i.e. 'regime transformation') and strategies directed at developing and strengthening low-carbon innovations (i.e. niche development) (see Chapter 4). While scholars in the field highlight that the low-carbon transition demands both niche development and regime transformation, strategies for regime transformation were underexplored, leading to uncertainty on how niche actors can transform the institutions of the regime (Smith et al., 2005; Smith, 2007; Smith & Raven, 2012). Strategies to develop and strengthen low-carbon innovations (see section 6.2.3.3) can be regarded as part of processes of 'niche development' (Geels & Raven, 2006; Raven et al., 201; Smith & Raven, 2012). As many of the LCIs studied in this dissertation could be realized thanks to some form of protection (e.g. subsidies, specific market segments), the findings underline the importance of 'shielding' low-carbon innovations from mainstream selection pressures (see Raven et al., 2015; Schot & Geels, 2008; Smith & Raven, 2012).

6.3.4 Reflections vis-à-vis institutional theory

In chapter 4, strategies to encourage scaling-up processes were examined in the light of institutional theory. Upholding an institutional perspective (see Chapter 4), horizontal and vertical scaling-up pathways can be perceived as two interrelated phases of institutional change where low-carbon innovations become institutionalized. Scholars in the field of institutional theory describe the process of institutional change as evolving through three stages (Johnson, Dowd, & Ridgeway, 2006; Morill, 2007; Tolbert & Zucker 1996) or 'diffusion' (Johnson et al., 2006; Greenwood et al., 2002) – some degree of social consensus regarding the value of an innovation supporting institutional structures is reached, which results in an increase in diffusion of the innovation on the basis of that consensus. The institutional pillars of the contextual environment are partly adjusted in favor of the low-carbon innovation. To accomplish this second stage, and during this stage, innovation advocates apply strategies for institutional entrepreneurship to transform existing institutions so that they align with the practices and principles of their innovation. In the final stage – termed 'sedimentation' (Tolbert & Zucker 1999) general validation' (Johnson et al., 2006), 'reinstitutionalization (Greenwood et al., 2002) and 'structuration' (Morill, 2001) – the institutional context is fully transformed so that the low-carbon innovation becomes dominant and taken for granted as the natural and appropriate arrangement (Garud et al., 2002; Greenwood et al., 2002).

Literature on institutional entrepreneurship and institutional work (DiMaggio, 1988; Lawrence & Suddaby, 2006; Lawrence et al., 2011) were relevant for exploring strategies directed at vertical pathways to scaling-up. By examining how actor characteristics and field-level conditions inform institutional entrepreneurs' strategy choice, an issue underexplored in literature, the findings of chapter 4 offer a contribution to theory on institutional entrepreneurship and institutional work.

6.4 RECOMMENDATIONS

6.4.1 Recommendations for future research

The findings of this PhD dissertation have generated new insights for conceptual and practical understanding of scaling-up processes and have led to new questions and topics for future research.

A first recommendation is to conduct longitudinal studies to assess whether scaling-up pathways are taking place and to examine the influence of different types of strategies on scaling-up pathways. Longitudinal studies can improve the evidence base of the repertoire of strategies that can be applied to accelerate horizontal and vertical scaling-up pathways (see section 6.2.3). Moreover, longitudinal studies are required to assess whether scaling-up processes are actually taking place, thereby improving our understanding on the role and potential of LCIs in accelerating the transition to low-carbon cities. In this PhD dissertation, it was found challenging to assess vertical pathways to scaling-up because of the difficulty in establishing causal relationships between lessons derived from LCIs and changes in the institutional environment. As noted in chapters 4 and 5, learning from experimentation within LCIs occurs through the accumulation and aggregation of various experiences, and institutional change favoring low-carbon innovations is thus probably the result of the knowledge derived from multiple LCIs. Nevertheless, as a feature of key LCIs is that they contest the status quo and institutional structures contributing to high-carbon path dependence, it is important to assess whether and how lessons from LCIs lead to institutional change favoring horizontal pathways to scaling-up.

A second recommendation is to critically explore the capacities of local governments in accelerating the low-carbon transition. The findings suggest that local governments can apply local strategies to address institutional barriers (Chapter 3), engage in institutional entrepreneurship (Chapter 5), and can play a role in governing learning processes (Chapter 5). Yet, at the same time, the findings also indicate that local governments experience challenges in terms of capacity to accomplish their climate goals (section 6.2.4). Future studies should further explore and specify the limitations and opportunities of accelerating the low-carbon transition through urban climate governance. What can local governments do? What capacities and resources are required to do this? But also: what are the limitations of the local scale and what is the function of the national government in fostering the low-carbon transition?

The third recommendation is to critically explore the societal implications of the scaling-up of LCIs focused on energy conservation in buildings, as well as LCIs implemented in different sectors. Actors can have different perspectives on what the concept of 'low-carbon transition' entails. This is reflected by the different innovations supported and approaches adhered to by actors implementing LCIs (e.g. community versus market-based approach) (see Chapter 4). Given this, future studies should offer critical reflections on the societal implications of the scaling-up of different types of LCIs and their capacity to generate transformative change in terms of the provision of societal functions, such as housing or energy supply. Such accounts should also reflect on questions of justice, such as 'who is able to participate in LCIs?' and 'who gains and loses from the different low-carbon futures? ' Illuminating such societal implications can encourage fundamental debates about the meaning of the low-carbon transition and diminish the agnostic character of pathways to low-carbon transitions. As noted by Meadowcroft (2009): *"It is important to remember that, depending on how the process actually unfolds, society could end up in a very different place"* (ibid: 327).

6.4.2 Recommendations for practice

The following section will shortly reflect on insights from this dissertation that are relevant for practice.

The first recommendation, directed at local governments, is to actively initiate and support strategies for scaling-up. They can: (1) support and institutionalize local strategies directed at horizontal pathways to scaling-up, (2) engage in institutional entrepreneurship, and (3) actively foster learning from LCIs and act as an intermediary actor by spreading knowledge within the broader policy network. The findings on practices and factors conducive to learning, discussed in chapter 5, can assist local governments in optimizing learning practices and creating organizational frameworks fostering the capitalization of knowledge from LCIs. We recommend local governments to set a mandate for experimentation with – and conducting evaluations of – LCIs.

A second recommendation, directed at public and private intermediary actors (in)directly involved in LCIs, is to work together in coordinating the evaluation and scaling-up of LCIs. Intermediaries should identify both instrumental knowledge related to the innovations applied and transformative knowledge, regarding institutional conditions that need to be addressed for large-scale application of the innovation to be possible. It is important that such evaluations are conducted in a structured and transparent manner, thereby creating an evidence-base that can be used to legitimize and inform strategies for scaling-up. Thus, experiences 'on the ground' by initiators of LCIs (such as policy or market barriers) should be used to inform and legitimize strategies directed at vertical scaling-up pathways. Intermediary actors should also be responsible for coordinating strategies for horizontal and vertical scaling-up. Two key types of strategies were discussed in this dissertation: local strategies directed at horizontal pathways to scaling-up and strategies of institutional entrepreneurship directed at vertical pathways to scaling-up. In addition, strategies were discussed that aim to strengthen the capacity of low-carbon innovations in solving societal challenges related to sustainability, which is a condition for scaling-up. To accomplish the transition to low-carbon cities, all strategies need to be applied and synergy between the strategies should be sought. To ensure that both horizontal and vertical pathways to scaling-up are encouraged, intermediaries with limited resources and skills should

specialize in certain strategies, rather than risking failing in all, and co-ordinate their strategies with other intermediary actors in the field to achieve maximum effect in accelerating scaling-up processes

6.5 FINAL REFLECTIONS

A quick look at the newspapers that appeared during the finalization of this thesis, i.e. September 2017, offers ample food for thought for a final reflection. Coverage of the hurricanes Harvey and Irma, show us the devastating financial and social impacts of extreme weather events, aggravated by climate change (Mann, 2017). The two hurricanes have afflicted billions in damages and given rise to social unrest (Horrowitz, 2017). Another article points out that Asia's mountain glaciers will lose a at least a third of their mass by the end of this century, leading to water scarcity, more intense flooding, heavier rains and super storms in this region (AFP, 2017).

These news items should make the public more concerned and spurge urgent action worldwide. Unfortunately, climate change is perceived as distant in time and space and people often find themselves blindsighted by the impacts, while it is happening right in front of us. At the same time, when confronted with the abstract figures on tonnes of CO2 that need to be mitigated and studies pointing out that there is only a 1% chance of achieving the 1.5-degree climate target (Milman, 2017), there is a tendency to say it is too late to do anything.

But there is no need to despair just yet. Cities are at the frontline of climate change and keep climate action on track (US Climate Group, 2017). In cities worldwide, low-carbon initiatives are initiated by pioneering public and private actors that offer us a glimpse of what a low-carbon future looks like. There are many reasons for being optimistic for the potential of LCIs to contribute to the transition to low-carbon societies. After all, these bottom-up initiatives are sources of creativity and innovation and demonstrate the local benefits of decarbonizing our practices, buildings, and communities. While many initiatives are driven by a sense of urgency to the global climate problem, they use the local community and local challenges and needs as a starting point. Another reason for being optimistic about local initiatives is that they can reduce local opposition and create public support for large-scale climate interventions and policies, such as wind farms of energy taxes. An article in the Dutch newspaper Volkskrant (Lindhout, 2017) noted that wind farms, a central aspect of Germany's 'Energiewende', are facing local opposition and resistance by the local communities nearby. This is the risk top-down interventions face, which can lead to implementation gaps. Yet, when local communities get involved and feel ownership about climate interventions, they will likely experience 'gains' of a low-carbon future, rather than 'pains'.

The local framing and embeddedness of LCIs are keys to their success. But are these local initiatives enough? The flipside of being local and small it that LCIs can be perceived as insignificant in the context of global sustainability challenges. However, while it might be challenging for one stone to change the flow of a river, it can create a ripple. By laying down more stones and coordinating their placement, we can eventually change its course.

REFERENCES

Abdellatif, M. & Al-Shamma'a, A., (2015). Review of sustainability in buildings. *Sustainable Cities and society*, 14, 171-177.

Agence France-Presse (2017, September 14). Asia's glaciers to shrink by a third by 2100, threatening water supply of millions. *The Guardian*. Retrieved from https://www.theguardian.com/environment/2017/sep/14/asia-glaciers-shrink-threatening-water-supply.

Agency for Sustainable Mediterranean Cities and Territories (AViTeM) & Government of Catalonia (2014). *Responding to challenges regarding energy efficiency and renewable energy in Mediterranean buildings.* Brussels: programme Med, European Commission.

Agentschap NL (2010) Guidance on solar projects. Report. Utrecht, the Netherlands: Agentschap NL.

Allen, J., Sheate, W.R., & Diaz-Chavez, R., (2012). Community-based renewable energy in the Lake District National Park – local drivers, enablers, barriers and solutions. *Local Environment*, 17(3), 261–280.

Ang S. L. & Wilkinson S.J. (2008). Is the social agenda driving sustainable property development in Melbourne, Australia? *Sustainable Property Development* 26(5), 331–343.

Anguelovski, I., & Carmin, J. (2011). Something borrowed, everything new: innovation and institutionalization in urban climate governance. *Current Opinion in Environmental Sustainability*, 3(3), 169–175.

Arentsen, M. & Bellekom S. (2014). Power to the people: local energy initiatives as seedbeds of innovation? *Energy Sustain Society*, 4(2), 1-12.

Argyris, M. & Schön, D. (1978). Organizational learning: A theory of action perspective. Reading, UK: Addison Wesley.

Atanasiu, B., Despret, C., Economidou, M., Maio, J., Nolte, I., & Rapf, O. (2011). *Europe's buildings under the microscope.* Brussels: BPIE.

Avelino, F., & Rotmans, J. (2009). Power in Transition: An Interdisciplinary Framework to Study Power in Relation to Structural Change. *European Journal of Social Theory, 12*(4), 543–569.

AviTem & Government of Catalonia (2014). Agency for Sustainable Mediterranean Cities and Territories (AViTeM) and Government of Catalonia. *Responding to challenges regarding energy efficiency and renewable energy in Mediterranean buildings.* Brussels: programme Med, European Commission.

Azevedo, I., Delarue, E., & Meeus, L. (2013) Mobilizing cities towards a low-carbon future: Tambourines, carrots and sticks. *Energy Policy,* 61, 894–900.

Baek, C., & Park, S. (2012). Policy measures to overcome barriers to energy renovation of existing buildings. *Renewable and Sustainable Energy Reviews*, 16(6), 3939–3947.

Bai, X, Roberts, B., & Chen, J. (2010). Urban sustainability experiments in Asia: Patterns and pathways. *Environmental Science & Policy*, 13, 312–325.

Battilana, J., Leca, B., & Boxenbaum, E. (2009). How Actors Change Institutions: Towards a Theory of Institutional Entrepreneurship. *The Academy of Management Annals, 3*(1), 65–107.

Batty, M. (2011). Commentary. When all the world's a city. *Environment and Planning A*, 43 (4), 765-772.

Beck, F., & Martinot, E. (2004). Renewable energy policies and barriers. In: Encyclopedia of Energy (pp. 365-383). San Diego, Ca.: Academic Press and Elsevier Science.

Bemelmans-Videc, M. Rist, M., & Vedung, E., (1998). *Carrots, sticks and sermons: policy instruments and their evaluation.* New York, NY: Transaction Publishers.

Bennett, C.J., & Howlett, M. (1992). The lesson of learning: Reconciling theories of policy learning and policy change. *Policy Sciences* 25, 275-294.

Berger, P., & Luckmann, T. (1966). *The social construction of reality: A Treatise on the sociology of knowledge.* Garden City, NY: Doubleday.

Berkhout, F., Angel, D., & Wieczorek, A.J. (2009). Sustainability transitions in developing Asia: Are alternative development pathways likely? *Technological Forecasting and Social Change,* 76 (2), 215-217.

Betsill, M. (2001). Mitigating Climate Change in US Cities: Opportunities and Obstacles. *Local environment,* 6(4), 393–406.

Betsill, M., & Bulkeley, H. (2006). Cities and the Multilevel Governance of Global Climate Change. *Global Governance*, 12(2), 141–159.

Betsill, M., & Bulkeley, H. (2007). Looking Back and Thinking Ahead: A Decade of Cities and Climate Change Research. *Local Environment,* 12(5), 447–56.

Birnie, P., Boyle, A., & Redgwell, C. (2009). *International law & the Environment.* Oxford: Oxford University Press.

Boardman, B. (2010). *Fixing Fuel Poverty: Challenges and Solutions. Routledge* (Vol. 1). London, UK: Earthscan.

Bomberg, E., & McEwen, N. (2012). Mobilizing community energy. *Energy Policy,* 51, 435–444.

van Boon, F.P., & Dieperink, C. (2014). Local civil society based renewable energy organisations in the Netherlands: Epxloring the factors that stimulate their emergence and development. *Energy Policy,* 69, 297-307.

van den Bosch, S., & Rotmans, J. (2008). *Deepening, Broadening and Scaling up.* Rotterdam, the Netherlands: Knowledge Centra for Sustainable System Innovations and Transitions (KCT).

BPIE (2016). *ZEBRA 2020 – Nearly Zero-Energy Building Strategy 2020. Strategies for a Nearly Zero-Energy Building market transition in the European Union.* Brussels, Belgium: BPIE.

Bradford, J., & Fraser, E. (2008). Local Authorities, Climate Change and Small and Medium Enterprises: Identifying Effective Policy Instruments to Reduce Energy Use and Carbon Emissions. *Corporate Social Responsibility and Environmental Management,* 15(3), 156–172.

Bresear (2015, December 3). *Building retrofits critical to Europe's low-carbon pathway.* Retrieved from bresaer.com

van Bueren, E.M., & Priemus, P. (2002). Institutional barriers to sustainable construction. *Environment and Planning B: Planning and Design,* 29(1), 75–86.

Brown, H.S., & Vergragt, P.J. (2008). Bounded socio-technical experiments as agents of systemic change: The case of a zero-energy residential building. *Technological Forecasting and Social Change,* 75(1), 107–130.

Bulkeley H, et al. (2009, June) *Cities and Climate Change: The Role of Institutions, Governance and Urban Planning. World Bank Urban Symposium on Climate Change.* Report prepared for the World Bank Urban Symposium on Climate Change, Marseille, France, 28–30 June, 2009.

Bulkeley, H. (2010). Cities and the Governing of Climate Change. *Annual Review of Environment and Resources,* 35(1), 229–53.

Bulkeley, H., & Betsill, M. (2003). *Cities and Climate Change: Urban Sustainability and Global Environmental Governance.* New York, NY: Routledge.

Bulkeley, H. & Betsill, M. (2005). Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change. *Environmental Politics,* 14(1), 42-63.

Bulkeley, H. (2013). *Cities and Climate Change.* Abingdon, UK: Routledge.

Bulkeley, H., Castán Broto,V, Hodson, M., & Marvin, S. (2011). *Cities and Low Carbon Transitions.* Oxon, NY: Routledge.

Bulkeley, H., Castán Broto,V. , & Maassen, A.. (2013). Low-Carbon Transitions and the Reconfiguration of Urban Infrastructure. *Urban Studies,* 51(7), 1471–86.

Bulkeley, H., & Castán Broto, V. (2013). Government by Experiment? Global Cities and the Governing of Climate Change. *Transactions of the Institute of British Geographers,* 38(3), 361–75.

Bulkeley, H., & Kern, K. (2006). Local Government and the Governing of Climate Change in Germany and the UK. *Urban Studies,* 43(12), 2237-2259.

Burch, S. (2010). Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada. *Global Environmental Change,* 20(2), 287–297.

Burnham, P. Gilland Luntz, K., Grant, W., & Layton-Henry, Z. (2008). Comparative methods. In: Burnham, P., Gilland Lutz, K., Grant, W., & Layton-Henry, Z. (Eds.) Research Methods in Politic (pp. 69-95). Basingstoke, UK: Palgrave MacMillan.

van Buuren, A., & Loorbach, D. (2009). Policy innovation in isolation? Conditions for policy renewal by transition areas and pilot projects. *Public Management Review*, 11(3), 375-392.

Cam, W.C. (2013). Fostering interconnectivity dimension of low-carbon cities: The triple bottom line re-interpretation. *Habitat International*, 37, 88-94.

Caputo, P., & Pasetti, G. (2015). Overcoming the inertia of building energy retrofit at municipal level: The Italian challenge. *Sustainable Cities and Society,* 15, 120–134.

Cash D.W., Adger W.N., Berkes F, Garden, P., Lebel, L. Olsson, P., ... Young, O. (2006) Scale and cross-scale dynamics: Governance and information in a multilevel world. *Ecology and Society,* 11(2).

Castán Broto, V., & Bulkeley, H. (2013). A Survey of Urban Climate Change Experiments in 100 Cities. *Global Environmental Change*, 23(1), 92–102.

Chmutina K, Wiersma B, Goodier, C.I. & Devine-Wright, P. (2014) Concern or compliance? Drivers of urban decentralised energy initiatives. *Sustainable Cities and Society*, 10, 122–129.

City of Copenhagen (2016). *Copenhagen Climate Projects. Annual report 2015*. Copenhagen, Denmark: Technical and Environmental Affairs, City of Copenhagen.

City of Copenhagen (2012). *Copenhagen Climate Plan 2025: A Green, Smart and Carbon Neutral City.* Copenhagen, Denmark: Technical and Environmental Affairs, City of Copenhagen.

Collier, U. (1997). Local authorities and climate protection in the EU. *Local Environment*, 2(1), 39–57.

Conefrey, T., & Fitz Gerald, J. (2010). *Managing Housing Bubbles in Regional Economies Under Emu: Ireland and Spain. National Institute Economic Review***,** 211, 27-44.

Cooke, R., Cripps, A., Irwin, A., & Kolokotrono, M. (2007). Alternative energy technologies in buildings: Stakeholder perceptions. *Renewable Energy,* 32 (14), 2320–2333.

Corfee-Morlot, J. Kamal-Chaioui, M., Donovan, M.G, Cochran, I., Robert A., & Teaddale, P.J. (2009) *Cities, climate change and multilevel governance* (Environmental Working Papers No. 14). Paris, France: OECD Publishing.

Cuchí, A., & Sweatman, P. (2013). *Strategy for buildings renovation. Keys to transform Spain's building sector.*Madrid, Spain: Green Building Council Espana.

C40 (2017, July 15). C40 Mayors Ask G20 Leaders to Listen to Cities and Their Citizens on Climate Change. *C40.* Retrieved from www.c40.org

Decanio, S. J. (1998). The efficiency paradox: bureaucratic and organizational barriers to profitable energy-saving investments. *Energy Policy*, 26(5), 441–454.

Deloitte (2015). Smart Cities, not just the sum of its parts. Monitor Deloitte: Retrieved from www2.deloitte.com/content/dam/Deloitte/xe/Documents/strategy/me_deloitte-monitor_smart-cities.pdf

Denscombe, M. (1998). *The good research guide*. Buckingham, UK: Open University Press.

Dieperink, C., Brand, I., & Vermeulen, W. (2004). Diffusion of energy-saving innovations in industry and the built environment: Dutch studies as inputs for a more integrated analytical framework. *Energy Policy*, 32(6), 773–784.

DiMaggio, P.J. (1988). *Interest and Agency in Institutional Theory.* Cambridge: Ballinger Publisher Co.

DiMaggio, P., & Powell, W.W.(1982). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48 (2), 147-160.

Dixon, N. (1994). *The Organizational Learning Cycle: How can we Learn Collectively.* Aldershot, UK: Gower.

Dorado, S. (2005). Institutional Entrepreneurship, Partaking, and Convening. *Organization Studies*, 26(3), 385–414.

van Doren, D., Driessen, P. P., Runhaar, H., & Giezen, M. (2016). Scaling-up low-carbon urban initiatives: Towards a better understanding. *Urban Studies* [online]. https://doi.org/10.1177/0042098016640456

Douthwaite B, Kuby T, van de Fliert E,, & Schulz, S. (2003). Impact pathway evaluation: An approach for achieving and attributing impact in complex systems. *Agricultural Systems,* 78(2), 243–265.

Dowson M, Poole A, Harrison D, et al. (2012). Domestic UK retrofit challenges: Drivers, barriers and incentives leading into the Green Deal. *Energy Policy,* 50, 294–305.

Driessen, P.P.J., Dieperink, C., van Laerhoven, F.S.J., Runhaar, H.A.C., & Vermeulen, W.J.V. (2012). Towards a conceptual framework for the study of shifts in modes of environmental governance: experiences from the Netherlands. *Environmental Policy and Governance,* 22 (3), 143-160.

Driessen, P.P.J., Behagel, J., Hegger, D., Mees, H. Almesjo, L., Andresen, S, ...Verbruggen, A. (2012, May). *Societal transformations in the face of climate change***.** Paper prepared for JPI Climate. Brussels.

Eisenstadt, S.N. (1980). Cultural orientations, institutional entrepreneurs, and social change. Comparative analyses of traditional civilisations. *American Journal of Sociology,* 85 (4), 840-869.

Elzen, B., Geels, F.W., & Green, K. (Eds.) (2004). *System innovation and the transition to sustainability.* Cheltenham, UK: Edward Publishing Ltd.

Emmert, S., van de Lindt, M., and Luiten, H. (eds.) (2011). *BarEnergy: barriers to changes in behaviour among end consumers and households.*

Energy Cities (2014, January 22). *2030 Framework. Who will reclaim Europe's competitiveness and climate leadership?* Retrieved from: www.energy-cities.eu.

Energy Efficiency Financial Institutions Group (EEFIG) (2014). *Energy Efficiency- the first fuel for the EU Economy- How to drive new finance for energy efficiency investments.* Brussels, Belgium: European Commission.

Erhorn, H. & Erhorn-Kluttig, H. (2014). *Selected examples of Nearly Zero-Energy Buildings. Concerted Action Energy Performance of Buildings* Retrieved from www.epbd-ca.eu.

Etheridge, L. (1981). Government learning: An overview. In S.L. Long (Ed), *The Handbook of Political Behavior* (Vol. 2). New York, NY: Pergamon.

European Commission of the Regions (ECR) (2017, June 2). Europe's cities and regions will not waver in their commitment to the Paris Agreement. *European Commission of the Regions.* Retrieved from: http://cor.europa.eu.

European Commission (EC) (2015). *Energy Efficiency: Buildings.* Retrieved from: European Commission's Science and Knowledge Service: www. ec.europea.eu.

European Commission (EC) (2016). *Energy Efficiency: Energy Consumption Trends.* Retrieved from the website of the European Commission's Science and and Knowledge Service: www.ec.europea.eu.

European Energy Agency (2017). Urban Environment. Available at the website of the European Energy Agency. Retrieved February 22, 2017, from www.eea.europea.eu/themes/urban.

European Parliament (2016). Review of the energy performance of building directive 2010/31/EU. Retrieved from http://www.europarl.europa.eu/legislative-train/theme-resilient-energy-union-with-a-climate-change-policy/file-energy-performance-of-buildings-directive-review.

European Union (2011). *Energy Roadmap 2050.* Brussels, Belgium: European Union.

European Union (2016). *Energy efficiency: Buildings.* Retrieved September 1, from https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings.

Evans, J., & Karvonen, A. (2014). 'Give me a labratory and I will lower your carbon footprint! - Urban labratories and the Governance of Low-Carbon Futures. *International Journal of Urban and Regional Research*, 38 (2), 413-430.

Evans, J., Karvonen, A., & Raven, R. (eds.). (2016). The Experimental City. London, UK: Routledge.

De Groote, M., Lefever, M., & Reinaud, J. (2016). Scaling up deep energy renovations. Unleashing the potential through innovation and industrialization. 124c Initiative and the Buildings Performance Institute Europe (BPIE). Retrieved September 7, 2017 from: http://bpie.eu/publication/scaling-up-deep-energy-renovation.

Farreny R., Oliver-Sola J., Montlleo Enric Escriba, M., Gabarrell, X., & Rieradevall, J. M. (2011). Transition towards sustainable cities: Opportunities, constraints, and strategies in planning. A neighbourhood ecodesign case study in Barcelona. *Environment and Planning A,* 43(5), 1118–1134.

Feige, A, Wallbaum,. H and Krank, S. (2011) Harnessing stakeholder motivation: Towards a Swiss sustainable building sector. *Building Research & Information,* 39(5), 504–517.

Feist, W., Schneider, J., Dorer, V., & and Haas, A. (2005). Re-inventing air heating: Convenient and comfortable within the frame of the Passive House concept. *Energy and Buildings,* 37 (11), 1186-1203.

Femenias, P. (2004). Demonstration projects for sustainable building. PhD thesis, Chalmers University of Technology, Gothenburg, Sweden.

Feola, G. (2015). Societal transformation in response to global environmental change: A review of emerging concepts. *Ambio,* 44 (5), 376-390.

Fichman, R., & Kemerer, C.F. (1997). The Assimilation of Software Process Innovations : An Organizational Learning Perspective. *Management Science,* 43(10), 1345–63.

Fleiter, T., Schleich, J., & Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs- An empirical analysis based on energy audit data from Germany. *Energy Policy*, 51 (0), 863–875.

Fligstein, N. (1997). Social skill and institutional theory. *American behavioural Scientist*, 40, 397-405.

Fuenfschilling, L., & Truffer, B. (2014). The Structuration of Socio-Technical Regimes - Conceptual Foundations from Institutional Theory. *Research Policy*, 43(4), 772–91.

Fuenfschilling, L. & Truffer B., (2016). The interplay of institutions, actors and technologies in socio-technical systems – An analysis of transformations in the Australian urban water sector. *Technological Forecasting & Social Changing,* 103, 298-312.

Garud, R., Jain, S., & Kumaraswamy, A. (2002). Institutional Entrepreneurship in the Sponsorship of Common Technological Standards: the Case of Sun Microsystems and Java. *Academy of Management Journal*, 45 (1), 196–214.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6-7), 897–920.

Geels, F. (2011). *The role of cities in technological transitions: Analytical clarifications and historical examples* (pp. 13-28). In: Bulkeley H, Broto VC, Hodson M, et al. (Eds) Cities and Low Carbon Transitions. Oxon, NY: Routledge.

Geels, F., & Deuten, J. (2006). Aggregation Activities. Local and Global Dynamics in Technological Development: A Socio-Cognitive Perspective on Knowledge Flows and Lessons from Reinforced Concrete. *Science and Public Policy*, 33(4), 265–75.

Geels, F. W., & Kemp, R. (2007). Dynamics in Socio-Technical Systems: Typology of Change Processes and Contrasting Case Studies. *Technology in Society* 29(4), 441–55.

Geels, F., & Raven, R. (2006). Non-linearity and expectations in niche-development trajectories: Ups and downs in Dutch biogas development (1973-2003). *Technology Analysis & Strategic Management*, 18(3-4), 375–392.

Geels, F., & Schot J. (2007). Typology of sociotechnical transition pathways. *Research Policy,* 36 (3), 399-417.

Gerring, J. (2004). What is a case study and what is it good for? *American Political Science Review*, 98 (2), 341-354.

Gibson, C.C., Ostrom, E., & Ahn T.K. (2000). The concept of scale and the human dimensions of global change: A survey. *Ecological Economics*, 32 (2), 217–239.

Gillespie, S. (2004). *Scaling up Community-Driven Development: A Synthesis of Experience.* Washington, DC: International Food Policy Research Institute.

Granberg, M., & Elander, I. (2007). Local Governance and Climate Change: Reflections on the Swedish Experience. *Local Environment* 12(5), 537–48.

Greenwood, R., Oliver, C., Suddaby, R., & Sahlin, K. (Eds.). (2008). *The Sage Handbook of organizational institutionalism.* London, UK: SAGE Publications.

Grimm, N.B., Faeth, S., Golubiewski, E., Redman, C.L., Wu, J., Bai, X., & Briggs, J.M. (2008). Global change and the ecology of cities. *Science*, 318 (5864), 756-760.

Grin, J.G. Rotmans, J., & Schot, J. (2010). Transitions to Sustainable Development. New directions in the study of long-term transformative change.New York, NY: Routledge.

De Groote, M. Fabbri. M., Rapf, P., & D'Angionella, R. (2016). Buildings as micro energy hubs delivering climate solutions. *The REHVA European HVAC Journal* 53(3), 53.

GWL-terrein (2010) *GWL Terrain: An urban eco area: Factsheets. Report.* Retrieved June 2014 from: www.gwl-terrein.nl.

Hajer, M. (2001). *The energieke samenleving '(the Energetic Society').* The Hague, the Netherlands: Planbureau voor de Leefomgeving.

van Hall, A. (2000). *Beyond the Demonstration Project: The Diffusion of Environmental Innovations in Housing.* Aneas: Boxtel.

Hall, P. A. (1988). *Policy paradigms, social learning and the state.* Paper presented tot he International Political Science Association, Washington, D.C.

Hansen, M. T., Nohria, N., & Tierney, T. (1999), What's your strategy for managing knowledge? *Harvard Business Review,* 77(2), 106-116.

Hardy, C., & Maguire, S. (2008). Institutional entrepreneurship. In R. Greenwood, C. Oliver, K. Sahlin, & R. Suddaby (Eds.). *The Sage Handbook of organizational institutionalism.* Thousands Oaks, Ca: SAGE.

Hargreaves, T. Hielscher, S., Seyfang, G., & Smith, A. (2013). Grassroots innovations in community energy: the role of intermediaries in niche development. *Global Environmental Change*, 23(5), 868-880.

Hillebrand, B, Kok, R., & Biemand, W.G. (2001). Theory-testing using case studies. A comment on Johnson, Leach and Liu. *Industrial marketing and management*, 30 (8), 651-657.

Heclo, H. (1978). Issue networks and the executive establishment. In A. King (Ed.), *The New American Political System* (pp 87-124). Washington D.C.: American Enterprise Institute for Public Policy Research.

Hoffman, M.J. (2011). *Climate Governance at the Crossroads: Experimenting with a Global Response after Kyoto.* Oxford: Oxford University Press.

Hoff, J., & Gausset, Q. (2016). Community Governance and citizen-driven initiatives in climate change mitigation: an introduction. In: *Community Governance and Citizen-Driven Initiatives in Climate Change Mitigation.* (Eds. Jens Hoff and Quentin Gausset). London, UK: Routledge.

Hoffman, A. J., & Henn, R. (2008). Overcoming the Social and Psychological Barriers to Green Building. *Organization Environment*, 21(4), 390–419.

Holgate, C. (2007). Factors and Actors in Climate Change Mitigation: A Tale of Two South African Cities. *Local Environment,* 12(5), 471–84.

Hoogma, R. Kemp, R, Schot, J., & Truffer, B. (2002). *Experimenting for Sustainable Transport: The Approach of Strategic Niche Management.* New York, NY: Spon Press.

Hoppe, T., & Bueren, E. (2015). Guest editorial: governing the challenges of climate change and energy transition in cities. *Energy, Sustainability and Society*, 5(19).

Horrowitz, J. (2017, September 26). Hurricanes Irva and Harvey have racked up billions in damages. Who pays? CNN. Retrieved from: http://money.cnn.com/2017/09/15/news/economy/irma-harvey-damage-who-pays/index.html.

Huber, G.P. (1991). Organizational learning: The contributing process and the literature. *Organization Science*, 2(1), 88.

Hunt, A., & Watkiss, P. (2011). Climate change impacts and adaptation in cities: a review of the literature. Climate Change, 104(1), 13-49.

Hwang B., & Tan J.S. (2012). Green building project management: Obstacles and solutions for sustainable development. *Sustainable Development,* 20 (5), 335–349.

ICLEI (2016, October 20). From Bankok to Quito: cities at the forefront of our sustainable future. Local Governments for Sustainability. Retrieved from: www.iclei.org.

IIRR (2001) *Going to scale: Can we bring more benefits to more people more quickly? Workshop highlights presented by the CGIAR-NGO Committee and the Global Forum for Agricultural Research.* Silang: IIRR.

Immendoerfer, A., Winkelmann, M., & Stelzer, V. (2014). *Energy Solutions for Smart Cities and Communities, Recommendations for Sustainable Energy Solutions for communities in 58 cities in 23 countries.* Brussels, Belgium: European Union.

International Energy Agecy (IEA) (2008). Promoting Energy Efficiency Investments: case studies in the residential sector. Paris, France: International Energy Agency.

International Energy Agency (IEA) (2009). *Cities, towns & Renewable energy: Yes in my front yard.* Paris, France: International Energy Agency.

International Energy Agency (IEA) (2013). *Transition to Sustainable Buildings*. Paris, France: International Energy Agency.

IPCC (2007). *Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland: Intergovernmental Panel on Climate Change.

IPCC (2014). *Mitigation of Climate Change. Summary for Policymakers. Technical Summary. Part of the Work Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva: Intergovernmental Panel on Climate Change.

Jacobssen, S., & Bergek, A. (2004). Transforming the energy sector: the evolution of technological systems in renewable energy technology. *Industrial and Corporate Change,* 13 (5), 815-849.

Jenkins, Nordhaus, T., & Shellenberger (2011). *Energy Emergence: Rebound and Backfire as Emergent Phenomena.* Oakland, Ca: the Breakthrough Institute.

Johnson, C. Dowd, T. & Ridgeway (2006). Legitimacy as a social process. *Annual review of sociology,* 32 (1), 53-78.

Jolly, S., & Raven, R. P. J. M. (2015). Collective institutional entrepreneurship and contestations in wind energy in India. *Renewable and Sustainable Energy Reviews,* 42, pp. 999–1011.

Jordan, A. (2008). The governance of sustainable development: taking stock and looking forwards. Environment and Planning C: Government and Policy, 26(1), 17-33.

Jordan, A., Wirzel, R., & Zito, A. (2003). New instruments of environmental governance: patterns and pathways of change. *Environmental Politics* 12(1), 1-24.

Kasioumi, E. (2011). Sustainable Urbanism: Vision and Planning Process Through an Examination of Two Model Neighborhood Developments. *Berkeley Planning Journal,* 24(1), 91–114.

Kemp R., Schot, J., & Hoogma, R. (1998) Regime shifts to sustainability through processes of niche formation the approach of strategic niche management. *Technology Analysis and Strategic Management,* 10(2), 175–198.

Kemp, R. Loorbach, D., & Rotmans, (2007). Assessing the Dutch energy transition policy: how does it deal with dilemmas of managing transitions? *Journal of Environmental Policy and Planning* 9, 315-331.

van Kersbergen, K. & van Waarden, F. (2004). 'Governance' as a bridge between disciplines: Cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy. *European Journal of Political Research,* 43(2), 143-171.

Khakee, A. (2010). Assessing Institutional Capital Building in a Local Agenda 21 Process in Göteborg. *Planning Theory & Practice,* 3(1), 53–68.

Kickert W.J.M., Klijn, E.H., & Koppenjan, J.F.M. (1997) Introduction: A management perspective on policy networks (pp. 1-13). In: Kickert WJM, Klijn, JFM E-H & Koppenjan L (Eds) *Managing Complex Networks. Strategies for the Public Sector.* London, UK: SAGE.

Kingdon, J. A. (1995). *Agendas, alternatives and public policies* (Second ed). New York, NY: Harper-Collins.

Kivimaa, P., Hilden, M., Huitema, D., Jordan, A., & Newig, J. (2017). Experiments in Climate Governance: A Systematic Review of Research on Energy and Built Environment Transitions. *Journal of Cleaner Production,* 169 (1), 1–13.

Klein Woolthuis, R., Hooimeijer, F., & Bossink, B. (2013). Institutional entrepreneurship in sustainable urban development: Dutch successes as inspiration for transformation. *Journal of Cleaner Production,* 50 (1), 91–100.

Kostka, G., Moslener, U., & Andreas, J. (2013). Barriers to increasing energy efficiency: Evidence from small-and medium-sized enterprises in China. *Journal of Cleaner Production,* 57, 59–68.

Kranzl, L., Müller A., Hummel, M., & Toleikyte, A. (2014).Laying down the pathways to nearly zero-energy buildings: a toolkit for policy makers. Vienna, Switzerland: ENTRANZA.

Kukk, P., Moors, E.H.M., & Hekkert, M.P. (2016). Institutional power play in innovation systems: The case of Herceptin. *Research Policy* 45 (8), 1558-1569.

Lam, A. (2010). Tacit Knowledge, Organizational Learning and Societal Institutions: An Integrated Framework. *Organization Studies,* 21(3), 487–513.

Lange, P. de, Driessen, P.P.J., Sauer, A., Bornemann, B., & Burger, P. (2013). Governing towards sustainability; conceptualizing modes of governance. *Journal of environmental policy and planning,* 15(3), 403-425.

Lawhon, M. & Murphy, J.T. (2011) Socio-technical regimes and sustainability transitions: Insights from political ecology. *Progress in Human Geography,* 36(3), 354–378.

Lawrence, T. B. (1999). Institutional strategy. *Journal of Management, 25*(2), 161–188.

Lawrence, T.B., & Suddaby, R. (2006). Institutions and institutional work (pp. 215-254). In: Clegg, S., Hardy, C., Lawrence, T.B., Nord, W. (eds.). *The Sage Handbook of Organizational Studies.* London, UK: Sage Publications.

Lawrence, T.B., Suddaby, R., & Leca, B. (2009). Introduction:Theorizing and studying institutional work (pp 1-27). In Lawrence, T.B.., Suddaby, R., Leca, B. *Institutional Work: Actors and Agency in institutional studies of organizations.* Cambridge, UK: University Press.

Lawrence, T. B., Suddaby, R., & Luca, B. (2011). *Institutional work: Actors and agency in institutional studies of organizations* (Vol. 53). Cambridge, UK: Cambridge University Press.

Lemos, M.C. and Agrawal, A. (2006). Environmental Governance. *Annual Review Environmental Resources*, 31 (1), 297-325.

Levine, M., D. Ürge-Vorsatz, K. Blok, L. Geng, D. Harvey, S. Lang, G. ,..., H. Yoshino (2007). Residential and commercial buildings. In B. Metz, O. Davidson, P. Bosch, R. Dave, & L. Meyer (Eds.), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovnmental Panel on Climate Change.* Cambridge, New York, NY: Cambridge University Press.

Levitt, B., & March, J.G. (1988). Organizational learning. *Annual review of Sociology,* 14 (1), 319-340.

Levine, M. et al., (2007). Residential and commercial buildings. In B. Metz et al., eds. *Climate Change 2007: Mitigation. Contribution o f Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge and New York: Cambridge University Press.

Lindhout, S. (2017, September 6). *Is de Duitse 'Energiewende' mislukt? Op dit eiland vinden ze Merkels windmolens maar niks'.* Retrieved from: www.volkskrant.nl/buitenland/is-de-duitse-energiewende-mislukt-op-dit-eiland-vinden-ze-merkels-windmolens-maar-niks~a4515094.

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures,* 42(3), 237-246.

Lowndes, V., & Pratchett, L. (2012). Local governance under the coalition government: Austertity, localism, and 'the Big Society'. *Local Government Studies,* 38(1), 21-40.

Mann, M.E. (2017, August 28). It's a fact. Climate Change made Hurricane Harvey more deadly. *The Guardian.* Retrieved from: www.theguardian.com/commentisfree/2017/aug/28/climate-change-hurricane-harvey-more-deadly

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy, 41*(6), 955-967.

Mastop, H., & Faludi, A. (1997). Evaluation of strategic plans: the performance principle. *Environmental Planning B: Planning and Design,* 24 (6), 815-822.

McAdam, D., John. D. McCarthy, & Mayer, N. Zald (Eds.) (1996). *Comparing perspectives on Social Movements.* New York, NY: Cambridge University Press.

McGuirk, P., Dowling ,R., Brennan, B., & Bulkeley, H. (2015). Urban Carbon Governance Experiments: The Role of Australian Local Governments. *Geographical Research,* 53(1), 39–52.

Meyer, A.D. (1982). Adapting to environmental jolts. *Administrative Science Quarterly,* 27 (4), 515-537.

Middlemiss, L.., & Parrish, B.D. (2010) Building capacity for low-carbon communities: The role of grassroots initiatives. *Energy Policy,* 38(12), 7559–7566.

Meyer, J.W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology,* 83(2), 340-363.

Milman, O. (2007, July 31). Planet has just 5% chance of reaching Paris climate goal, study says. *the Guardian* Retrieved from: www.theguardian.com/environment/2017/jul/31/paris-climate-deal-2c-warming-study

Ministry of Economic Affairs (2016). *Energy report: transition to sustainability.* The Hague, the Netherlands: Ministry of Economic Affairs.

Mintzberg, H. (1987). The Strategy Concept I: Five Ps for Strategy Management. *California Management Review,* Fall, 11-24.

Moorman, C., & Miner, A.S. (1998). Organizational improvisation and organizational memory. *Academy of Management review,* 23 (4), 698-723.

Mulugetta Y., Jackson T., & Van der Horst D (2010) Carbon reduction at community scale. *Energy Policy,* 38 (12),7541–7545.

Municipality of Utrecht (2011). *Program 'Energy of Utrecht' 2011-2014 (programma Utrechtse Energie 2011-2014).* Utrecht, the Netherlands: Municipality of Utrecht.

Municipality of Utrecht (2015). *Utrecht: energiek middelpunt van het land. Energieplan Utrecht.* Utrecht, the Netherlands: City of Utrecht.

Municipality of Valencia (2014). *Smart City Strategy.* Valencia, Spain: Anytamiento de Valencia.

Murphy, R., & Sachs, D. (2013, May 2). The rise of social entrepreneurship suggests a possible future for global capitalism. *Forbes.* Retrieved from: www.forbes.com/sites/skollworldforum/2013/05/02/the-rise-of-social-entrepreneurship-suggests-a-possible-future-for-global-capitalism/#5d54b5d0348c.

New Building Institute (2017). *Zero Net Energy* [online]. Retrived August 2015 from: https://newbuildings.org/hubs/zero-net-energy/.

Newman, P., Beatley, T., & Boyer, H. (2009). *Resilient Cities: Responding to Peak Oil and Climate Change.* Wahsington, D.C.: Island Press.

Nijkamp, P., & Pepping, G. (1998). A meta-analytical evaluation of sustainable city initiatives. *Urban Studies,* 35(9), 1481-1500.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14-37.

Noordhollands Dagblad (2012, December 3). Part Heerhugowaard copied in China. *Noord Hollands Dagblad.* Retrived from: www.noordhollandsdagblad.nl/stadstreek/alkmaar/article19362943.ece.

North D.C. (1990). *Institutions, Institutional Change, and Economic Performance.* Cambridge: Cambridge University Press.

Oteman, M. Wieing M., & Helderman, J. (2014). The institutional space of community initiatives for renewable energy: a comparative case study of the Netherlands, Germany and Denmark. *Energy, Sustainability and Society* 4 (11), 1-17.

Painuly J.P. (2001). Barriers to renewable energy penetration: A framework for analysis. *Renewable Energy,* 24 (1), 73–89.

Pelenur, M. & Cruickshank, H. (2012). Closing the energy efficiency gap: A study linking demographics with barriers to adopting energy efficiency measures in the home. *Energy,* 47(1), 348-357.

Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings,* 40(3), 394–398.

Perkmann, M., & Spicer, A. (2008). How are management fashions institutionalized? The role of institutional work. *Human Relations*, 61(6), 811–844.

Pickvance, C.G. (2001). Four varieties of comparative analysis. *Journal of Housing and the Built Environment* 16, 7-28.

Prencipe, A., & Tell, F. (2001). Inter-project learnign: Processes and Outcomes of Knowledge Codification in Project-Based Firms. *Research Policy,* 30 (9), 1373-1394.

Rashman, L.,Withers, E., & Harley, J. (2009). Organizational Learning and Knowledge in Public Service Organizations: A Systematic Review of the Literature. *International Journal of Management Reviews,* 11(4), 463–94.

Raven, R., Kern, F., Verhees, B., & Smith, A. (2016). Niche construction and empowerment through socio-political work. A meta-analysis of six low-carbon technology cases. *Environmental Innovation and Societal Transitions,* 18, 164–180.

Ravetz, J. (2008). State of the stock - What do we know about exisitng buildings and their future prospects? *Energy Policy,* 36 (12), 4462-4470.

Reddy, S., & Painuly, J. P. (2004). Diffusion of renewable energy technologies-barriers and stakeholders' perspectives. *Renewable Energy,* 29(9), 1431–1447.

Rhodes, R.A.W. (1996). The New Governance: Governing without Government. Political Studies, 44(4), pp. 652-667.

Rip, A. (1997). A cognitive approach to the relevance of sciences. *Social Science Information,* 36 (4), 615-640.

Rogers, E.M. (1995). *Diffusion of Innovation.* New York, NY: The Free Press.

Romero-Lankao, P. (2012) Governing carbon and climate in the cities: An overview of policy and planning challenges and options. *European Planning Studies,* 20(1), 7–26.

Rose, R. (1991). What is lesson-drawing. *Journal of Public Policy,* 11 (1), 3-30.

Rotmans, J. & Loorbach, D. (2006) Transition management: Reflexive steering of societal complexity through searching, learning and experimenting (pp. 15-46). In: van den Berg JCJM and Bruinsma FR (eds) *The Transition to Renewable Energy: Theory and Practice.* Cheltenham, UK: Edward Elgar.

Rutherford, J.., & Jaglin, S. (2015). Introduction to the special issue - Urban Energy Governance: Local actions, capacities and politics. *Energy Policy* 78, 173-178.

Sabatier, P. (1988). An advocacy coalition framework of policy change and the role of policy-oriented learning therein. *Policy sciences,* 21 (2), 129-168.

Scarbrough, H. , Swan, J. , Laurent, S. , Bresnen, M. , Edelman, L., & Newell, S. (2004). Project-Based Learning and the Role of Learning Boundaries. *Organization Studies* 25(9), 1579–1600.

Scheff, T.J. (2006). *Goffman unbound! A new paradigm for social science: the sociological imagination.* Boulder, UK: Paradigm Publishers.

Schimschar, S., Blok, K., Boermans, T., & Hermelink, A. (2011). Germany's path towards nearly zero-energy buildings—Enabling the greenhouse gas mitigation potential in the building stock. *Energy Policy,* 39(6), 3346–3360.

Schleich, J. (2009). Barriers to energy efficiency: A comparison across the German commercial and services sector. *Ecological Economics,* 68(7), 2150–2159.

Schot, J., & Geels., F.W. (2008). Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy. *Technology Analysis & Strategic Management,* 20(5), 537–54.

Schreurs, M. (2008). From the Bottom Up: Local and Subnational Climate Change Politics. *The Journal of Environment & Development,* 17(4), 343–55.

Schroeder, H., & Bulkeley, H. (2009). Global Cities and the Governance of Climate Change: What is the role of law in cities? *Fordham Urban Law Journal,* 36 (2), 313-359.

Schneider D.C. (2001) The rise of the concept of scale in ecology. *Bioscience,* 51(7), 545–553

Scott, W.R. (2001). *Institutions and organizations* (2nd ed.). Thousand Oaks, CA: Sage.

Seawright, J. & Gerring, J. (2008). Case selection techniques in case study research: A menu of qualitative and quantitative options. *Political Research Quarterly,* 61(2), 294-308.

Selman, P. (1998). Local Agenda 21: Substance or Spin? *Journal of Environmental Planning and Management* 41(5), 533–53.

Selman, P. and Parker, J. (1997). Citizenship, civicness and social capital**.** *Local Environment,* 2 (2), 171-84.

Senge, P.M. (1990). The Fifth Discipline: The art and practice of the learning organization. New York, NY: DoubleDay.

Senge, P.M. (1993). Transforming the practice of management. *Human Resource Development Quarterly,* 4 (1), 5-23.

Sengers, F., Wieczorek, A.J., & Raven, R. (2016) (in press). Experimenting for sustainability transitions: A systemic literature review. *Technological Forecasting and Social Change.* https://doi.org/10.1016/j.techfore.2016.08.031

SER (2013). *Energy accord for sustainable growth.* The Hague, The Netherlands: Social Economic Council.

Seyfang, G., & Smith, A. (2007). Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda. *Environmental Politics,* 16 (4), 584-603.

Seyfang, G. (2010). Community action for sustainable housing: Building a low-carbon future. *Energy Policy,* 38(12), 7624-7633.

Seyfang, G., & Haxeltine, A. (2012). Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy,* 30, 381-400.

Sherriff, G. (2013). Drivers of and barriers to urban energy in the UK: a Delphi survey. *Local Environment,* 19(5), 497–519.

Smith, A. (2007). Translating sustainabilities between green niches and socio-technical regimes. *Technology Analysis & Strategic Management,* 19(4), 427–450.

Smith, A., Hargreaves, T., Hielscher, S., Martiskainen, M., & Seyfang, G. (2016). Making the most of community energies: three perspectives on grassroots innovation. *Environment and Planning A,* 48 (2), 407-432.

Smith, A., Kern, F., Raven, R., & Verhees, B. (2013). Spaces for sustainable innovation: solar photovoltair electricity in the UK. *Technological Forecasting & Social Change,* 81, 115-130.

Smith, A., & Raven, R. (2012). What Is Protective Space? Reconsidering Niches in Transitions to Sustainability. *Research Policy,* 41(6), 1025–1036.

Smith, A. & Seyfang, G. (2013) Constructing grassroots innovations for sustainability. *Global Environmental Change,* 23 (5), 827-829.

Smith, A., & Stirling, A. (2010). The Politics of Social-Ecological Resilience and Sustainable Socio-Technical Transitions. *Ecology and Society,* 15(1).

Smith, N. (1990). *Uneven Development: Nature, Capital and the Production of Space.* Oxford, UK: Blackwell.

Strang, D., & Meyer, J.W. (1993). Institutional conditions for diffusion. *Theory and Society,* 22, 487-511.

Suchman, M. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review,* 20 (3), 571-611.

Suddaby, R., & Greenwood, R. (2005). Rhetorical strategies of legitimacy. *Administrative Science Quarterly,* 50 (1), 35-67.

Steg, L. (2008). Promoting household energy conservation. *Energy Policy,* 36(12), 4449–4453.

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behavior: An integrative review and research agenda. *Journal of Environmental Psychology,* ***29***(3), 309–317.

Stern, N. (2007). *The Economics of Climate Change: The Stern Review.* New York, NY: Cambridge University Press.

Stieß, I., & Dunkelberg, E. (2013). Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. *Journal of Cleaner Production,* 48, 250–259.

Stoker, G. (1988). Governance as theory: five propositiosn. *International Social Science Journal,* 50 (150), 17-28.

Stoknes, P. E. (2014). Rethinking climate communications and the "psychological climate paradox." *Energy Research & Social Science,* 1, 161–170.

Sullivan, R., Gouldson, A., & Webber, P. (2013). Funding low carbon cities: Local perspectives on opportunities and risks. *Climate Policy,* 13(4), 514–529.

Swyngedouw, E. (1997). Excluding the other: The production of scale and scales politics. In: Lee R & Wills J (Eds) *Geographies of Economies* (pp. 167-176). London, UK: Arnold.

Tarrow, S. (1998). *Power in Movement: Social Movements and Contentious Politics.* New York: Cambridge University Press.

Tolbert, P. S., & Zucker, L. G. (1996). The Institutionalization of Institutional Theory. *Handbook of Organization Studies,* 175–190.

Tragopoulos, G., & Sweatman, P. (2012). *Challenges and Funding Opportunities for the Energy Efficient Renovation of Spain ' s Residential Building Stock.* Madrid, Spain: WWF.

Trianni, A., & Cagno, E. (2012). Dealing with barriers to energy efficiency and SMEs: Some empirical evidences. *Energy, 37*(1), 494–504.

Troy, A. (2014). The very hungry city: Urban energy efficiency and the economic fate of cities. New Haven: Yale University Press.

Tuominen, P., Klobut, K., Tolman, A., Adjei, A., & de Best-Waldhober, M. (2012). Energy savings potential in buildings and overcoming market barriers in member states of the European Union. *Energy and Buildings,* 51, 48–55.

UN (2014). *World Urbanization Prospects: The 2014 Revision.* New York, NY: United Nations.

UNDP (2016). *Scaling Up Climate Action to Achieve the Sustainable Development Goals.* New York, NY: UNDP.

UNEP (2009). *Buildings and Climate Change.* Paris, France: UNEP.

UNEP (2011). *Buildings. Investing in energy and resource efficiency.* Nairobi, Kenia: UNEP.

UNEP (2016). *The emissions gap report 2016.* Nairobi, Kenia: UNEP.

UN-Habitat (2011). *The State of the World's Cities.* Nairobi, Kenia: UN-HABITAT.

UN-Habitat (2016). *Urbanization and Development: Emerging Futures.* Nairobi, Kenia: UN-HABITAT.

Urban, F., & Nordensvard, J. (2013). Low carbon development. In: Urban F and Nordensvard J (Eds) *Low Carbon Development: Key Issues* (pp. 3-22). Oxon, NY: Routledge.

US Climate Group (2017, September 18). US States, cities and businesses keep climate action on track. *the Climate Group.* Retrieved from: https://www.theclimategroup.org/news/us-states-cities-and-businesses-keep-us-climate-action-track

Uvin, P. (1995) Fighting hunger at the grassroots: Paths to scaling up. *World Development,* 23(6), 927–939.

Uvin, P., Jain P.S., & Brown, L.D. (2000) Think large and act small: Toward a new paradigm for NGO scaling up. *World Development* 28(8), 1409–1419.

Vedung, E. (1998). Policy Instruments: Typologies and Theories. In: M.L. Bemelmans-videc, R.C. Rist and E. Vedung (eds). *Carrots, Sticks, & Sermons: Policy Instruments & Their Evaluation* (pp. 21-58). New Brunswick, NJ: Transaction Publishers.

van der Vegt, G. S., & Bunderson, J.S. (2005). Learning and Performance in Multidisciplinary Teams: The Importance of Collective Team Identification. *The Academy of Management Journal*, 48(3), 532–547.

Verhoef, L., Hollenberg, A., & Sellger, E. (2009) *City of the Sun: Reflections.* Boxtel, the Netherlands: Aneas.

Verschuren, P. & Doorewaard, H. (1999). *Designing a research project.* Utrecht, the Netherlands: LEMMA.

Voytenko, Y., McCormick, K. Evans, J. G., & Schliwa, G. (2016). Urban living labs for sustainability and low-carbon cities. Towards a research agenda. *Journal of Cleaner production,* 123, 45-54.

Vringer, K., van Middelkoop, M., & Hoogervorst, N. (2014). *Energie besparen gaat niet vanzelf. Evaluatie energiebesparingsbeleid voor de gebouwde omgeving.* Den Haag, the Netherlands: Planbureau voor de Leefomgeving.

van der Waals, J.F.M., Vermeulen, W.J., & Glasbergen P. (2003) Carbon dioxide reduction in housing: Experienced in urban renewal projects in the Netherlands. *Environment and Planning C: Government and Policy* 21 (3), 411–427.

Walker, G., Hunter, S., Devine-Wright, P., Evans, B., & Fay, H. (2007). Harnessing Community Energies: Explaining and Evaluating Community-Based Localism in Renewable Energy Policy in the UK. *Global Environmental Politics,* 7(2), 64-82.

Walker, G. (2008). What are the barriers and incentives for community-owned means of energy production and use? *Energy Policy*, 36(12), 4401–4405.

Wang, C.L., & Ahmed, P.K. (2003). Organisational learning: a critical review. *The Learning Organization,* 10 (1), 8-17.

Williams, J. (2013) The role of planning in delivering low-carbon urban infrastructure. *Environment and Planning B,* 40 (5), 683–706.

Williams, K., & Dair, C. (2007). What is stopping sustainable building in England? Barriers experienced by stakeholders in delivering sustainable developments. *Sustainable Development,* 15(3), 135–147.

Williams, K., Joynt, J. L. R., Payne, C., Hopkins, D., & Smith, I. (2012). The conditions for, and challenges of, adapting England's suburbs for climate change. *Building and Environment,* 55, 131–140.

Wilson, F., & Post, J.E. (2013). Business models for people, planer (& profits): exploring the phenomena of social busienss, a market-based approach to social value creation. *Small Business Economics,* 40, 715-737.

van Winden, W., & van den Buuse (2017). Smart City Pilot Projects: Exploring the Dimensions and Conditions of Scaling Up. *Journal of Urban Technology,* 24(4), 51-71.

World Bank J. (2003). *Scaling-Up the Impact of Good Practices in Rural Development* (Report no. 26031).Washington, D.C.: World Bank Agriculture and Rural Development Department.

World Bank (2010). *Cities and Climate Change: An Urgent Agenda. Urban development series* (knowledge papers no. 10.). Washington, D.C.: World Bank.

World Commission on Environment and Development (1987). *Our Common Future.* London, UK: Oxford University Press.

Yao, R., Li, B. and Steemers, K. (2005). Energy policy and standard for built environment in China. *Renewable Energy,* 30 (13), 1973–1988.

Yin, R.K. (2014). *Case study research: design and methods* (Fifth ed.) New York, NY: Sage Publication.

Yohe, G.W. (2001). Mitigative Capacity - the Mirror Image of Adaptive Capacity on the Emission Side. *Climatic Change,* 49(3), 247–62.

Zhang, X., Platten, A. & Shen, L. (2011) Green property development practice in China: Costs and barriers. *Building and Environment,* 46(11), 2153–2160.

Zhang, X., Shen, L., & Wu, Y. (2011). Green strategy for gaining competitive advantage in housing development: a China study. *Journal of Cleaner Production,* 19 (2-3), 157–167.

Zollo, M., & Winter, S.G. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science,* 13 (3), 339–51.

APPENDICES

APPENDIX A. List of respondents and energy conservation initiatives (chapter 3)

ABBREVIATION RESPONDENT	POSITION	INITIATIVE	DATE OF INTERVIEW
		CASE UTRECHT	
U1	Initiator, community-led initiative	Community-led initiative focused on energy conservation and renewable energy generation in a residential neighborhood in Utrecht	23-03-2015
U2	Coordinator, community-led initiative Energie-U	Community-led initiative focused on energy conservation in residential buildings in Utrecht	24-03-2015
U3	Initiator, community-led initiative	Community-led initiative focused on energy conservation and renewable energy generation in a residential neighborhood in Utrecht	10-04-2015
U4	Initiator, community-led initiative	Community-led initiative focused on energy conservation and renewable energy generation in a residential neighborhood in Utrecht	16-07-2015
U5	Energy ambassador, Energiesprong	National operating expert involved in various energy conservation initiatives in residential and rental buildings	13-08-2015
U6	Coordinator, Economic Board of Utrecht	Regional operating expert, involved in various energy conservation initiatives in residential and commercial buildings	02-09-2015
U7	Fund manager, Energy Fund Utrecht	Regional operating expert involved in various energy conservation initiatives in commercial buildings	13-05-2015
U8	Process manager, Municipality of Utrecht	Sustainable business district 'Sustainable Lage Weide', Utrecht	10-06-2015
U9	Process manager, independent consultant	Sustainable business park 'Rijnsweerd' Utrecht	02-07-2015
U10	Process manager and business developer, Grontmij	Sustainable business Park 'Papendorp' and sustainable office park 'De Weterin Haarrijn', Utrecht	21-07-2015
U11	Process manager, MKB Nederland	Initiative 'Green Deal SMEs in Utrecht' and 'Sustainable Office Initiative Utrecht'	14-08-2015
U12	Co-program manager Utrechtse Energie, Municipality of Utrecht	Regional operating expert involved in various energy conservation initiatives in commercial buildings in Utrecht.	10-07-2015
U13	Energy advisor, Energieloket	National operating expert involved in various energy conservation initiatives in residential and commercial buildings	05-06-2015
U14	Energy advisor, Energieloket	National operating expert involved in various energy conservation projects in residential and commercial buildings	05-06-2015
U15	Advisor and manager energy efficiency, DCMR	National operating expert involved in various energy conservation initiatives in commercial buildings	09-07-2015

ABBREVIATION RESPONDENT	POSITION	INITIATIVE	DATE OF INTERVIEW
		CASE UTRECHT	
U16	Advisor energy efficiency, DCMR	National operating expert involved in various energy conservation initiatives in commercial buildings	11-08-2015
U17	Consultant and installer energy conservation measures, Wolter and Dros	National operating expert involved in various energy conservation initiatives in commercial buildings	03-07-2015
U18	Consultant and coordinator, Klimaatverbond	National operating expert involved in various energy conservation initiatives in residential buildings	04-06-2015
		CASE VALENCIA	
V1	Architect and consultant, Valencia Institute of Building	Pilot project 'Elih-Med': energy retrofitting of two apartment blocks in Valencia: Fontanares and Pio XII	14-09-2015
V2	Architect consultant, Valencia Institute of Building	Pilot project 'Elih-Med': energy retrofitting of two apartment blocks in Valencia: Fontanares and Pio XII	14-09-2015
V3	Architect consultant, Valencia Institute of Building	Smart and Sustainable Office Project Valencia	10-09-2015
V4	Architect consultant, Valencia Institute of Building	Smart and Sustainable Office Project Valencia	05-10-2015; 18-09-2015
V5	Researcher and consultant energy conservation	Regional operating expert in the field of sustainable buildings	05-10-2015
V6	Researchers and coordinator, University of Valencia	Smart and Sustainable Office project Valencia	20-10-2015
V7	Architect and consultant, Valencia Institute of Building	Smart and Sustainable Office Project Valencia	18-09-2015
V8	Architect and professor in urban planning and sustainability	National operating expert in the field of sustainable buildings	15-10-2015
V9	Engineer and energy consultant, La Ribera Energy Agency	Regional operating expert involved in various initiatives focused on awareness raising and behavioral change regarding energy conservation in Valencia.	15-10-2015
V10	Architect	Regional operating expert in the field of sustainable buildings	15-10-2015

APPENDIX B. Characteristics of institutional entrepreneurs (chapter 4)

INSTITUTIONAL ENTREPRENEUR	CHARACTERISTICS	INNOVATION CHARACTERISTICS	STRATEGIES	RESPONDENT
Energiesprong	Government-led Innovation platform (2010-2016) set up by the Ministry of the Interior and Kingdom Relations.	Market-based, technical and social innovation; zero-energy building innovation concept (ZEB), that encapsulates the *trias Energetica* principle (maximum isolation, remaining energy comes from PV); novel contractual arrangements (e.g., contracts where the energy performance fee is equal or less than the energy bill)	*Niche development:* visioning; coalition-building; theorization; standardizing; constructing learning communities *Regime transformation:* visioning, coalition-building; lobbying; vesting; educating; demonstrating.	**R1-4**
Stroom-versnelling	Market-led innovation platform consisting of housing associations, building companies, suppliers, financers, grid operators, and municipalities; Initiated in 2016 (successor of Energy Leap)	Market-based, technical and social innovation; zero-energy building innovation concept (ZEB), that encapsulates the *trias Energeticas* principle (maximum isolation, remaining energy comes from PV); novel contractual arrangements (e.g., contracts where the energy performance fee is equal or less than the energy bill)	*Niche development:* visioning; coalition-building; theorization; standardizing; constructing learning communities *Regime transformation:* visioning, coalition-building; lobbying; vesting; educating; demonstrating.	**R3-R4**
Urgenda, thuisbaas	Independent association promoting climate mitigation.	Market-based technical and social innovation. Zero-energy building concept , using techniques that are available at this moment and that should not cost more than 35.000 euro per household. Solutions are household specific. Also works on developing novel organizational and financial models	*Niche development:* visioning; coalition-building; standardizing; construction of a learning community *Regime transformation*: visioning, coalition-building demonstrating; educating; changing normative associations	**R5**
Hier Klimaatbureau	Independent association promoting climate mitigation	Community-based social innovation; community cooperatives organize energy retrofits and renewable energy generation.	*Niche development:* visioning, coalition-building, theorizing; standardizing; construction of learning communities; constructing new identities *Regime transformation:* visioning; coalition-building demonstrating; educating; changing normative associations	**R6**

INSTITUTIONAL ENTREPRENEUR	CHARACTERISTICS	INNOVATION CHARACTERISTICS	STRATEGIES	RESPONDENT
Klimaatverbond	Association of local governments promoting sustainable urban development	Supports a variety of social and technical innovations for organizing deep retrofits	*Niche development:* Visioning; coalition-building; theorizing; construction of learning communities *Regime transformation:* visioning; coalition-building; lobbying; vesting; demonstrating; educating; changing normative associations	**R7-R8**
ODE Decentraal	Independent association representing decentralized energy initiatives	Community-based social innovation; community energy initiatives organize energy retrofits and renewable energy generation	*Niche development:* visioning; coalition-building; construction of learning communities; construction of identities *Regime transformation:* visioning; coalition-building; lobbying; demonstrating; construction of normative associations	**R9**
Energy Accord of Gelderland	Coalition of public and private actors promoting an energy transition in the province of Gelderland	Combining market- and community-based social innovation: Social enterprise based energy service company to realize energy neutral neighbourhoods	*Niche development:* visioning; coalition-building; theorizing; standardizing; construction of learning communities; construction of identities *Regime transformation:* visioning; coalition-building; lobbying; demonstrating; changing normative associations	**R10**
Transition Towns Netherlands	Transnational grassroots movement that seeks to build community resilience in the face of challenges related to climate change and peak oil	Community-based social innovation; community energy initiatives organize energy retrofits and renewable energy generation	*Niche development:* visioning; coalition-building; standardizing; construction of learning communities; constructing new identities; *Regime transformation:* visioning; coalition-building; demonstrating; educating; changing normative associations	**R11**
Nature and Environmental Federations	Independent association promoting environmental protection	Community-based social innovation; community energy initiatives organize energy retrofits and renewable energy generation	*Niche development:* visioning; coalition-building; construction of learning communities; constructing new identities *Regime transformation:* visioning; coalition-building; lobbying; vesting; demonstrating; educating; changing normative associations;	**R12**

INSTITUTIONAL ENTREPRENEUR	CHARACTERISTICS	INNOVATION CHARACTERISTICS	STRATEGIES	RESPONDENT
Buurkracht	Non-profit initiative of Enexis with the objective to promote energy conservation in the built environment	Community energy initiatives organize energy retrofits and renewable energy generation	*Niche development:* visioning; coalition-building; standardizing; constructing of learning communities; constructing new identities *Regime transformation:* visioning; coalition-building; demonstrating; changing normative associations	**R13**
Hoom	National energy cooperative (non-profit)	Community-based social innovation; energy cooperative organized energy retrofits	*Niche development:* visioning; coalition-building; theorizing; standardizing; construction of a learning community *Regime transformation*: visioning; coalition-building demonstrating; educating	**R14**
RVO	Netherlands enterprise agency encourages entrepreneurs in sustainable and innovative businesses	Market-based technical and social innovation; Zero-energy building concepts; energy performance contracts	*Niche development:* visioning; coalition-building; theorizing; standardizing; construction of learning communities. *Regime transformation:* visioning; coalition-building; demonstrating; educating	**R15**
ESCO network	Network promoting the use of energy performance contracts for the retrofitting of buildings	Market-based social innovation; energy performance contracts	*Niche development:* visioning; coalition-building; theorizing; standardizing; construction of learning communities *Regime transformation:* visioning; coalition-building; demonstrating	**R15**

APPENDIX C. QUESTIONNAIRE (CHAPTER 4)

Approach for the institutionalization of low-carbon innovations

- What are the vision and objectives of the organization with respect to the decarbonization of the built environment?
  - Open coding
- What are the key characteristics of the innovation that is supported as a solution for reducing the carbon footprint of the built environment?
  - Coding: market-based or community-based innovation; social or technical innovation
- What are key barriers that need to be addressed in order to promote the institutionalization of the innovation?
  - Coding: internal barriers and/or barriers related to the regime compatibility. Barriers related to regime dimensions are coded in accordance with the different regime dimensions.

Strategies

- What strategies are applied to promote the institutionalization of the innovation? Please reflect on the strategies stated in table 1 (see Table 4.1, non-exhaustive list) and provide examples.
  - Coding: visioning; coalition-building; lobbying; vesting; theorizing; demonstrating; standardizing; educating; constructing learning communities; changing normative associations and constructing new identities.
- Why have the respective strategies been deployed?
  - Coding: niche development and/or regime transformation
- Why have the other strategies not been applied?
  - Open coding

Factors informing strategy choice

- Problem perception
  - What barriers are addressed with the different strategies?
    - Coding: internal barriers and/or barriers related to the regime compatibility. Barriers related to regime dimensions are coded in accordance with the different regime dimensions.
- Capacity
  - What capacity does the organization have?
    - Coding: resources: human, mental, monetary, artifactual, natural (non-exhaustive)**.** Skills: political, analytical, cultural (non-exhaustive).
  - What capacity is required for the deployment of the different strategies? Please list per strategy the type of resources and skills that are required for the successful deployment thereof. Resources may include human, mental, monetary, artifactual, and natural resources and skills may encompass political, analytical, and cultural skills (non-exhaustive).
  - How does the capacity of the organization influence strategy choices?
- Field-level conditions
  - Do exogenous events or conditions influence the organization's strategy choice?
    - Coding: political opportunity structure; jolts or crises; actions of other actors (non-exhaustive)
  - If yes, how and why?
    - Open coding

APPENDIX D. LIST OF INTERVIEWEES (CHAPTER 5)

INTER-VIEWEE	FUNCTION	LOW-CARBON INITIATIVE	DATE AND LENGTH OF INTERVIEW
R1	Project leader, Technical and Environmental Administration, City of Copenhagen	Ryesgade 30	06-03-2017; 60 minutes
R2	Architect, Technical and Environmental Administration, City of Copenhagen	Ryesgade 30	06-03-2017; 60 minutes
R3	Project manager, Climate Unit, City of Copenhagen	Energyleap	09-03-2017 & 14-03-2017; 90 minutes
R4	Project manager, Climate Unit, City of Copenhagen	Energyleap	02-03-2017 & 15-03-2016; 90 minutes
R5	Project manager HOFOR	Energyleap	23-03-2017
R6	Project manager, Climate Unit, City of Copenhagen	Carbon 20	13-03-2017 & 29-03-2017; 90 minutes
R7	Project leader, Technical and Environmental Administration, City of Copenhagen	Klimakarre	09-03-2017 & 31-03-2017; 90 minutes
R8	Project leader, Technical and Environmental Administration, City of Copenhagen	Klimakarre	30-03-2017; 60 minutes
R9	Project leader, Technical and Environmental Administration, City of Copenhagen	Hedebygadekarree	31-03-2017; 60 minutes
R10	Project leader, Technical and Environmental Administration, City of Copenhagen	Integrated urban renewal initiative Sydhavnen	24-03-2016; 60 minutes
R11	Project coordinator, Technical and Environmental Administration, City of Copenhagen	Integrated urban renewal initiative Sydhavnen	24-03-2017; 60 minutes
R12	Department leader, Copenhagen Properties, City of Copenhagen	Municipal pilot projects	06-03-2016; 90 minutes
R13	Project leader, Copenhagen Properties, City of Copenhagen	Municipal pilot projects	06-03-2017; 90 minutes
R14	Program coordinator, Climate Unit, Technical and Environmental Administration, City of Copenhagen	Climate policy and learning practices City of Copenhagen	15-03-2017; 90 minutes
R15	Energy specialist, Climate Unit, Technical and Environmental Administration City of Copenhagen	Climate policy and learning practices City of Copenhagen	15-03-2017; 90 minutes
R16	Political coordinator, Climate Unit, Technical and Environmental Administration City of Copenhagen	Climate policy and learning practices City of Copenhagen	15-03-2017; 70 minutes
R17	Project Director Carbon Neutral Strategy, Climate Unit, Technical and Environmental Administration City of Copenhagen	Climate policy and learning practices City of Copenhagen	28-03-2017; 70 minutes
R18	Project leader, Climate Unit, Technical and Environmental Administration City of Copenhagen	Climate policy and learning practices City of Copenhagen	20-03-2017; 70 minutes
R19	Project leader, Technical and Environmental Department, City of Copenhagen	Climate policy and learning practices City of Copenhagen	10-03-2017; 60 minutes

APPENDIX E. QUESTIONNAIRE (CHAPTER 5)

Interview questions for stakeholders involved in the low-carbon initiatives

A. General characteristics of the low-carbon initiative

— What are/were the sustainability goals of the initiative?
  - Coding: environmental, social and/or economic goals

— To what extent will/have these been achieved?
  - Coding: goals are/will be achieved; goals are not/ will not be achieved

— What are the innovation characteristics of the initiative?
  - Coding: social or technical innovation

— Why and how can this initiative offer a solution for reducing energy consumption in the building stock?
  - Open coding

B. Lessons learned from the low-carbon initiative

— What are key lessons learned from the implementation of the initiative (until now) related to:
  - The innovation(s) applied
    - Coding: instrumental knowledge
  - The approaches or strategies applied that contributed to the successful implementation of the initiative
    - Coding: instrumental knowledge

— What are key institutional conditions that need need to be addressed to make the large-scale application of the initiative possible ?
  - Coding: transformative knowledge. Institutional barriers can relate to the: policy, market, industry, or the socio-cultural institutional context

C. Learning outcomes: use of knowledge for scaling-up processes (dependent variable)

— Have the lessons derived from the initiative been used as a reference for horizontal scaling-up processes?
  - Coding: yes (use of knowledge for other initiatives), no (no use of knowledge for other initiatives), likely (in the future) (it is expected that knowledge will be used for other initiatives)

— Have the lessons derived from the initiative been used as a reference for vertical scaling-up processes?
  - Coding: yes (use of knowledge for promoting institutional change), no (no use of knowledge for promoting institutional change), likely (in the future) (it is expected that the knowledge will be used for promoting institutional change).

D. Learning practices

— Where there mechanisms in place to accumulate knowledge generated by the initiative? If yes, what mechanisms?
  - Open coding

— Did the project team reflect on experiences and lessons learned during the initiative? If yes, how?
  - Open coding

— Have the articulated lessons been codified? If yes, how?
  - Open coding

— Has the knowledge generated by the low-carbon initiative been distributed within and outside the local government? If yes, how?
  - Open coding

E. Explanatory factors for learning

— What factors can enable or impede learning from low-carbon initiatives? How and when can these factors promote or impede learning?
  - Coding of factors: resources, skills, motivation
  - Coding per stage of the learning cycle: knowledge accumulation, knowledge articulation, knowledge codification, knowledge distribution

Interview questions for policy-makers and decision-makers

— What is the function of low-carbon initiatives, such as pilot projects, for accomplishing the local government's goal to become a carbon neutral city?
  - Open coding

— What formal and informal mechanisms or practices are in place to promote that knowledge derived from low-carbon initiatives are used for scaling-up processes? Please reflect on practices related to the different stages as depicted in figure 1 [see figure 5.1]
  - Open coding in accordance with different stages of the learning cycles

— What factors facilitate the ability of the local government to learn from initiatives? During what stage(s) do these factors play a role?
  - Coding factors: resources, skills, motivation
  - Coding stages: knowledge accumulation, knowledge articulation, knowledge codification, knowledge distribution

— What factors challenge learning from initiatives? During what stage(s) do these factors play a role?
  - Coding factors: resources, skills, motivation
  - Coding stages: knowledge accumulation, knowledge articulation, knowledge codification, knowledge distribution

SUMMARY

In cities worldwide, low-carbon initiatives (LCIs) are realized by pioneers that demonstrate that climate mitigation can be reconciled with urban development needs. Examples include the creation of eco-districts or the large-scale retrofitting of building blocks. LCIs encompass forms of experimentation with socio-technical innovations that have the potential to contribute to societal change fostering low-carbon development. In particular LCIs that focus on energy conservation in the existing building stock can greatly contribute to the decarbonization of cities as the building stock is responsible for approximately 40% of global energy consumption and corresponding GHG emissions. While scholars and practitioners reflect on the need to scale-up LCIs beyond local initiatives in order to accomplish low-carbon societal change, limited conceptual clarity on the concept of 'scaling-up' exists and it is unclear how such a processes can be governed.

The aim of this dissertation is to contribute to theory and practice on urban climate governance by analyzing and exploring factors and strategies that influence the scaling-up of low-carbon initiatives focused on energy conservation in the existing urban building stock. This is undertaken in three stages: (1) by operationalizing the concept of scaling-up, (2) by exploring factors influencing the scaling-up of LCIs, and (3) by identifying strategies that can be applied at the local scale to promote scaling-up processes. In the exploration of strategies, attention is paid to strategies that can be applied by local governments and private actors. Special attention is paid to the role of local governments as local governments worldwide have been allocated, or have taken up the policy mandate, to promote energy conservation and accelerate the low-carbon transition. The research aim and research steps have been translated into the following research questions:

i. What does the concept of scaling-up entail and how can the scaling-up of low-carbon initiatives contribute to the transition to low-carbon cities?
ii. What factors influence the uptake and scaling-up of low-carbon initiatives focused on energy conservation in the existing building stock?
iii. What strategies can be applied to promote the scaling-up of low-carbon initiatives?
iv. How can local government learn from low-carbon initiatives in order to contribute to their scaling-up?

In order to develop the analytical frameworks used to answer these questions, this dissertation combines perspectives from various research disciplines, including theory on urban climate governance, sustainability transitions, institutional entrepreneurship, and organizational learning. Empirical work in cities in the Netherlands (Utrecht), Spain (Valencia), and Denmark (Copenhagen) was conducted to apply and develop the frameworks and to explore how, via strategies, barriers can be addressed and drivers can be created, with the ultimate aim of accelerating the transition to low-carbon cities.

Chapter 2 offers conceptual clarity on the scaling-up of scaling-up. The concept is defined as 'increasing the impact of LCIs from a small to large scale in terms of low-carbon development' and this can be achieved through two pathways to scaling-up: horizontal and vertical. Horizontal pathways to scaling-up imply that LCIs increase their impact on a spatial scale, and this can result from internal growth, replication, or the uptake of similar initiatives. However, LCIs can also increase their impact in

terms of promoting low-carbon development on an institutional scale through vertical pathways to scaling-up. This encapsulates a process where the knowledge generated by LCIs serves as the basis for institutional change favoring the low-carbon innovations applied in the LCI. Chapter 2 also introduced an initial conceptual framework consisting of explanatory factors of which it is expected that they influence to the scaling of LCIs. Two case studies of pioneering LCIs in the Netherlands were conducted to illustrate the framework. The case studies are illustrative but suggest that the framework allows for a systematic understanding of how the impact of former initiatives can be explained, and how their scaling-up can be promoted.

Chapter 3 investigates barriers to the uptake and horizontal scaling-up of LCIs focused on energy conservation in the urban building stock and explores how local strategies can address the respective barriers. This was done by identifying barriers to scaling-up, perceived by actors that have been involved in the implementation of LCIs in residential and commercial building in the cities of Utrecht and Valencia, and by exploring local strategies that can be applied to address these barriers. Strategies are identified that can be applied by private initiators of LCIs and strategies deemed appropriate for implementation by local government. The chapter offers an overview of general and context-specific barriers to the scaling-up LCIs and discusses local strategies that can be applied to overcome barriers, thereby improving our understanding of the relation between barriers and solutions. Three types of strategies were identified: informative, cooperative, and financial strategies. Informative strategies focus on the provision of information and advice by local, trusted actors that can apply a local framing and tailor the communication to the specific local needs and interests of the audience, thereby addressing barriers such as information asymmetry and insufficient awareness, priority and capacity of households to conserve energy. Cooperative strategies are directed at offering process guidance and improving the quality and efficiency of realizing LCIs through sector collaborations. Financial strategies, such as collective purchasing agreements, strive to make LCIs more financially feasible and attractive.

Chapter 4 discusses strategies that can be applied to advance institutional change favoring the low-carbon innovations applied in LCIs. To develop the framework for the exploration of strategies, use was made of theory on institutional entrepreneurship and institutional work, two bodies of literature that examine agential processes of institutional change and study how actors can transform their institutional environment. An embedded case study design regarding the institutionalization of innovations contributing to a low-carbon building stock in the Netherlands was adopted to refine and illustrate the framework. The chapter concludes that two meta-categories of strategies can be applied to promote the institutionalization of low-carbon innovations applied in LCIs: (I) strategies to create and strengthen low-carbon innovations and institutional structures around it, such as standardizing and the creation of a learning community and (II) strategies to transform dominant institutional structures in favor of the low-carbon innovations, such as lobbying and educating. The chapter also illustrates how actor characteristics, such as resources and skills, and field-level conditions, such as jolts and crises, influence actor's strategy choices.

Chapter 5 explores how local government can learn from low-carbon initiatives and use this knowledge to promote horizontal as well as vertical scaling-up processes. Local governments are experimenting with low-carbon initiatives (LCIs) to learn how the transition to low-carbon cities can be advanced. However, while there may be a significant amount of learning within such initiatives, little is known

about how local governments can capitalize lessons and use it to accelerate scaling-up processes. Using a qualitative case study in the City of Copenhagen – a sustainability frontrunner - this chapter explores the complex relationship between low-carbon initiatives and learning processes at the level of the local government. First, the chapter offers an overview of the type of knowledge that can be derived from low-carbon initiatives relevant for accelerating scaling-up processes. Second, it provides a concrete overview of learning practices and offers an overview of explanatory factors, which can act as barrier or drivers, influencing a local government's capacity to learn.

In the concluding chapter, the most important findings are summarized and reflected upon following the four research questions. This leads to the following conclusions:

i. The concept of scaling-up implies that LCIs increase their impact in terms of low-carbon development from a small to a large scale and can result from horizontal and vertical pathways to scaling-up. It is important to emphasize that the concepts of horizontal and vertical pathways to scaling-up are theoretical concepts and that the distinction is analytical. In practice, the horizontal and vertical pathways to scaling-up are interlinked and there is great potential for synergy. The more horizontal scaling-up occurs, the greater the chance that LCIs will inform their (local) institutional environment. Vertical scaling-up leads to a facilitative institutional context, thereby promoting the uptake of new and similar initiatives, i.e. horizontal scaling-up processes. Nevertheless, the analytical distinction between the two forms of scaling-up constitutes a valuable framework for scholars and practitioners working in the field of urban climate governance as it allows them to monitor and evaluate the different types of impact that LCIs can have in terms of promoting low-carbon development. If LCIs do not contribute to horizontal and vertical pathways to scaling-up, they can be criticized for not systematically contributing to urban climate governance.

ii. Building on the preliminary explanatory framework proposed in chapter 2 and the further specification thereof in succeeding chapters, factors influencing the uptake and scaling-up of LCIs can relate to: (i) the characteristics of the low-carbon socio-technical innovations, (ii) operational arrangements, and (iii) institutional and physical context in which LCIs are implemented. Key drivers to the scaling-up include a willingness to pioneer among developers and households and a facilitative (local) policy environment offering public support to LCIs. Key factors hampering scaling-up processes identified include insufficient long-term national policy frameworks fostering energy conservation in buildings, insufficient collaboration among industry and market actors in developing integrative solutions for reducing the energy consumption of buildings, the challenge of financing (deep) retrofits, and lack in urgency, awareness and capacity among building owners and users to invest in energy conservation.

iii. Building on the findings from the different empirical chapters, two meta-strategies can be identified: local strategies directed at horizontal pathways to scaling-up, and strategies of institutional entrepreneurship directed at vertical pathways to scaling-up. The strategies have the objective to address contextual barriers to the scaling-up of LCIs. Strategies for horizontal scaling-up have the purpose to address barriers at the local scale, thereby promoting the growth, replication, or uptake of new initiatives. On the other hand, strategies for vertical scaling-up have the goal to address institutional barriers at different political scales.

iv. Local governments can learn from LCIs to promoting horizontal and vertical scaling-up processes by optimizing learning practices and creating organizational frameworks fostering the capitalization of instrumental and transformative knowledge from initiatives. Instrumental knowledge includes knowledge related to innovation features and strategies that contributed to project success, relevant for accelerating horizontal scaling-up pathways. Transformative knowledge comprises reflections on the institutional barriers that need to be addressed in order for large-scale application of the innovations to be possible and this type of knowledge is therefore required for accelerating vertical pathways to scaling-up. Four categories of learning practices exist: experience accumulation, knowledge articulation, knowledge codification, and knowledge distribution. The ability of local government to implement such learning practices is influenced by their motivation, resources, and skills.

To conclude, this dissertation contributes to theory and practice on urban climate governance by developing an in-depth understanding of factors and strategies influencing the scaling-up of LCIs. Cities are at the forefront of climate action and act as laboratories for experimentation with low-carbon innovations in LCIs. This dissertation has offered theoretical guidance and practical instructions to scholars and practitioners that can be used to promote the scaling-up of LCIs, thereby accelerating the transition to low-carbon cities.

SAMENVATTING

Wereldwijd wordt er in steden geëxperimenteerd met lokale, energiezuinige initiatieven. Voorbeelden zijn eco-districten en grootschalige energierenovaties. Dit soort initiatieven kunnen conceptueel worden beschreven als initiatieven waarin wordt geëxperimenteerd met energiezuinige, sociaal-technische innovaties die de potentie hebben om bij te dragen aan de transitie naar duurzame, energiezuinige steden. Vooral initiatieven die zich richten op energiebesparing in de bestaande bouw kunnen aan deze transitie bijdragen, aangezien de gebouwde omgeving verantwoordelijk is voor meer dan 40% van het mondiale energieverbruik en bijbehorende broeikasemissies. Binnen de wetenschap en in de praktijk wordt veel gesproken over het belang van het 'opschalen' van lokale, energiezuinige initiatieven. Er is echter weinig conceptuele helderheid over het begrip 'opschalen'. Evenmin is duidelijk welke strategieën kunnen worden ingezet om opschaling te bevorderen.

Dit proefschrift beoogt bij te dragen aan het wetenschappelijke debat en de praktijk op het gebied van klimaatbeleid door een systematische analyse van factoren en strategieën die van invloed zijn op het opschalen van lokale initiatieven gericht op energiebesparing in de gebouwde omgeving. Dit gebeurt in drie stappen: (1) het operationaliseren van het concept van opschalen, (2) het onderzoeken van factoren die het opschalen van lokale initiatieven beïnvloeden en (3) het identificeren van strategieën die door lokale overheden en particuliere actoren kunnen worden toegepast om opschaling te bevorderen. Met name de rol van lokale overheden is daarbij van belang aangezien zij in toenemende mate beleidsverantwoordelijkheid nemen of krijgen om energiebesparing te bevorderen en de transitie naar een duurzame, energiezuinige samenleving te versnellen. Om de doelstellingen van het onderzoek te realiseren worden in dit proefschrift de volgende vier vragen beantwoord:

i. Wat betekent het begrip 'opschalen' en hoe kan het opschalen van lokale, energiezuinige initiatieven bijdragen aan de transitie naar duurzame, energiezuinige steden?
ii. Welke factoren beïnvloeden het realiseren en opschalen van lokale, energiezuinige initiatieven gericht op energiebesparing in de gebouwde omgeving?
iii. Welke strategieën kunnen worden toegepast om de opschaling van lokale, energiezuinige initiatieven te bevorderen?
iv. Hoe kunnen lokale overheden leren van lokale, energiezuinige initiatieven om opschaling te bevorderen?

Op basis van literatuur over stedelijk klimaatbeleid, institutionele theorie en organisatieleren zijn conceptuele en analytische kaders ontwikkeld, die vervolgens zijn toegepast voor de analyse van case studies in Nederland (Utrecht), Spanje (Valencia) en Denemarken (Kopenhagen). De case studies dragen bij aan de beantwoording van de bovenstaande onderzoeksvragen en daarmee aan kennis over hoe via lokale strategieën barrières kunnen worden aangepakt en kansen kunnen worden gecreëerd, met het ultieme doel om de transitie naar duurzame, energiezuinige steden te versnellen.
In hoofdstuk 2 wordt conceptuele helderheid geboden over het begrip opschalen. Het concept wordt gedefinieerd als 'het vergroten van de impact van lokale, energiezuinige initiatieven van een kleine naar een grote schaal in termen van duurzame, energiezuinige ontwikkeling'. Er worden twee paden benoemd die tot opschaling kunnen leiden: horizontale en verticale opschaling. Horizontale opschaling omvat een proces waarbij initiatieven hun impact op een ruimtelijke schaal vergroten, als

gevolg van interne groei, replicatie of de realisatie van soortgelijke initiatieven. Initiatieven kunnen echter ook op een institutionele schaal hun impact op het gebied van duurzame, energiezuinige ontwikkeling vergroten. Dit omvat een proces waarbij de kennis die is opgedaan in lokale initiatieven wordt gebruikt voor het realiseren van institutionele veranderingen ten gunste van energiezuinige innovaties, waarmee wordt geëxperimenteerd in lokale initiatieven. In hoofdstuk 2 wordt ook een analytisch kader gepresenteerd bestaande uit verklarende factoren waarvan wordt verwacht dat ze invloed zullen hebben op het opschalen van initiatieven. Twee case studies van baanbrekende initiatieven in Nederland zijn gebruikt om deze twee vormen van opschalen te illustreren. De case studies illustreren dat het ontwikkelde conceptuele kader kan worden gebruikt om op een systematische manier de impact van initiatieven te meten, te verklaren en om te verkennen hoe opschaling kan worden bevorderd.

Hoofdstuk 3 richt zich op het onderzoeken van barrières tot de realisatie en opschaling van initiatieven gericht op energiebesparing in de bestaande bouw en onderzoekt lokale strategieën die kunnen worden toegepast om deze barrières te beïnvloeden. Dit is gedaan door de percepties op barrières te identificeren van actoren die betrokken zijn geweest bij de implementatie van initiatieven gericht op energiebesparing in residentiële en commerciële gebouwen in Utrecht en Valencia. Daarnaast worden lokale strategieën geïdentificeerd die kunnen worden toegepast om deze belemmeringen weg te nemen. Zowel strategieën die initiatiefnemers kunnen toepassen als strategieën die lokale overheden kunnen implementeren zijn verkend. Daarbij zijn drie type strategieën geïdentificeerd: informatieve, coöperatieve en financiële strategieën. Informatieve strategieën zijn gericht op het verstrekken van informatie en advies door lokale, vertrouwde actoren die bekend zijn met de lokale situatie en hun communicatie kunnen afstemmen op de specifieke behoeften en belangen van het publiek. Met informatieve strategieen kunnen barrieres, zoals informatie-asymmetrie en onvoldoende bewustzijn, prioriteit en capacititeit van huishoudens om energie te besparen, worden geaddreseerd. Coöperatieve strategieën zijn gericht op het bieden van procesbegeleiding en verbeteren van de kwaliteit en efficiëntie van initiatieven door middel van sectorale samenwerkingsverbanden. Financiële strategieën, zoals collectieve inkoopovereenkomsten, streven ernaar initiatieven financieel aantrekkelijk en haalbaar te maken.

Hoofdstuk 4 bespreekt strategieën die kunnen worden toegepast om institutionele veranderingen te realiseren ten gunste van de duurzame, energiezuinige innovaties die worden toegepast in lokale initiatieven ('verticaal opschalen'). Om dit te kunnen doen is een analytisch raamwerk ontwikkeld waar gebruik is gemaakt van theorie over 'institutioneel ondernemerschap' en 'institutioneel werk', twee theorieën die kunnen worden gebruikt om te bestuderen hoe actoren hun institutionele omgeving kunnen beïnvloeden. Een vergelijkende case studie methode is gebruikt om het analytisch raamwerk te verfijnen en om te bestuderen welke strategieën worden toegepast door verschillende actoren om energiezuinige innovaties - waarmee wordt geëxperimenteerd in lokale inititieven - te institutionaliseren. Het hoofdstuk concludeert dat er twee metastrategieën zijn om innovaties te institutionaliseren: (I) het *creëren* van nieuwe institutionele structuren die de ontwikkeling van energiezuinige innovaties bevorderen (bijvoorbeeld standaardisatie en het opzetten van leergemeenschappen) en (II) het *transformeren* van dominante institutionele structuren ten gunste van de betreffende innovaties (zoals lobbyen en educatie). Het hoofdstuk illustreert ook hoe kenmerken van actoren (zoals hulpmiddelen,

vaardigheden en probleempercepties) en die van de bredere context (zoals maatschappelijke trends en crises) de strategiekeuzes van actoren beïnvloeden.

Hoofdstuk 5 onderzoekt hoe lokale overheden kunnen leren van duurzame initiatieven en deze kennis kunnen gebruiken om zowel horizontale als verticale opschalingsprocessen te bevorderen. Lokale overheden experimenteren met lokale initiatieven om te leren hoe de transitie naar duurzame, energiezuinige steden kan worden bevorderd. Hoewel er binnen dergelijke initiatieven veel kan worden geleerd, is er weinig bekend over hoe lokale overheden lessen op een systematische wijze kunnen vastleggen om opschalingprocessen te versnellen. Met behulp van een case studie binnen de gemeente Kopenhagen - een voorloper op het gebied van duurzaamheid - onderzoekt dit hoofdstuk de complexe relatie tussen lokale initiatieven en leerprocessen op het niveau van de lokale overheid. Het hoofdstuk biedt een overzicht van de verschillende types kennis die kunnen worden verkregen uit lokale initiatieven die relevant zijn voor opschalingsprocessen. Daarnaast biedt het hoofdstuk een overzicht van leerpraktijken en succes- en faalfactoren daarbinnen, die van invloed zijn op het leervermogen van een lokale overheid.

In het concluderende hoofdstuk worden de meest belangrijke bevindingen samengevat en wordt er gereflecteerd op de vier eerdergenoemde onderzoeksvragen van dit proefschrift. Dit resulteert in de volgende vier conclusies:

i. Het concept 'opschalen' betekent dat lokale initiatieven hun impact in termen van duurzame, energiezuinige ontwikkeling verhogen van een kleine naar een grote schaal. Dit kan het gevolg zijn van horizontale en verticale paden van opschaling. Het moet worden benadrukt dat de concepten 'horizontaal opschalen' en 'verticaal opschalen' theoretische begrippen zijn en dat het onderscheid analytisch is. In de praktijk lopen horizontale en verticale opschalingsprocessen door elkaar heen en kunnen zij elkaar versterken. Hoe meer horizontale opschaling plaatsvindt, hoe groter de kans dat initiatieven hun (lokale) institutionele omgeving zullen beïnvloeden. Verticale opschaling leidt tot een institutionele context die faciliterend is en bevordert zodoende de realisatie van nieuwe initiatieven, oftewel horizontale opschaling. Niettemin is het analytisch onderscheid tussen de twee vormen van opschalen waardevol voor wetenschappers en professionals op het gebied van stedelijk klimaatbeleid, omdat het hen in staat stelt de verschillende soorten impact die initiatieven kunnen hebben te evalueren. Als lokale initiatieven niet bijdragen aan horizontale of verticale opschalingsprocessen kan worden gesteld dat zij niet systematisch bijdragen aan stedelijk klimaatbeleid.
ii. Voortbouwend op het analytisch raamwerk dat is geïntroduceerd in hoofdstuk 2 en de verdere specificatie daarvan in volgende hoofdstukken, kunnen factoren die de realisatie en opschaling van lokale initiatieven beïnvloeden betrekking hebben op de volgende aspecten: (1) karakteristieken van de innovaties waarmee wordt geëxperimenteerd, (2) de organisatorische kant van het initiatief, en (3) de institutionele en fysieke context waarin initiatieven worden geïmplementeerd. Belangrijke succesfactoren voor de realisatie en het opschalen van initiatieven zijn onder meer een bereidheid om te pionieren bij ontwikkelaars en/of gebouweigenaren en een faciliterende (lokale) beleidscontext die ondersteuning biedt aan initiatieven. Belangrijke barrières die opschaling in de weg zitten zijn: onvoldoende helder- en lange termijn energie- en klimaatbeleid, onvoldoende ketensamenwerking tussen industrie- en marktpartijen in het ontwikkelen van

integrale oplossingen voor het verminderen van energieverbruik van gebouwen, de financiering van energiebesparende maatregelen en energierenovaties en, tot slot, onvoldoende prioriteit, bewustzijn en capaciteit bij gebouweigenaren om te investeren in energiebesparing.

iii. Op basis van de bevindingen van de verschillende hoofdstukken kunnen twee metastrategieën worden geïdentificeerd die opschaling kunnen bevorderen: strategieën gericht op horizontale opschaling en strategieën gericht op verticale opschaling. Beide typen strategieën hebben als doel om contextuele belemmeringen tot opschaling weg te nemen. Strategieën voor horizontaal opschalen hebben het doel om belemmeringen op de lokale schaal weg te nemen, waardoor de groei, replicatie of opname van nieuwe initiatieven kan worden bevorderd. Strategieën voor verticaal opschalen hebben het doel om institutionele belemmeringen op verschillende politieke schalen aan te pakken.

iv. Lokale overheden kunnen leren van initiatieven om opschaling te bevorderen. Dit kunnen zij doen door leerpraktijken te optimaliseren en organisatorische kaders te ontwikkelen die bevorderlijk zijn voor het systematich vastleggen van instrumentele en transformatieve kennis. Instrumentele kennis omvat kennis met betrekking tot innovaties en succesfactoren (zoals strategieën) die hebben bijgedragen aan het succes van het project. Deze kennis is relevant voor het versnellen van horizontale opschalingsprocessen. Transformatieve kennis omvat inzichten over institutionele belemmeringen die moeten worden geadresseerd om de grootschalige toepassing van de energiezuinige innovaties, waarmee wordt geëxperimenteerd in lokale initiatieven, mogelijk te maken. Dit type kennis is dus met name van belang voor het bevorderen van verticale opschalingsprocessen. Het hoofdstuk identificeert vier verschillende vormen van leerpraktijken: kennisaccumulatie, kennisarticulatie, kenniscodificatie en kennisdistributie. Het vermogen van lokale overheden om dergelijke praktijken goed uit te voeren wordt beïnvloed door hun motivatie, hulpmiddelen en vaardigheden.

Deze conclusies leveren een belangrijke bijdrage aan het wetenschappelijk debat en de praktijk omtrent stedelijk klimaatbeleid. Steden zijn in de voorhoede van klimaatactie en fungeren als broedplaatsen en laboratoria voor het experimenteren met duurzame, energiezuinige innovaties. Dit proefschrift biedt theoretische helderheid en praktische handvatten voor wetenschappers en professionals om opschaling van lokale initiatieven te bevorderen, wat van groot belang is om de transitie naar duurzame, energiezuinige steden te versnellen.