Business strategies in sustainable energy

van den Buuse, D.J.H.M.

Publication date
2018
Document Version
Final published version
License
Other

Link to publication

Citation for published version (APA):
van den Buuse, D. J. H. M. (2018). *Business strategies in sustainable energy*.

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IN SUSTAINABLE ENERGY

DANIEL J.H.M. VAN DEN BUUSE

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ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor

aan de Universiteit van Amsterdam

op gezag van de Rector Magnificus

prof. dr. ir. K.I.J. Maex

ten overstaan van een door het College voor Promoties ingestelde commissie,

in het openbaar te verdedigen in de Aula

op woensdag 27 juni 2018, te 11:00 uur

door Daniel Jacobus Henderikus Marinus van den Buuse

geboren te Middelburg

Promotiecommissie:

Promotor:	prof. dr. A. Kolk	Universiteit van Amsterdam
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This research was supported by the Centre for Applied Research on Economics and Management, Amsterdam University of Applied Sciences.

BUSINESS STRATEGIES IN SUSTAINABLE ENERGY

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LIST OF ABBREVIATIONS AND ACRONYMS

ARE	Alliance for Rural Electrification
BOP	Bottom/Base of the Pyramid
BP	British Petroleum
CCS	Carbon Capture and Storage
CO2	Carbon Dioxide
CSR	Corporate Social Responsibility
DSE	Decision Support Environment
EC	European Commission
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ERDF	European Regional Development Fund
EU	European Union
FSA	Firm-Specific Advantage
GaWC	Globalization and World Cities
GHG	Greenhouse Gas
GIS	Geographic Information System
GS	Grameen Shakti
HPS	Husk Power Systems
IB	International Business
ICT	Information and Communication Technology
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
IoE	Internet-of-Everything
IT	Information Technology
M&A	Mergers & Acquisitions
MLP	Multi-Level Perspective
MNE	Multinational Entreprise
MW	Mega-Watts
NAFTA	North American Free Trade Agreement
NGO	Non-Governmental Organization
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
R&D	Research & Development

RBV	Resource-Based View
REN21	Renewable Energy Policy Network for the 21st Century
RET	Renewable Energy Technology
ROR	Rest of the Region
ROW	Rest of the World
SHS	Solar Home System
SME	Small and Medium-sized Enterprises
TEF	Triple Embeddedness Framework
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
US	United States
WCED	World Commission on Environmental Development
WHO	World Health Organization
WRI	World Resource Institute
WSSD	World Summit on Sustainable Development

CHAPTER 1: INTRODUCTION

Moving towards a more sustainable energy future is widely regarded as one the key challenges for the 21st century, given the negative economic, political, environmental, and social externalities associated with fossil fuel dependence. The international diffusion of technologies which enable more sustainable modes of energy production and consumption across the world is a central factor in this respect. Related to energy production, this implies that major investments in renewable energy technologies (RETs) are needed to replace fossil fuel-based technologies as a source for power generation (Holdren, 2006; Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000). For energy consumption, this primarily entails the widespread deployment of technologies which enable energy-intensive economic activities to become more energy efficient (Herring, 2006; Herring and Sorrell, 2009; REN21, 2017). The need for an energy transition has been widely recognised in general (Geels, 2011a; 2018; Grin et al., 2010; Smith et al., 2010; Van den Bergh et al., 2011; Wilson, 2018; Wilson and Tyfield, 2018), and the importance of business as an actor in this regard has been often emphasised (Farla et al., 2012; Geels, 2014; Markard et al., 2012).

Interestingly, international business and management scholars have recently stressed the importance of conducting phenomenon-based research to explore business strategies in response to 'grand challenges' in society, including the global energy transition (Buckley et al., 2017; Doh, 2015; Kolk, 2016). Multinational enterprises (MNEs), as crucial and powerful players in addressing such global issues, have received considerable attention with regard to their corporate social responsibility (CSR) (for a recent comprehensive review, see Pisani et al., 2017) as well as their strategic responses to environmental policy in general (Christmann, 2004; Christmann and Taylor, 2001; Dowell et al., 2000; Rugman and Verbeke, 1998; 2000; 2001) and to a topic such as climate change in particular (Kolk and Levy, 2001; Kolk and Pinkse, 2004; 2005; 2008; Levy and Kolk, 2002; Pinkse and Kolk, 2009, 2012). Despite this existing literature, review articles in the field of international business and management have emphasized the need for more research into the analysis of energy and the energy transition (Kolk, 2016; Kolk et al., 2017), as strategies in response to sustainable energy have remained relatively underexplored. This dissertation examines the strategies of firms in developing and marketing technologies for sustainable energy production and consumption in multiple heterogeneous contexts, with specific attention for the role of MNEs.

The remainder of this chapter proceeds as follows. The next section introduces the research question and sub-questions, and provides an overview of the structure of the dissertation as well as the overall methodology used. Section 1.2 gives a synopsis of the theoretical perspectives from the business and management literature which are adopted in the chapters, and identifies opportunities for each of these perspectives to contribute to insight into business responses to the diffusion of sustainable energy in society. This is followed by a specification of the empirical research contexts for sustainable energy production and consumption in section 1.3, and an assessment of the importance of addressing business strategies in each context. Finally, section 1.4 introduces the chapters in the dissertation.

1.1 Research questions, structure and methodology

The dissertation adopts a phenomenon-based research approach, which “begins with a strong research question related to a contemporary, real-world phenomenon and then identifies a theory or set of theories that can inform that reality” (Doh 2015, 609). This dissertation explores business strategies in heterogeneous contexts for sustainable energy, informed by business and management theories, and seeks to shed light on the following overall question:

Research question: *How does business strategically respond to the diffusion of technologies for sustainable energy production and consumption?*

This research question is divided into two interrelated sub-questions, which will be explained next.

Sub-question A: *How do MNEs strategically address the diffusion of renewable energy technologies for energy production and of energy efficiency technologies for energy consumption?*

This sub-question is examined in chapters 2, 3, and 4, which each conduct an organizational-level, industry-specific analysis, focused on MNEs with established positions in their respective industries. Chapter 2 explores how firms in the information and communication technology (ICT) industry strategically approach the market for smart city technologies, and assesses their role in addressing energy consumption in cities and urban areas on a global scale. Chapter 3 focuses on electric utilities with established positions in the European electricity market, and examines how technology-specific investments in power generation technologies are shaped by transformative changes in the institutional environment. Chapter 4 addresses the strategic investments of European firms in the oil industry in developing and commercializing RETs to diversify their power generation portfolio, taking both internal resources and capabilities and external industry dynamics into account.

Sub-question B: *How does business address challenges related to the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption?*

This second sub-question is addressed in chapters 5 and 6, considering respectively rural and urban settings. Chapter 5 focuses on access to energy in developing countries, and explores business models of entrepreneurial firms to introduce RET-based solutions in rural areas without access to the national electricity grid. Chapter 6 identifies which dimensions and conditions affect the potential for urban energy efficiency solutions to be scaled up beyond pilot projects, and examines how business-led approaches can create a broader environmental and social impact beyond the local level. Figure 1.1 provides an overview of the sub-questions and the related empirical chapters in the dissertation, and also shows the introductory and concluding chapters.

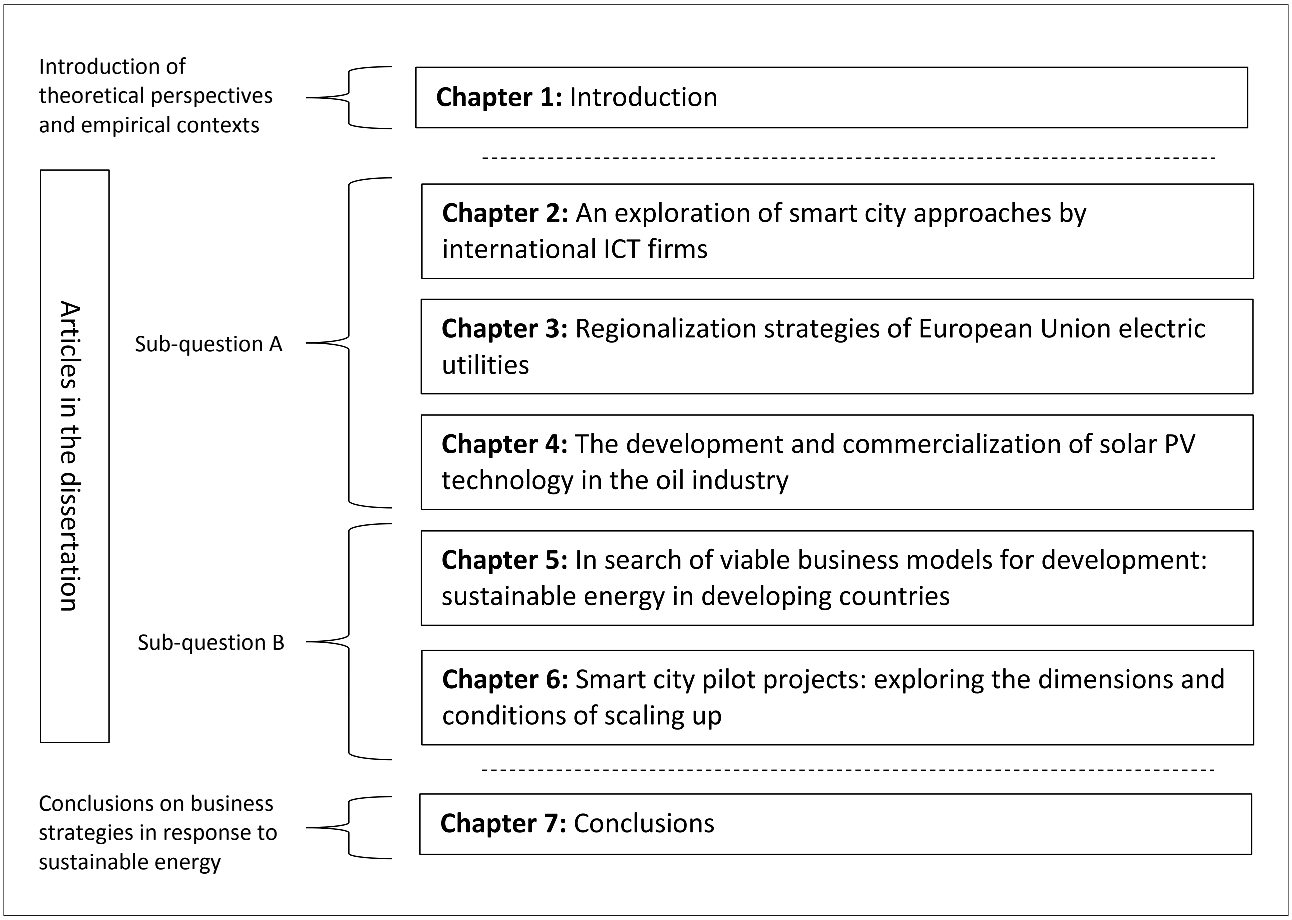

Table 1.1: Overview of the chapters in the dissertation in relation to the sub-questions

Methodology

The research methodology adopted in the dissertation is qualitative in nature, and based on a multiple case study design for empirical chapters, given that it is particularly well-suited to study and understand a phenomenon within its real-life context (Eisenhardt, 1989; Yin, 1994). Given that each of these chapters is written as an article, with four of them already published in academic journals, the method section in each chapter provides more details on the specificities of the case selection and data collection process. Here a generic, brief description is given in this introduction.

For the three chapters related to sub-question A, the case study selection process was based on the identification of leading MNEs in their respective industries, which have developed sizable activities in developing and marketing technologies for sustainable energy production and consumption. For chapter 2, ICT firms with leading positions as global smart city technology suppliers were selected as case studies in this way. For chapters 3 and 4, the largest firms in the European electricity and oil industry based on annual revenues were selected as case studies, thus exploring strategic approaches to sustainable energy of firms with incumbent positions within each industry. For the two chapters related to sub-question B, cases were selected based on their ability to illustrate how market-based approaches and mechanisms enhance the scalability, accessibility, and affordability of sustainable energy solutions in practice, and on the opportunities to obtain access to representatives of focal organizations to conduct interviews. In this way, entrepreneurial firms in Asia were selected and contacted based on web-based sources for chapter 5, and were visited to conduct interviews as part of a field research trip in this region. For chapter 6, representatives of partner organizations involved in pilot projects part of the Amsterdam Smart City network were approached for interviews, based on existing contacts of the Amsterdam University of Applied Sciences within this network.

Several data collection methods were adopted for each chapter, in order to establish data triangulation by drawing on multiple sources of evidence (Yin, 1994). For chapters 2, 5, and 6, data was collected from documentation (annual reports, corporate social responsibility reports, and issue-specific publications) combined with semi-structured interviews. All interviews were conducted face-to-face with firms in the Netherlands for chapters 2 and 6, and in Thailand, Cambodia, and Laos for chapter 5. Due to logistic reasons, several interviews for chapter 5 were also conducted via Skype calls with representatives of organizations in other Asian countries, which were not visited for face-to-face interviews. For chapters 3 and 4, data was also collected from similar sources of documentation, combined with newspaper articles from reputable sources retrieved from the LexisNexis database, including the New York Times, Wall Street Journal, Washington Post, Guardian, Economist, and Time magazine. This allowed for data triangulation in all case studies conducted in the five chapters.

1.2 Theoretical background

The role of business in the transition to sustainable energy

In the broader context of the societal transition towards more sustainable energy production and consumption, scholarly work in the field of sustainability transitions has yielded theoretical as well as empirical insights. Markard et al. (2012, 956) state that “a transition involves far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural”, and “involve a broad range of actors and typically unfold over considerable time-spans (e.g. 50 years and more)". The Multi-Level Perspective (MLP) (Geels, 2002; 2004) has been influential in conceptualizing how transition processes unfold in socio-technical systems. The MLP characterizes socio-technical systems as a nested hierarchy model consisting of landscapes (macro-level), socio-technical regimes (meso-level), and technological niche environments (micro-level), in which transition processes emerge over time as a result of landscape-regime-niche level interactions (Geels, 2002; 2004). Other publications have provided more detailed insight into different trajectories and pathways for transition processes in socio-technical systems (Geels, 2005a; Smith et al., 2005; Geels and Schot, 2007; Raven, 2007; Smith, 2007; Smith and Raven, 2012), and the creation and management of 'shielded environments' to develop sustainable technologies away from regime-level pressures (Kemp et al. 1998; Raven et al., 2010; Rotmans et al., 2001; Schot and Geels, 2008).

Empirically, these theoretical perspectives have been applied to historic transition processes in a broad range of industries, such as the transition from horse-drawn carriages to automobiles between 1860–1930 (Geels, 2005b), the development of the Dutch electricity system between 1960–2004 (Verbong and Geels, 2007), the transformation of American factory production between 1850–1930 (Geels, 2006), the developments of the British coal industry between 1913–1967 (Turnheim and Geels, 2013), and a number of other contexts (Brown et al., 2013; Geels, 2005c; Geels, 2007; Geels and Raven, 2006; 2007; Raven and Geels, 2010). These empirical studies predominantly provide a narrative account of a transformative change in a broad range of industries, which spans over several decades, and mostly focus on a national context in their geographic scope (Markard et al., 2012). In addition, several publications have specifically addressed the emergence of RETs in relation to energy sector transformation (Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000; Jacobsson and Lauber, 2006).

While these theoretical and empirical contributions have been instrumental in conceptualizing how transition processes unfold in society, examining the influence of actors in shaping these processes has been identified as a key area for further research (Farla et al., 2012). To examine actor strategies in this realm, Farla et al. (2012, 992) pose the following question: "what strategies do actors adopt to shape sustainability transitions and what resources do they mobilize and deploy in the realization of these strategies?". By making investments in technologies which enable more sustainable energy production and consumption (Wüstenhagen and Menichetti, 2012), firms can be central actors in the creation of an industry around a novel technology (Bohnsack et al., 2016), and in the wider process of energy transition in society. In this context, the Triple Embeddedness Framework (TEF) (Geels, 2014) has provided an initial theoretical conceptualization of the co-evolution between firms and their environments. It identifies interactions between 'firms-in-industries' and their environments as bi-directional, which can be 'outside-in' (i.e. from environments towards firms-in-industries) and ‘inside-out’ (i.e. strategic responses from firms-in-industries towards the environments). Geels (2014, 268) states in this respect that “firms-in-industries not only adapt to external pressures but also strategically attempt to shape their environments”. Empirical work which explores the strategic approaches of firms to the diffusion of technologies for sustainable energy production and consumption, can shed more light on the role of business in sustainability transitions.

This dissertation aims to provide further insight into the internal and external factors which shape the strategic responses of firms to their environments, and offer a more fine-grained analysis of business strategies in sustainable energy. The studies in the dissertation are rooted in multiple perspectives from the business and management literature. Related to sub-question A, the strategic approach of MNEs to the diffusion of technologies for sustainable energy production and consumption will be studied from two interrelated perspectives: (i) an international business perspective on the geographic expansion of firms, and (ii) a strategic management perspective on technological innovation. Related to sub-question B, two perspectives are adopted to explore business-led and market-based approaches to enhance the scalability, affordability, and accessibility of sustainable energy solutions: (iii) a business model perspective to explore the characteristics of market-based approaches to sustainable development, and (iv) a management perspective on the ability of firms to scale up sustainable energy solutions beyond pilot projects. Each of these organizational-level perspectives will be discussed in more detail below.

Theoretical perspectives from the business and management literature

Related to sub-question A, an international business perspective is adopted to explore MNE strategies in RETs for sustainable energy production, and smart city technologies for sustainable energy consumption. A central theme in this literature is the need for MNEs to balance environmental pressures for global integration and the effective coordination of activities distributed across the firm’s international network, with responsiveness to the demands and conditions of the heterogeneous host environments in which the firm is embedded (Bartlett and Ghoshal, 1989; Devinney et al., 2000; Johnson; 1995; Prahalad and Doz, 1987; Roth and Morrison, 1990; Taggart, 1997). This embeddedness in host environments can enable firms to build firm-specific advantages (FSAs), which can be shared throughout the MNE network to achieve sustained, profitable international growth (Verbeke and Asmussen, 2016). These FSAs are rooted in a firm’s proprietary knowledge and capability to control, coordinate, and manage its assets over geographic distances (Rugman and Verbeke, 1992; 2003). When FSAs can be integrated and leveraged throughout the MNE network (McCann and Mudambi, 2005; Mudambi 2002; Mudambi and Swift, 2011), they can provide a potential basis for building competitive advantages. Meyer et al. (2011, 241) state in this respect that the “ability to create, transfer, recombine, and exploit resources in multiple contexts is the rationale for the existence of the MNE”, which enables firms to “tap into resources and capabilities from multiple local contexts and integrate and leverage them to create a range of competitive advantages”. The degree of liability of foreignness experienced by firms is a key factor in this respect. This implies that firms incur costs outside their home market, because of unfamiliarity with the economic, political and cultural peculiarities of the host environment, and the need to coordinate activities across geographic locations (Zaheer, 1995). When firms experience a lower degree of liability of foreignness in their international activities, FSAs can be exploited throughout the MNE network more efficiently (Rugman and Verbeke, 2007).

From this perspective, the location choice of MNEs as part of the international strategies impacts their ability to integrate and leverage FSAs from multiple local contexts. Given that MNEs purposively locate their activities in centres of economic agglomeration within countries (Beugelsdijk and Mudambi, 2013; Taylor et al., 2014), the concept of ‘global cities’ (cf. Sassen, 2000; 2005) has been adopted to explain how location choice is associated with the degree of liability of foreignness experienced by firms at the sub-national level. Global cities are characterized by three distinctive features, including a high degree of global interconnectedness, the prevalence of a cosmopolitan environment, and the widespread availability of advanced producer services, making them deeply connected and interlinked (Sassen, 2000; 2005). Goerzen et al. (2013) identify that MNEs have a strong inclination to locate activities in global cities, which lowers the degree of liability of foreignness that firms experience in host environments outside their home market (Mehlsen and Wernicke, 2016). Related to sub-question A, an international business perspective can shed light on the potential for MNEs to develop FSAs in technologies for sustainable energy, from their embeddedness in multiple local contexts. Chapter 2 examines how, and to which degree, ICT MNEs can potentially build competitive advantages as international smart city technology suppliers, which are developed through their smart city engagements in a large number of cities and urban areas globally.

In addition, the influence of the region in shaping the international expansion of MNEs has emerged as a major theme in the international business literature (Rugman and Oh, 2013). In this literature, the region is supra-national in nature, and focuses on how economic and political integration, stemming from multilateral trade agreements such as the European Union (EU) and the North American Free Trade Agreement (NAFTA) (Rugman and Verbeke, 2004; 2005), influence the international growth strategies of MNEs. Rugman and Verbeke (2004; 2005) identified that the geographic dispersion of MNEs is largely concentrated in their home triad region (i.e. EU, NAFTA, or Asia) rather than globally (Rugman, 2001; Rugman and Hodgetts, 2001). This is explained by regional economic, political, and cultural coherence, which drives firms towards intra-regional rather than inter-regional expansion (Asmussen, 2009). Regional institutional coherence decreases the liability of foreignness experienced by MNEs in their international expansion within the region (Rugman and Verbeke, 2007; Kudina, 2012), and offers the potential for lower intra-regional investment costs and/or greater efficiency in the development and exploitation of non-location-bound FSAs (Rugman and Verbeke, 2004, 2005; 2008c). Rugman and Verbeke (2004, 16) note in this respect that "most large MNEs have an average of 80% of total sales in their home triad", and that "strategies of MNEs are embedded in - and co-evolve with - the broader competitive, organizational and institutional contexts at the regional level". This regionalization perspective of the firm has been well-established in multiple product- and service-oriented industries (Collinson and Rugman, 2008; Filippaios and Rama, 2008; Gardner and McGowan, 2010; Oh and Rugman, 2006; Rugman and Collinson, 2004; Rugman and Girod, 2003; Rugman and Verbeke, 2008b), and applies to sustainability services as well (Kolk and Margineantu, 2009). In exploring the strategies of MNEs in the diffusion of sustainable energy, this implies that the regional institutional context in which an MNE is embedded can be an important factor which shapes their growth strategy in a particular industry (Verbeke and Asmussen, 2016). Chapter 3 studies how the international growth strategies of European electric utilities are influenced by factors in the (supra-)national institutional environment (i.e. the EU and their home country), taking both fossil fuel-based technologies and renewable energy for power generation into account.

In addition to the international business perspective, a strategic management perspective is adopted in relation to sub-question A, to examine the investments of MNEs in sustainability-oriented technological innovation from a resource-based view of the firm (Wernerfelt, 1984; 1995; Peteraf, 1993; Barney, 1991; 2001a; 2001b). This provides insight into the role of a firm's resources and capabilities shape their technology-specific investments in sustainable energy, and explains how firm-specific factors enable them to build competitive advantages in an industry context. It includes "all assets, capabilities, organizational processes, firm attributes, information, knowledge", which "enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness" (Barney 1991, 101). This is closely related to the concept of FSAs discussed previously (Kolk and Pinkse, 2008), which is adopted in the international business literature, and consists of a firm's proprietary knowledge and capability to control, coordinate, and manage its assets over geographic distances (Rugman and Verbeke, 1992; 2003). A strategic management perspective can shed light on the investment motives of MNEs in sustainability-oriented technological innovations, embedded in the broader discussion on incumbent firms and incremental/radical innovation. The literature suggests that incumbent firms in an industry are inclined to engage in incremental innovation, in order to sustain and optimize the performance of existing technologies, rather than investing in more radical and disruptive innovations which can potentially diminish the value of existing resources and capabilities (Anderson and Tushman, 1990; Baumol, 2002; Bower and Christensen, 1995; Danneels, 2004; Hill and Rothaermel, 2003; Tushman and Anderson, 1986). Given that power generation sources are controlled by a relatively small number of incumbent firms in the energy industries, and that the uptake of RETs for power generation is crucial to diminish fossil fuel dependence (Holdren, 2006; Unruh, 2000; 2002), this provides an internally oriented research lens to study MNEs and their sustainable energy investments. The strategic management perspective is adopted to explore the development and commercialization of solar photovoltaic (PV) technology by oil firms in chapter 4.

Related to sub-question B, a management perspective is adopted to explore how business-led and market-based approaches can enhance the scalability, accessibility, and affordability of solutions for sustainable energy production and consumption. It focuses on contexts which have historically relied on donor funding and subsidization from (non)governmental organizations (see section 1.3 for a further specification of these contexts). Scaling up sustainable energy solutions independent of donor funding and subsidization is pivotal for their long-term diffusion in society, and to create a wider environmental and social impact. The World Bank (2005, 16) notes in relation to upscaling that "implicit in the concept of scaling up is the need to go beyond business as usual, to embrace new technologies, new institutional arrangements, and new approaches". Hartmann and Linn (2008, 8) complement this by stating that upscaling is about "expanding, adapting and sustaining successful policies, programs or projects in different places and over time to reach a greater number of people". While scaling up sustainable energy solutions without support of donor funding could make them more accessible and affordable on a larger scale, multiple economic, regulatory, and technological complexities associated with upscaling processes make this a challenging endeavour. Firms therefore have an important role in this context. By developing business-led and market-based approaches to upscaling, firms can potentially contribute to the diffusion of sustainable energy solutions in an economically viable manner.

In this context, the business model perspective is adopted in relation to sub-question B to examine how market-based approaches can stimulate the wider diffusion of sustainable energy solutions, independent from donor funding and subsidization. Given that "business models seek to explain both value creation and value capture" (Zott et al. 2011, 1020), it provides an actor-centric lens to analyse the core characteristics of business-led approaches in this realm. This contributes to making these solutions accessible and affordable to a wider audience, in an economically viable manner. The business model perspective has been widely adopted related to sustainability issues (Boons and Lüdeke-Freund, 2013; Boons et al., 2013; Lüdeke-Freund, 2009; Roome et al., 2016; Schaltegger et al., 2016; Schaltegger et al., 2012), including electric vehicles (Bohnsack et al., 2014;

Christensen et al., 2012; Kley et al., 2011), renewable energy (Gabriel and Kirkwood, 2016; Matos and Silvestre, 2013; Richter, 2013; Wadin et al., 2017), and how to reach consumers at the bottom/base of the pyramid (BOP) (Bittencourt Marconatto et al., 2016; Kolk et al., 2014; Palomares-Aguirre et al., 2017). As exemplified by these studies, the business model perspective can provide a framework to analyse how firms create and capture value. Firm-specific components which contribute to value creation may include the firm's customer value proposition, key resources and processes, profit/cost structure, and type of investment model (Eyring et al., 2011; Morris et al., 2005; Shafer et al., 2005), and provide "a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network" (Shafer et al. 2005, 202). This can provide an actor-centric perspective on the opportunities for market-based approaches to create economic, environmental, and social value, and ascertain how this contributes to enhance the scalability, affordability, and accessibility of sustainable energy solutions. The business model perspective will be applied in chapter 5, to examine how entrepreneurial firms are able to develop and market RET-based off-grid solutions to establish access to energy in developing countries.

In addition, a management perspective on upscaling can shed light on the factors which enable firms to scale up technological innovations beyond pilot projects, and thereby contribute to the wider diffusion of sustainable energy solutions. Three factors stand out in this respect. First, firms need complementary resources and capabilities for both exploration and exploitation activities, to be able to scale up sustainable energy solutions. Explorative activities, such as research and development (R&D) activities to develop novel technological innovations, require different resources and capabilities than the exploitation activities aimed to commercialize technological innovations. Firms need to have an ambidextrous ability to simultaneously pursue exploration and exploitation activities (March, 1991), and manage both effectively by adopting a balanced approach (Andriopoulos and Lewis, 2009; Lavie and Rosenkopf, 2006; Lavie et al., 2010; Raisch and Birkinshaw, 2008; Raisch et al., 2009). Second, prospects to achieve economies of scale, which lead to lower unit costs because fixed costs can be spread out over a larger volume (O'Sullivan et al, 2003), are key to upscaling. Firms inherently have commercial incentives to scale promising technological innovations, given that their external environment is shaped by market-based mechanisms, while (non)governmental organizations can have a tendency "to move from one new idea to the next, from one project to another" (Hartman and Linn 2008, 19), without sufficiently scaling up existing solutions. Third, upscaling processes are enabled by knowledge transfer between locations and departments (Du Plessis, 2007; Foos et al., 2006; Seidler-De Alwis and Hartmann, 2008; Tamer Cavusgil et al., 2003), which can be facilitated by internal knowledge sharing mechanisms. For MNEs, the efficient organization of knowledge flows enables firms to exploit local knowledge, by acting as an intermediary, integrator, and facilitator of knowledge sharing (McCann and Mudambi, 2004; 2005; Mudambi, 2002). Alongside an ambidextrous approach to exploration and exploitation, and the prospects of economies of scale, knowledge sharing facilitates firms in enhancing the scalability, accessibility, and affordability of sustainable energy solutions. This management perspective will be adopted in chapter 6, to study trajectories for scaling up sustainable energy solutions beyond pilot projects.

Towards insights into firms as actors in sustainability transitions

These business and management perspectives can shed more light on the role of firms as actors in the broader transition towards more sustainable energy production and consumption. Related to sub-question A, the strategic management and international business literature can elucidate how internal and external factors which impact MNE strategies in sustainable energy, and explain how these factors influence technology-specific investments of MNEs. Geels (2014) identifies that incumbent firms can influence sustainability-oriented transition processes by developing and marketing radical technological innovations, but can be reluctant to do so because of sunk investments in existing fossil fuel-based technologies, and the risk of potentially disrupting existing resources and capabilities (cf. Tushman and Anderson, 1986). Unruh (2000, 817) refers to the concept of 'carbon lock-in' in this respect, which implies that "industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional increasing returns to scale", which "arises through a combination of systematic forces that perpetuate fossil fuel-based infrastructures in spite of their known environmental externalities and the apparent existence of cost-neutral, or even cost-effective, remedies". Erickson et al (2015) note in this respect that carbon lock-in is greatest for coal power plants, gas power plants, and oil-based vehicles, based on an analysis of major energy-consuming assets in the power, buildings, industry, and transport sectors. Exploring how firm-specific resources and capabilities influence the strategic approach to sustainable energy, focused specifically on firms with established positions in the energy industry, can provide insight into their role in the widespread diffusion of novel technologies (Geels, 2002; 2004).

In addition, the strategic management and international business literature can also shed light on the potential role of firms from non-fossil fuel industries to contribute to more sustainable energy production and consumption. Erlinghagen and Markard (2012) identify that firms from the ICT industry can be particularly relevant catalysts for systemic transformation in the energy sector, based on their analysis of smart grid projects in Europe. Erlinghagen and Markard (2012) state in this respect that "incumbent firms from the ICT sector have gained influence and drive transformation through the creation of variety, in terms of technology, business models and value chains", and that incumbents from the energy sector “have recently acquired many start-ups specialized in ICT technology and thus expanded their competence base” as a strategic response (Erlinghagen and Markard 2012, 895). Similarly, Geels (2018, 225) notes that a transition in electricity production goes beyond the deployment of RETs for power generation, and depend on “complementary innovations in electricity networks and demand” as well, including smart grids, energy storage, and network expansion. This shows that ICT firms can have an impact on transformative change in the energy industry, based on exploiting firm-specific resources and capabilities in developing and marketing ICT-based network and infrastructure solutions. Geels (2014, 261) mentions in this context that the accumulation of external pressures can stimulate firms with established positions in an industry “to overcome lock-in mechanisms and reorient towards more radical innovations”, and consequently can have a potentially positive influence on the widespread diffusion of novel technologies for sustainable energy production and consumption.

Furthermore, the international business perspective can show how external factors, related to the (supra-)national institutional environment in which firms are embedded, shape the investments in sustainable energy of MNEs as part of their internationalization strategies. The European electricity market provides an interesting regional context in this respect, given that it has been fundamentally reshaped over the last two decades by a process of market liberalization, and the EU’s aim of establishing an European internal electricity market (Meeus et al., 2005). Institutional differences between countries continue to exist at the national level, because market liberalization is incomplete in multiple European countries (Joscow, 2008). A regionalization perspective on the internationalization patterns of MNEs the European electricity industry can explain how regional institutional coherence impacts the profitability, growth, and survival of these firms (Rugman and Hodgetts, 2001; Rugman and Verbeke, 2004; 2005). Related to investments in power generation technologies, this can explain how differences in home-country public policies for renewable energy can influence firm-specific investments in RETs. Specifically, it can show how favourable public policies can provide incentives for MNEs to increase their sustainable energy investments in their home market, and leverage FSAs built up in this process for their international expansion (Rugman and Verbeke, 2007).

Related to sub-question B, the business and management literature can provide an actor-centric perspective on the ability of firms to develop and scale up sustainable energy solutions in contexts which have historically relied on donor-funded projects and subsidized activities. In sustainability-oriented transition processes, the wider diffusion of technological innovations from ‘niche environments’ is a central tenet (Geels, 2002; 2004). These environments are characterized as ‘incubation rooms’ or ‘protected spaces’ for experimentation and early adoption of technological innovations (Geels, 2005a; Kemp et al., 1998; Smith and Raven, 2012), and can facilitate the market formation of radical, potentially disruptive innovations (Carvalho, 2014). Findings from the studies related to sub-question B can shed light on the potential for novel business models and market-based approaches to enable the wider diffusion of technological innovations in an economically viable manner. This provides an actor-centric perspective on how business responses to sustainable energy can influence (i.e. stimulate or hinder) the wider diffusion of sustainable energy solutions, and thereby enhance their environmental and social impact. This perspective complements existing conceptualizations of transition trajectories and pathways in the sustainability transitions literature (Geels and Schot, 2007; Raven, 2007; Smith et al., 2005). Given that "actor-related patterns are important building blocks to understand accelerations and slowing down in diffusion and breakthrough" (Geels 2005a, 692), this contributes to further insight into how transition processes towards sustainable modes of energy production and consumption unfold in society.

1.3 Empirical contexts

This dissertation will apply perspectives from the business and management literature identified in section 1.2 to multiple heterogeneous contexts which are important in the broader transition towards a sustainable energy future. Related to sustainable energy production, this includes the centralized grid-connected application of RETs for power generation in the energy industries, to diversify their portfolio away from fossil fuel-based technologies, and the decentralized off-grid application of RETs, to establish access to energy in developing countries. For sustainable energy consumption, this entails the application of ICT-based solutions (i.e. smart city technologies) to address resource efficiency in highly energy-intensive contexts. Both renewable energy production and efficient energy consumption are central to a sustainability-oriented transition process, as reflected in sustainable energy targets set by intergovernmental organizations. The EU's 20/20/20 targets for sustainable energy are illustrative in this respect, as they stipulate a 20% cut in greenhouse gas (GHG) emissions from 1990 levels, a 20% share of energy produced from renewable energy sources, and a 20% improvement in energy efficiency by 2020. Each context is discussed in more detail below.

To move towards more sustainable energy production, the diversification of power generation sources away from fossil fuel-based technologies is a central challenge (Holdren, 2006; Jacobsson and Johnson, 2000; Jacobsson and Bergek, 2004). A wide variety of RETs has become available to diversify energy supply by replacing fossil fuel-based power generation (Gross et al., 2003), including solar PV technology, onshore and offshore wind power, biomass, and geothermal energy. Global investments in RETs amounted to US$241.6 billion in 2016, and the installed capacity of all modern RETs combined (excluding traditional biomass) accounted for 10.2% of final energy consumption (REN21, 2017). Multiple RETs, including wind power and solar PV technology, have reached economic competitiveness with fossil fuel-based technologies (World Economic Forum, 2016). Overall, investments in RETs for power generation outpaced fossil fuel-based technologies in 2016, and accounted for more than 55% of global investments in newly installed power generation capacity (UNEP, 2017). Firms with established positions in the energy industry have a central role in the diffusion of RETs, related to their technology-specific investments to diversify power generation portfolios. Their large financial investments gives them major decision-making power over the diversification of energy production, and thus the broader diffusion of RETs. The empirical sections of chapters 3 and 4 therefore explore business strategies and investments of energy firms in grid-connected RETs, and assess their contribution to the diffusion of technologies for sustainable energy production in the energy industry.

In addition to grid-connected RETs for energy production, the decentralized off-grid application of RETs to establish access to energy in developing countries forms another important context for the diffusion of sustainable energy. While grid-connected electricity is oftentimes available in urban areas, a combination of financial, technological, and organizational challenges hinder the extension of the electricity grid to all rural parts of a country (ARE, 2008). It is projected that approximately 1.2 billion people will remain without electricity in 2030 (IEA, 2010), with 80% of these people living in rural areas (ARE, 2008). Given that access to clean and reliable sources of energy is an essential condition for social and economic development (Biswas et al., 2001; Davis, 1998; Dincer, 2000; Sagar, 2005; Sharma, 2006), developing economically viable solutions to establish decentralized off-gird electrification beyond the reach of the electricity grid is important for sustainable development. A diverse range of RET-based solutions has become available in this respect, including systems based on solar, wind, hydro and hybrid technologies (ARE, 2008; REN21, 2010). This creates opportunities to address access to energy through RET-based power generation, as an alternative to extending the electricity grid powered by centralized fossil fuel-based power plants. While donor-funded projects by international organizations have historically been the dominant paradigm in this realm, the importance of market-based approaches to achieve long-term sustainable development has been increasingly recognized by academics, practitioners, and international organizations. Yet, Chesbrough et al. (2006) note that many technologies developed with the intention to be implemented in developing countries did not achieve economic viability, or remained limited to charitable distribution programmes of (inter)national donor organizations. Embedded in the broader debate on private sector development to achieve long-term sustainability, the empirical section of chapter 5 explores business strategies for the diffusion of off-grid, RET-based solutions for access to energy in rural areas in developing countries.

Related to more sustainable energy consumption, the deployment of technology-enabled solutions to achieve energy efficiency in cities is a principal challenge, given that cities account for approximately 60% to 80% of energy consumption and carbon emissions (UNEP, 2011), making them the most energy-intensive contexts globally (Grimm et al., 2008). The process of urbanization combined with population growth will intensify urban energy consumption even further in the decades to come. The number of people living in cities and urban areas is expected to grow from 3.6 billion at present towards approximately 6.3 billion in 2050 (UN, 2009), while population growth projections for 2050 range from 9.6 billion people in a medium-variant scenario, to 10.9 billion people in a high-variant scenario (UN, 2013). In order to address sustainability challenges related to urban energy consumption, a large number of ICT-based solutions has been developed and marketed in recent years, collectively labelled as smart city technologies. These technologies enable city governments to address urban sustainability issues, improve the efficiency of urban services, and contribute to the economic competitiveness and liveability of their cities (EU, 2014; Hollands, 2008; Townsend, 2014). Carvalho et al. (2013, 5) observe that cities and urban areas are increasingly important in issues related to energy and climate change on high-profile international networks as well as in local-level initiatives, and thereby provide “key places for experimentation, early adoption, market formation and social legitimization of new energy solutions”. The growing interest from both public and private stakeholders in smart cities has resulted in a proliferation of smart city initiatives and pilot projects globally, and has created a market for smart city technologies which is expected to grow in volume from US$400 billion to US$1.5 trillion by 2020 (Deloitte, 2015). As part of the emergent phenomenon of smart cities (Albino et al., 2015; Allwinkle and Cruickshank, 2011; Ahvenniemi et al., 2017; De Jong et al., 2015; Gil-Garcia et al., 2015; Höjer and Wangel, 2015), the empirical sections of chapters 2 and 6 explore business strategies for the diffusion of smart city technologies to address urban energy consumption, which contributes to sustainable development in cities and urban areas.

1.4 Overview of the chapters

This dissertation consists of five empirical chapters, which are coupled with the sub-questions presented in section 1.1. Chapter 2, entitled *‘An exploration of smart city approaches by international ICT firms’,* examines how firms in the ICT industry strategically respond to the emergence and spread of smart city technologies to address energy efficiency in cities and urban areas. The chapter provides an overview of existing scholarly work on smart cities from different interdisciplinary academic backgrounds. The empirical section focuses on three MNEs from the ICT industry (IBM, Cisco, and Accenture), which have established leading positions as global smart city technology suppliers over the last decade (Navigant, 2013; 2014). It draws on semi-structured interviews with all focal firms, as well as public authorities in one specific urban context (Amsterdam, the Netherlands), combined with a documentation study on the activities in smart city technologies of each firm. The study explores to which degree these firms have developed FSAs by accessing resources and capabilities from their smart city activities in multiple heterogeneous cities and urban areas, and sheds light on the role of ICT MNEs in addressing urban sustainability issues though the spread of smart city technology-based solutions. Given that energy consumption is concentrated in cities and urban areas, this chapter contributes to insight into the role of firms in addressing energy efficiency in the most energy-intensive contexts at present.

Chapter 3, entitled *'Regionalization strategies of European Union electric utilities'*, explores the internationalization patterns of MNEs in the European electricity industry. In order to establish an European internal electricity market, multiple EU directives aimed at market liberalization and increasing institutional coherence have fundamentally reshaped the European electricity industry since 1996. This has had major strategic implications for (formerly state-owned) electric utilities in terms of their internationalization expansion outside their home markets, and has created policy-related investment opportunities in RETs to diversify their power generation portfolios. This chapter sheds light on the (changing) role of the home country/region in internationalization processes, based on the regionalization perspective of firm internationalization (Rugman and Verbeke, 2004; 2005), The empirical section explores the internationalization patterns of seven firms (E.ON, RWE, EDF, GDF-SUEZ, Vattenfall, Enel, and Iberdrola) from five European home countries (Germany, France, Italy, Spain, and Sweden). It draws on data collected from annual and CSR reports for multiple time intervals (2000; 2005; 2010), as well as Financial Times reporting on the seven firms between 2000 and 2012. By distinguishing between their installed fossil fuel-based and RET-based power generation capacity, this chapter provides a comparative analysis of firm-specific internationalization patterns related to developments in the European institutional environment. It gives insight into the ability of firms to create unique FSAs from RET-oriented policy incentives and regulatory frameworks in their home markets, and reflects how this shapes the internationalization patterns of MNEs.

Chapter 4, entitled *'The development and commercialization of solar photovoltaic technology in the oil industry'*, addresses the strategic investments of incumbent firms in the development and commercialization of RETs for power generation. By taking into account both internal factors related to firm-specific resources and capabilities, and external factors related to industry dynamics, this chapter presents a research model to analyse the investments of MNEs in solar PV technology. The model distinguishes between three factors which impact firm-specific strategic decision-making processes: (i) the perceived degree of complementarity between a novel technology and existing resources and capabilities (Davis, 2006; Milgrom and Roberts, 1990); (ii) their approach to technology development, based on internal development or external acquisition (Davis, 2006; Levy and Kolk, 2002); and (iii) their strategy for technology commercialization, either towards mainstream or niche markets (Raven, 2007). The empirical section draws on three major MNEs with established positions in the oil industry (BP, Shell, and Total) and their investments in solar PV technology, based on archival data collected from annual reports and newspaper articles. This leads to a longitudinal account of firm-specific investments and divestures in solar PV technology spanning over two decades, which unravels the strategic decision-making processes of MNEs in developing and commercializing this specific RET. This contributes to understanding how both internal and external factors shape MNE investments in renewable energy, which is crucial in the broader diversification of power generation technologies away from fossil fuel dependence.

Chapter 5, entitled *'In search of viable business models for development: sustainable energy in developing countries',* explores how market-based approaches are emerging as an alternative to donor-funded projects to establish access to energy in developing countries. This chapter provides an in-depth review of scholarly work on private sector involvement in sustainable development, and identifies which financing schemes and delivery models have been applied in development studies to establish access to energy. It provides a categorization of delivery and financing models (ARE, 2008; Nygaard, 2009; Umree and Harries, 2006; Zerriffi, 2011) on two dimensions (subsidized-unsubsidized; public-private), which reflect the nature of existing approaches to establish access to energy. Building on these existing studies, this chapter adopts a business model perspective to analyse how entrepreneurial firms aim to create economic, social, and environmental value in this market, and assesses whether this leads to commercially viable business models. The empirical section explores the activities of four entrepreneurial firms in Asia (Kamworks, Sunlabob, Husk Power Systems, and Grameen Shakti), which aim to develop market-based business models for access to energy in their respective home countries (Cambodia, Laos, India, and Bangladesh), using decentralized RET-based solutions for off-grid electrification. The study draws on semi-structured interviews with managing directors of these firms, international organizations, non-governmental organizations (NGOs), and energy experts. It sheds light on the core components of business models for sustainable energy, and highlights the complexities involved in building fully commercial business models in this market.

Chapter 6, entitled *'Smart city pilot projects: exploring the dimensions and conditions of scaling up',* explores the dynamics underlying upscaling trajectories of ICT-based solutions for sustainable urban development, which have been developed in donor-funded smart city pilot projects.

While such locally developed pilot projects for urban sustainability have proliferated in European cities in recent years (EU, 2014), many projects have failed to generate scalable solutions that contribute to sustainable urban development. This study presents three scaling trajectories based on insights from development studies (Cooley and Kohl, 2005; Hartmann and Linn 2008; Uvin, 1995; World Bank, 2005), and provides an overview of economic, regulatory, and technological factors which can potentially drive or hinder upscaling processes. The empirical section explores upscaling trajectories in three smart city pilot projects in the field of energy efficiency and sustainable mobility (Energy Atlas, Climate Street, and Cargohopper), which have been developed in a specific urban context (Amsterdam, The Netherlands) as part of the Amsterdam Smart City network. Drawing on semi-structures interviews with public and private organizations involved in each pilot project, combined with a review of internal project documentation, this chapter identifies how upscaling trajectories are influenced and shaped by each of these factors. The chapter contributes to understanding the dynamics involved in upscaling trajectories, and the role of the private sector in this process. It establishes insight into the conditions underlying the potential to scale up locally developed energy efficiency solutions, to achieve a wider impact on sustainable urban development.

Finally, chapter 7 presents the main contributions from each study, and discusses the broader implications for the role of firms in the diffusion of technologies for sustainable energy production and consumption in society. It also reflects on research limitations, and on opportunities for further research emerging from this dissertation.

CHAPTER 2

AN EXPLORATION OF SMART CITY APPROACHES BY INTERNATIONAL ICT FIRMS

2.1 Introduction

In the transition towards a more sustainable energy future, the international diffusion of technologies which enable energy-intensive economic activities to become more energy efficient is a central factor (Herring, 2006; Herring and Sorrell, 2009). A substantial part of these activities is taking place in centres of urban agglomeration. For example, according to UN (2016) figures, approximately 4 billion people (54% of the world's population) live in cities and metropolitan areas, with 1.7 billion people living in cities with at least 1 million inhabitants. In terms of energy consumption, cities and urban areas account for approximately 60% to 80% of energy consumption and carbon emissions (UNEP, 2011). Hence, in addressing environmental sustainability issues related to societies' current dependence on fossil fuels, most notably the effect of greenhouse gas (GHG) emissions on global climate change, moving towards more efficient modes of urban energy consumption is a major challenge. City governments, particularly of capital cities and large urban areas, have increasingly started to address issues related to environmental sustainability and GHG emissions over the last decade (Bulkeley, 2010; Hodson and Marvin, 2009).

In the academic literature, cities and urban areas are also increasingly receiving attention as geographic contexts to address persistent sustainability issues in society (Bulkeley et al., 2010; Geels, 2011b; Hodson and Marvin, 2010; Nevens et al., 2013; Nevens and Roorda, 2014; Simmons et al., 2018), as part of the broader attention to the geography of sustainability transitions (Bridge et al., 2013; Coenen et al., 2012; Hansen and Coenen, 2015; Smith et al., 2010; Truffer and Coenen, 2012). As noted in Chapter 1, this stream of research has recently highlighted the need to examine responses of different types of actors in transition processes towards more sustainable modes of production and consumption in society (Farla et al., 2012; Markard et al., 2012). However, while the importance of firms in this regard has been emphasized as well (e.g. Geels, 2014), specific studies on the strategic approaches of 'firms-in-industries' in this realm are lacking, which is where insights from the business literature and concomitant conceptualizations can add value. This study aims to provide such a contribution, by examining strategies of multinational enterprises (MNEs) from the information and communication technology (ICT) industry in the emergence and spread of 'smart city technologies' for energy efficiency in cities and urban areas.

We embed our analysis in international business (IB) research, a field in which the geography of internationalization strategies has emerged as a central theme within the debate on globalization versus localization of MNEs (Beugelsdijk and Mudambi, 2013; Rugman and Verbeke, 2004; Verbeke and Asmussen, 2016). However, as will be further explained below, the sub-national level has been underexposed, although attention for especially the concept of so-called ‘global cities’ (cf. Sassen, 2000; 2005) has recently emerged for explaining the geographic dispersion of firm activities in host environments (Goerzen et al., 2013; Mehlsen and Wernicke, 2016). Conceptually, this chapter thus seeks to bridge the gap between geography/regional studies and international business research, while it empirically contributes a missing sustainability dimension in studies on MNEs and cities, and adds an actor-oriented perspective to the sustainability transitions literature. More specifically, we focus on ‘smart’ cities which, as part of the growing interest in the potential of cities and urban areas in addressing persistent sustainability issues, are increasingly becoming an ubiquitous phenomenon globally.

While a plethora of definitions and terminologies is used (Albino et al., 2015; Allwinkle and Cruickshank, 2011; De Jong et al., 2015; Gil-Garcia et al., 2015; Höjer and Wangel, 2015), a central tenet of ‘smart cities’ is the use of ICT to address one or more sustainability issues, improve the efficiency of urban services, and contribute to the economic competitiveness and liveability of cities (EU, 2014; Hollands, 2008; Townsend, 2014). For firms, particularly in the ICT industry, smart cities have emerged as strategic growth markets. ICT MNEs report investments in developing and marketing technologies which facilitate the creation of smart cities (Macomber, 2013), a market which is expected to grow from US$400 billion at present to US$1.5 trillion by 2020 (Deloitte, 2015). While firms in the ICT industry thus seem to be in a strong position to contribute to more sustainable modes of energy consumption in cities, as suppliers of smart city technology-based solutions, their strategic approach to smart cities has not been the subject of much research, with a few exceptions (Paroutis et al., 2014; Söderström et al., 2014). Based on an analysis of primary and secondary documents plus interviews, this chapter explores the approaches to smart cities taken by three ICT MNEs (IBM, Cisco, and Accenture). Specifically, it focuses on how these firms have leveraged their international network of subsidiaries to build a strategic presence as smart city technology suppliers in a large number of cities globally.

The chapter is structured as follows. The next section proceeds with an overview of the body of literature on smart cities from interdisciplinary backgrounds, and identifies opportunities to further explore the role of firms in smart cities based on these existing studies. This is followed by a theoretical framework rooted in the international business literature in section 2.3, which elaborates on the opportunities for MNEs to integrate and leverage resources and capabilities from embeddedness in multiple urban contexts in order to build their activities in the market for smart city technologies. Subsequently, section 2.4 gives an overview of the research methodology and selected empirical case studies, while 2.5 explores how the ICT MNEs approach smart cities and to which degree they perceive smart cities to become growth markets. The final section reflects on the findings in relation to the literature and discusses the main contributions, limitations and implications for the broader debate on firms as actors in transitions. It concludes with the identification of some opportunities for future research at the intersection of MNE strategies and sustainable urban development.

2.2 Smart city technologies and sustainable urban development

The existing body of literature on smart cities is interdisciplinary in nature, and predominantly rooted in urban studies, public governance, environmental studies, and computer science. While scholarly work on smart cities to date has addressed a diverse range of aspects related to smart cities, existing research in this field can be broadly categorized in two types of studies. The first category focuses on defining the phenomenon of smart cities at a high level of abstraction by reviewing existing definitions and terminologies adopted in existing publications, and by taking stock of a smart city's core components including economic, political, technological, institutional, infrastructural, social, and governance factors. The second category consists of single or multiple empirical case studies on specific smart city initiatives, which take a more practical perspective on how smart city initiatives and projects unfold in a specific context.

From the *first category of studies* on definitions and terminologies adopted to characterize the phenomenon of smart cities, it is evident that the smart city has remained a rather ambiguous concept to date. The lack of a clear-cut definition widely adopted in academic disciplines is also reflected in the terminology. Terms used for smart cities in different studies are largely used interchangeably, and include references to sustainable cities, green cities, low-carbon cities, eco-cities, intelligent cities, resilient cities, knowledge cities, and digital cities (Albino et al., 2015; Allwinkle and Cruickshank, 2011; Ahvenniemi et al., 2017; De Jong et al., 2015; Gil-Garcia et al., 2015; Höjer and Wangel, 2015). A very generic distinction can be made between terminologies and definitions for 'sustainable cities' and 'smart cities': the former includes a broad set of definitions incorporating many dimensions related to urban sustainability issues and the overall liveability of cities, while the latter explicitly includes the widespread deployment of technological innovation as central in addressing urban sustainability issues (EU, 2014). Kramers et al. (2014, 53) state in this respect that "ICT can be used to achieve cities' climate targets by lowering energy use and GHG emissions from other sectors", thereby providing "great potential for supporting the transition to more sustainable cities".

One of the most comprehensive definitions of smart cities is proposed by the International Telecommunication Union (2015), which is based on 120 definitions adopted by academics, international organizations, companies, and trade associations. Interestingly, it includes both smart and sustainable: “a smart and sustainable city is an innovative city that uses information and communications technologies and other means to improve living standards, efficiency of urban management and urban services and competitiveness whilst meeting the needs of current and future generations in the sectors of the economy, society and the environment” (International Telecommunication Union 2015, 13). This definition reflects that the deployment of ICT-based solutions to address urban sustainability issues and enhance the quality of urban services is an integral part of smart cities, embedded in broader development goals related to economic, environmental, and social dimensions. Other definitions adopted in scholarly work propose similar characterizations of smart cities (Angelidou, 2015; Caragliu et al., 2011; Giffinger et al., 2007; Hollands, 2008; Komninos, 2011; 2014; Leydesdorff and Deakin, 2011; Lombardi et al., 2012; Schaffers et al., 2011; Stratigea et al., 2015), in which technological solutions are deployed in cities and urban areas for sustainable development in fields such as energy, mobility, water and waste management, and other urban services.

The *second category of studies* on smart cities consists of single or multiple case studies of smart city initiatives, which mostly adopt an exploratory and interpretative approach, and focus on one or more local contexts. This includes studies on smart city initiatives in specific European cities which have been particularly active in this field, such as Barcelona (Bakıcı et al., 2013; Grimaldi and Fernandez, 2015) and Helsinki (Hielkema and Hongisto, 2013), as well as comparative studies on smart city initiatives in multiple cities in Europe, North America, and Asia (Alawadhi et al., 2012; Lee at al., 2014; Ojo et al., 2015). A particular subset of these studies addresses newly-built smart cities that have been purposively developed to test and experiment with smart city technologies in a controlled setting. Attention is paid to key characteristics of high-profile newly-built smart cities, including New Songdo City in South Korea, Masdar City in Abu Dhabi, Sitra Low2No in Finland, and PlanIT Valley in Portugal (Alusi et al., 2011; Amitrano et al., 2014). There are also publications that contain more in-depth, single case studies on specific initiatives, such as Caofeidian International Eco-City in China (Joss and Molella, 2013). For most of these initiatives, MNEs are identified as part of the consortium of public and private partners, thus working in collaboration with city governments, albeit their role is not explicitly addressed in these studies.

In addition to these two main types of studies on smart cities, scholarly work on ‘urban climate governance’ (Betsill and Bulkeley, 2006; Bulkeley and Betsill, 2005; Bulkeley et al., 2010), ‘urban climate change experiments’ (Broto and Bulkeley, 2013; Bulkeley and Broto, 2013), and ‘urban transitions labs' (Nevens et al., 2013; Nevens and Roorda, 2014) have yielded insight into the responses of city governments to sustainable urban development. While this literature does not explicitly refer to 'smart cities', it emphasizes the importance of implementing technological innovations to address urban sustainability issues related to climate change. Bulkeley and Betsill (2005, 45) state in this respect that many city governments "have undertaken innovative measures and strategies to reduce their impact on climate change, which can act as demonstration projects or form the basis for new experimentation", whereby "strategies to implement urban sustainability usually rest on the development of exemplary projects or 'best practices', from which lessons can be learned, and applied, within the urban arena or transferred between cities". This reflects that city governments have actively started to address urban sustainability issues on a global scale (Bulkeley, 2010; Hodson and Marvin, 2009), which has created opportunities for firms to develop and market technological innovations to facilitate this process.

Two studies specifically address the role of firms as suppliers of technological innovations for smart cities, both in relation to IBM's 'Smarter Cities' programme. Paroutis et al. (2014) examined how smart city technologies have provided IBM with a growth option in response to the economic recession of 2007-2008. The authors state that smart city technologies can provide ICT firms with a strategic growth option, and that IBM's strategic approach to smart cities "utilizes IBM's core competencies of solving complex problems and being a technical innovator", whereby it "re-uses existing components and solutions where possible" (Paroutis et al. 2014, 269). In addition, Söderström et al. (2014) characterize IBM Smarter Cities as a form of 'corporate storytelling', in which IBM aims to position itself to city governments as an 'obligatory passage point' to address urban sustainability issues through ICT-based solutions. They give a rather critical view of IBM's activities and mention that "the smarter city discourse is a framing device" which "is primarily a strategic tool for gaining a dominant position in a huge market" (Söderström et al., 2014, 315). However, both studies illustrate the potential growth market for ICT MNEs that supply technological solutions to make cities more sustainable and resource-efficient.

This chapter aims to further explore how, and to which degree, ICT MNEs have the potential to position themselves as international smart city technology suppliers, by developing and exploiting resources and capabilities which are rooted in their smart city engagements in a large number of cities and urban areas globally. This adds a novel actor-centric perspective on the role of the private sector in the creation of smart cities, and provides insight into the strategic approaches of ICT MNEs to the emergence and spread of smart city technologies in an international context. The next section will discuss how MNEs can integrate resources and capabilities from local contexts in which they are embedded through their network of subsidiaries, related specifically to the context of smart cities.

2.3 An international business perspective on firm strategies

The geography of international business strategies has emerged as a central theme in IB research, as part of the debate of the globalization versus localization of MNEs. While the influence of institutional coherence within the Triad regions (Rugman and Verbeke, 2004; 2005) and country-specific variations (Bartlett and Ghoshal, 1989; Prahalad and Doz, 1987) on the international strategies of MNEs has been well-established, the sub-national level has remained relatively unexplored to date. The sub-national level is an important unit of expansion, given that firms strategically locate their activities in particular agglomerations rather than in arbitrary locations within host countries, driven by sub-national spatial heterogeneity between locations (Beugelsdijk and Mudambi, 2013; Beugelsdijk et al., 2010).

Related to the international strategies of firms, the distinct characteristics of global cities have recently gained attention to explain their attractiveness for MNEs in their location strategies (Goerzen et al., 2013; Mehlsen and Wernicke, 2016). Goerzen et al. (2013) found that 77% of MNEs locate activities outside their home market in global cities, which the authors attribute to a combination of firm-level and subsidiary-level factors related to corporate strategy, investment motives, and proprietary resources and capabilities. The degree of liability of foreignness experienced by firms, which include cost incurred outside a firm's home market arising from unfamiliarity with the host environment and coordination of activities across geographic distances (Zaheer, 1995), is an important factor in this respect. Global cities are characterized by three distinctive features, including a high degree of global interconnectedness, the prevalence of a cosmopolitan environment, and the widespread availability of advanced producer services (Sassen, 2000; 2005), making them deeply connected and interlinked with each other despite a lack of geographic proximity (Sassen, 2005). Mehlsen and Wernicke (2016) state that locating activities in global cities rather than in peripheral areas is associated with a lower liability of foreignness, as a result of these distinct characteristics. This offers the potential for substantially lower investment costs and/or greater efficiency in developing and exploiting firm-specific advantages (FSAs) between different locations in the MNE network (Rugman and Verbeke, 2007; 2008c). As mentioned in chapter 1, FSAs can be characterized as a firm's proprietary knowledge and capability to control, coordinate, and manage its assets over geographic distances (Rugman and Verbeke, 1992; 2003), and are closely interlinked with a firm's resources and capabilities (Kolk and Pinkse, 2008), which include "all assets, capabilities, organizational processes, firm attributes, information, knowledge" (Barney 1991, 101).

For the international spread of smart city technologies, this implies that an MNE's presence in global cities can potentially facilitate the effective transfer of FSAs between different cities and urban areas, which have been developed through a multitude of local smart city engagements. Meyer et al. (2011, 241) state that MNEs are well-positioned to access resources and capabilities from multiple local contexts in order to create competitive advantages, and state that the “diversity of local contexts enables the MNE to access knowledge from many different knowledge clusters and hotspots”. Similarly, Mudambi and Swift (2011, 186) emphasize that MNEs can potentially develop competitive advantages from their embeddedness in multiple local contexts, given that this “allows them to tap into many local systems of innovation to access diverse knowledge bases and integrate them”. Related to the market for smart city technologies, this implies that an MNE’s ability to leverage resources and capabilities beyond a specific context, and deploy them throughout the wider MNE network of subsidiaries, is an important prerequisite in building their position as international smart city technology supplier.

In this respect, Rugman and Verbeke (1992) make a distinction between location-bound and non-location-bound FSAs. On the one hand, location-bound FSAs are limited in their deployment to their domain of operation. Given that their value is constrained to the local context in which they are embedded, these FSAs cannot be transferred throughout the MNE network and be utilized in other host contexts. On the other hand, non-location-bound FSAs can be deployed beyond the specific domain in which they have been developed in the MNE network, to other local contexts in which the MNE is present through its network of subsidiaries, making them particularly valuable for MNEs (Rugman and Verbeke, 1992; 2001; 2007). In order for FSAs developed at the local level to be non-location-bound, several criteria need to be met. Most importantly, local resources and capabilities need to be specialized, as well as valuable, rare, and imperfectly imitable from a resource-based perspective (Barney, 1991). If specialized resources and capabilities of subsidiaries are integrated with existing resources and capabilities embedded throughout the MNE network, they can become part of a firm’s FSAs (Rugman and Verbeke, 1992). In addition, a subsidiary’s specialized resources and capabilities need to be recognized by corporate management, and achieve legitimacy and acceptance in the wider MNE network, in order to be effectively utilized and leveraged to other localities (Rugman and Verbeke, 1992; 2001).

For non-location-bound FSAs, the degree of liability of foreignness experienced by firms is an important factor in their effective utilization throughout the wider MNE network. When the distance between home and host market in terms of regulatory, institutional, economic, and cultural dimensions increases, it limits the relevance of non-location-bound FSAs (Rugman and Verbeke, 1992; 2007). The preference for global cities in MNE location strategies for locating firm activities in host markets (Goerzen et al., 2013), implies that firms can transfer and deploy non-location-bound FSAs more effectively across national borders, given the reduced amount of liability of foreignness that is associated with locating firm activities in global cities (Mehlsen and Wernicke, 2016). This allows firms to deploy non-location-bound FSAs more efficiently throughout the MNE network, and in multiple cities at the same time. Yet, it remains important for firms to simultaneously develop location-bound FSAs in each local context in the MNE network. While these FSAs are limited to the context in which they are embedded, insights in local market conditions, customer needs and expectations, and government regulations are still important in each local situation (Rugman and Verbeke, 1992). To assess how MNEs can potentially develop non-location-bound FSAs from their activities in multiple urban contexts, a firm's ability to efficiently manage this interplay between location-bound and non-location-bound FSAs is a key factor.

In addition, the efficient transfer and integration of knowledge throughout the MNE's international network of subsidiaries facilitates firms in developing and exploiting non-location-bound FSAs. McCann and Mudambi (2004; 2005) identify that subsidiaries have two broad paths for sharing knowledge beyond local contexts: transferring the accessed knowledge to other subsidiaries and units throughout the MNE network, or integrating the accessed knowledge with existing knowledge bases. Both forms of intra-MNE knowledge sharing can potentially provide MNEs with the opportunity to build their resources and capabilities in any particular market or industry. Mudambi (2002) states that such flows of knowledge from subsidiary to parent form the basis for an MNE's network leverage, and enables MNEs to exploit local resources and capabilities by acting as an intermediary, integrator, and facilitator of intra-MNE knowledge sharing. In order for knowledge sharing to happen between subsidiaries in the MNE network, it is important to have organizational procedures in place. Persson (2006) mentions in this regard that an operational structure which facilitates intra-MNE knowledge sharing, as well as the presence of incentives to share knowledge, positively influence outbound knowledge transfer from subsidiaries to the broader MNE network. Hence, the transfer and integration of knowledge from multiple urban contexts can potentially enable ICT MNEs in developing non-location-bound FSAs as international smart city technology suppliers.

To explore the strategic approaches of ICT MNEs to the emergence and spread of smart city technologies, this study focuses on whether and how firms can leverage resources and capabilities which are developed through their smart city engagements in multiple cities and urban areas. Specifically, it examines how these firms use local contexts to build FSAs related to smart cities, and assesses how locally developed resources and capabilities are transferred throughout the MNE network, facilitated by a lower amount of liability of foreignness experienced from locating firm activities in global cities (Goerzen et al., 2013; Mehlsen and Wernicke, 2016). The next section elaborates on the methodology, and introduces the focal firms in the sample.

2.4 Method and sample

This study adopts a multiple case study design, and focuses on the strategic approaches of three MNEs from the ICT industry (IBM, Cisco, and Accenture), which have established leading positions as global smart city suppliers (Navigant, 2013; 2014). These firms were selected based on the initiatives that they have developed for their smart city technologies (IBM Smarter Cities, Cisco Smart+Connected Communities, and Accenture Intelligent Cities), and their international presence in prime cities for the spread of smart city solutions. The Globalization and World Cities (GaWC) inventory (Beaverstock et al., 1999; Beaverstock et al., 2000) was used to establish insight into the city-level presence of each MNE, given that firm reporting on key figures (revenues, assets, employees) is not available at this specific level. The GaWC inventory provides a relevant roster to account for firm presence at the sub-national level, as it categorizes cities in terms of their centrality in economic globalization (Beaverstock et al., 1999; Beaverstock et al., 2000; Derudder et al., 2003; Derudder and Witlox, 2004; Taylor et al., 2014). Table 2.1 shows the firms' presence in cities for the three globalization arenas in the GaWC (North America, Western Europe, and Asia-Pacific), which are considered to be prime cities for the spread of smart city technologies, based on their inclusion in three comparative rankings related to smart cities. They cover the 20 highest ranking cities in the Sustainable Cities Index for 2015 (Arcadis, 2015); the 20 highest ranking cities in Innovation Cities Index for 2014 (2thinknow, 2014); and the highest ranking cities in the Siemens Green City ranking for 2012 (Economist, 2009; 2011; 2012), including the European (10 highest ranking cities), North American (10 highest ranking cities), and Asia-Pacific ('above average' ranking cities) indices.

An exploratory analysis was conducted for each firm, based on data from documentation and semi-structured interviews. Firm-specific documentation came from annual reports, CSR and sustainability reports, and industry-specific publications on smart city technologies. All available documentation from web-based sources on the programmes of these MNEs for smart cities were collected and scrutinized. For IBM, the publications which were selected include: 'A vision for smarter cities' (IBM, 2009); 'Smarter city solutions: leadership and innovation for building smarter cities' (IBM, 2011a); 'Actionable business architecture for smarter cities' (IBM, 2011b); 'A foundation for understanding IBM smarter cities' (IBM, 2011c); 'Intelligent operations center for smarter cities' (IBM, 2012); and 'Smarter cities: creating opportunities through leadership and innovation' (IBM, 2014). For Cisco, they consist of 'Connecting cities: achieving sustainability through innovation' (Cisco, 2010); 'Smart+Connected city services' (Cisco, 2011); 'Smart city framework: a systematic process for enabling Smart+Connected Communities' (Cisco, 2012); 'Smart cities and the Internet-of-Everything' (Cisco, 2013a); 'The Internet-of-Everything for cities' (Cisco, 2013b); and 'Smart+Connected

Communities: envisioning the future of cities now' (Cisco, 2014). For Accenture, the analysis is based on 'Building and managing an intelligent city' (Accenture, 2011); 'Intelligent urban infrastructure' (Accenture, 2012); 'Accenture sustainability services' (Accenture, 2013); 'Open energy data: a prerequisite for cities to become low-carbon (Accenture, 2015); and 'Capabilities for tomorrow's digital city hall' (Accenture, 2017). Key statements from these publications for each MNE and their activities in smart city technologies are summarized in appendix A. To complement firm-specific documentation, publications of leading consultancy and accountancy firms with expert industry knowledge were collected and analysed, including reports by Navigant, Frost & Sullivan, McKinsey, KPMG, PWC, and Deloitte. This helped to gain a broader perspective on the economic, technological, environmental, and social aspects of smart cities.

Firm presence in cities part of the GaWC inventory				
Geographic location	**Included in comparative ranking**	**IBM**	**Cisco**	**Accenture**
Arena 1: Western Europe				
Amsterdam, Netherlands	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Berlin, Germany	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Brussels, Belgium	Sustainable Cities; Green Cities	X	X	X
Copenhagen, Denmark	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Frankfurt, Germany	Sustainable Cities	X	X	X
Hamburg, Germany	Innovation Cities	X	X	X
Helsinki, Finland	Green Cities	X	X	X
London, United Kingdom	Sustainable Cities; Innovation Cities	X	X	X
Madrid, Spain	Sustainable Cities	X	X	X
Munich, Germany	Innovation Cities	X	X	X
Oslo, Norway	Green Cities	X	X	X
Paris, France	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Stockholm, Sweden	Innovation Cities; Green Cities	X	X	X
Vienna, Austria	Innovation Cities; Green Cities	X	X	X
Zurich, Swiss	Green Cities	X	X	X
Arena 2: North America				
Boston, United States	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Chicago, United States	Sustainable Cities	X	X	X
Denver, United States	Green Cities	X	X	X
Los Angeles, United States	Innovation Cities; Green Cities	X	X	X
Minneapolis, United States	Green Cities	X	X	X
New York, United States	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
San Francisco, United States	Innovation Cities; Green Cities	X	X	X
Seattle, United States	Innovation Cities; Green Cities	X	X	X
Toronto, Canada	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Vancouver, Canada	Green Cities	X	X	X
Washington D.C., United States	Green Cities	X	X	X
Arena 3: Asia-Pacific				
Hong Kong, China	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Melbourne, Australia	Sustainable Cities	X	X	X
Seoul, South Korea	Sustainable Cities; Innovation Cities; Green Cities	X	X	X
Singapore, Singapore	Sustainable Cities; Green Cities	X	X	X
Sydney, Australia	Sustainable Cities; Innovation Cities	X	X	X
Taipei, Taiwan	Green Cities	X	X	X
Tokyo, Japan	Innovation Cities; Green Cities	X	X	X

Table 2.1: Sample firms' presence in cities part of the GaWC inventory

In addition, semi-structured interviews were conducted with representatives of all firms in the sample, who have expert knowledge of firm-specific activities in smart city technologies and addressing urban energy efficiency issues through technology-enabled solutions. Complementary to these interviews with the focal firms, interviews with Amsterdam-based representatives of other public and private stakeholders in smart cities were held, to gain insight into the specificities of this market as illustrative example, and the nature of the resources and capabilities that MNEs can potentially access in relation to smart cities. They included interviews with firms from other industries, members of the Amsterdam Smart City strategic team, and representatives of the City of Amsterdam with expert knowledge on smart cities on urban energy consumption. Appendix B shows more information about the interviewees and the interviews which were all recorded, and lasted between 45 to 120 minutes each. Combined with the data collected from documentation, a narrative account on the strategic approach of each ICT MNE to the international emergence and spread of smart cities was constructed.

2.5 Smart city approaches by international ICT firms

IBM

IBM Smarter Cities has been IBM's main programme for its smart city technologies and city-oriented consultancy services since 2009, and focuses on the deployment of ICT-based innovations in cities to address a broad range of urban sustainability challenges. It is part of the broader IBM Smarter Planet strategy, which was launched in 2008 as IBM's novel corporate strategy, aimed to develop intelligent and interconnected systems and infrastructures for different actors (firms, governments, city authorities) and sectors (energy, transportation, banking, healthcare, education). Big data and analytics, cloud computing, and 'cognitive technology' (e.g. artificial intelligence, machine learning) have been central drivers in the firm's strategic reorientation in recent years, whereby IBM (2015, 22) states that it is "transforming into a cognitive solutions and cloud platform company". In the firm's approach to smart cities, it emphasizes the importance of developing a holistic approach to managing a city's core systems, which is in line with this strategic reorientation. IBM (2009, 1-2) identifies in this respect that "cities are based on six core systems composed of different networks, infrastructures and environments related to their key functions: people, business, transport, communication, water and energy", which together form a "system of systems" that should be addressed in an integral way.

An important part of IBM's activities in smart cities comes from consulting activities coupled with city management technologies, such as IBM's 'Actionable Business Architecture for Smarter Cities' and 'Smarter City Assessment Tool'. These smart city technologies build on efficient management of core elements of urban systems, and enable IBM (2011b, 4) in "defining a city through 185 business components and identifying transformation initiatives". Through these city management technologies, platforms, and applications, as well as city-centric consultancy services to city governments, IBM's positions itself as a long-term partner for cities. This includes defining a city's strategy strategic approach to addressing sustainability issues in multiple urban systems related to city-specific goals and aspirations, improving a city's performance and identifying performance indicators in line with this approach, and the deployment of ICT-based technological solutions (IBM, 2011a). These components are reflected in the IBM's Smarter City Challenge as part of the Smarter Cities programme, which provides pro bono consultancy services and technological solutions to selected cities globally, to address a specific urban sustainability issue related to energy efficiency, urban mobility, water and waste management, and digitalization of urban services. IBM (2017) states that it has deployed 800 IBM employees to 130 cities globally for the Smarter Cities Challenge since 2008, with consulting activities worth US$500.000 per city, with a total value of approximately US$65 million since the start of the programme[1].

Strategically, the IBM Smarter Cities programme and Smarter Cities Challenge have been important for the international spread of smart city technologies in three distinct ways. First, it has been instrumental in developing in-depth knowledge of urban sustainability issues in different cities globally, and provided opportunities for organizational learning on addressing these issues trough smart city technology deployment in heterogeneous contexts. Second, it has enabled IBM to build relationships with city governments, which fits the broader positioning of the firm in their smart city technologies as a strategic partner for city governments, in addition to being a smart city technology supplier. And third, the Smarter Cities programme has enabled IBM to position itself as a leading firm for ICT-based solutions in urban development, which could potentially be a strategic growth market for the firm.

While the total value of pro bono consulting activities as part of the Smarter Cities Challenge is relatively small in comparison to IBM's annual revenues during the 2008-2017 time period, it does provide opportunities to build expert knowledge on addressing urban sustainability issues and optimizing urban services with ICT-based solutions. Also, it facilitates the development of a portfolio of exemplary projects and best practices in the smart city realm. The IBM interviewee referred to the fact that the firm has developed expert knowledge in building complex systems and infrastructures for large public and private clients over decades, and thus has expert knowledge on integrating and optimizing processes within complex systems and infrastructures. In addition, the firm's recent strategic reorientation towards big data and analytics, cloud computing, and cognitive technology (IBM, 2015) can also be applied in the urban management domain. In this respect, IBM's smart city

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[1] For an overview of the approximately 130 cities which have been selected for the IBM Smarter Cities Challenge since 2008, see: https://www.smartercitieschallenge.org/. Amsterdam was selected for the IBM Smarter Cities Challenge in 2015, see: https://www.smartercitieschallenge.org/cities/amsterdam-netherlands.

activities leverage existing resources and capabilities, and are complementary to this novel strategic direction. This underscores that the IBM Smarter Cities programme can be characterized as a ‘framing device’ to develop a strategic presence in this market (Söderström et al., 2014), which utilizes the firm’s existing resources and capabilities in building and managing complex ICT systems and infrastructures (Paroutis et al. 2014).

In developing FSAs in the market for smart city technologies from embeddedness in multiple local contexts, these smart city engagements have enabled IBM to build non-location-bound FSAs which can be leveraged throughout the MNE network. The firm states that “IBM Smarter Cities solutions capitalize on insights gained through thousands of client implementations worldwide” (IBM 2014, 4), which has allowed the development of global best practices in the deployment of smart city technologies based on common models, such as IBM’s ‘Actionable Business Architecture for Smarter Cities’ model and its ‘Smarter City Assessment Tool’. Smart city activities in heterogeneous local contexts are therefore claimed to have allowed IBM to develop ”repeatable best practices that can be applied to cities of all sizes” (IBM, 2011b, 4), thus creating opportunities to achieve economies-of-scale from replication through the wider MNE network. In this vein, the firm’s technological solutions for smart cities draw on communalities between each urban system. The interview with IBM confirmed that presence in prime cities for the spread of smart city technologies is important as that provides insight into prevalent sustainability issues at the local level, and gives opportunities for developing resources and capabilities in managing urban systems and infrastructures. In view of the heterogeneity of each urban environment, such knowledge of local systems creates location-bound FSAs. Yet, the firm’s ability to build location-bound FSAs through its embeddedness in a particular city, in combination with non-location-bound FSAs developed from smart city engagement throughout the MNE network, has contributed to the firm’s ability to position itself as a leading international smart city technology supplier (Navigant, 2013; 2014).

Intra-MNE knowledge transfer is instrumental in the wider dissemination of non-location-bound FSA throughout the MNE network, and occurs in multiple ways. The first entails interdisciplinary collaboration between employees on a project basis. The IBM Smarter Cities Challenge sends an interdisciplinary project team to address a specific urban sustainability issue in a selected city, which is assembled from employees with different functional backgrounds, working in diverse geographic locations. This IBM team provides consulting services to a specific city governments, and identifies opportunities to address issues through the application of ICT-based solutions. As these temporary teams consist of employees from different locations and backgrounds, this facilitates post-project knowledge transfer throughout different subsidiaries in the MNE network, and allows IBM to create and integrate knowledge from these multiple city-specific activities in smart cities. Second, the interview with IBM identified several other forms of knowledge sharing which occur in relation to their smart city activities between locations, which includes sharing knowledge via internal information systems, video conferencing, and other forms of online and offline communication. Thus, the lack of geographic proximity between locations is not considered to be a barrier for intra-MNE knowledge sharing between subsidiaries.

Cisco

In Cisco's strategic approach to smart cities, the firm emphasizes that ICT-based solutions should improve urban infrastructure and create scalable systems for urban management which contribute to economic growth and environmental sustainability (Cisco, 2011). The Smart+Connected Communities programme is Cisco's leading programme for smart city activities, which has been developed based on earlier experiences with city-centric consulting activities in Cisco's Connected Urban Development programme, a joint collaboration with city governments in seven pilot cities (San Francisco, Amsterdam, Seoul, Birmingham, Hamburg, Lisbon, and Madrid) established in 2006. Underlying Cisco's activities related to smart cities is the assumption that energy-efficient ICT-based solutions can contribute to a reduction of energy consumption and GHG emissions in cities. Cisco (2010, 7) states that "building partnerships with these and many other cities in the Smart+Connected Communities program to promote innovative practices using ICT to develop economic, environmental, and social sustainability". Both programmes have been initially developed as corporate social responsibility programmes to develop proof-of-concept projects in specific cities, and demonstrate how ICT-based solutions can help cities to address urban sustainability issues. These proof-of-concept projects have demonstrated "how to reduce carbon emissions by introducing fundamental improvements in the efficiency of urban infrastructures" (Cisco 2012, 3), and contributed to the firm's ability to build specialized knowledge in this market.

In relation to smart cities, Cisco can build on existing resources and capabilities which are rooted in the development and marketing of ICT-based solutions for a wide range of industries (manufacturing, energy, transformation, banking, healthcare, education), which include building network architectures, performing data analytics, and creating Internet-of-Everything (IoE) and cloud-based solutions (Cisco, 2013a; 2013b). The firm characterizes cities as complex systems that face fundamental sustainability issues, which can be "mitigated through the adoption of scalable solutions that take advantage of ICT" (Cisco 2012, 2). Our interview with a smart city expert for Cisco's European markets revealed that smart city technologies are not a stand-alone market for Cisco, but rather a domain in which ICT-based solutions are integrated to optimize the efficiency of urban systems. The Smart+Connected Communities programme bundles the firm's portfolio of platforms, products, and services, to provide city governments with "vertical solutions built on the network as an open, integrated platform" (Cisco 2010, 2). The interviewee characterized the firm's strategy in smart cities as emergent rather than planned, given that it builds on insights and knowledge developed from local smart city engagements, in which the firm collaborates with city governments and other public and private partners (e.g. facilitated by collaborations within the Connected Urban Development and Smart+Connected Communities programme). Intra-MNE knowledge sharing between teams and technical experts in different locations occurs through information systems, webinars, and other forms of communication. This allows for the exchange of knowledge between subsidiaries in the MNE network, and provides the potential to leverage non-location-bound FSAs beyond a specific urban context.

Responsiveness to city-specific sustainability demands and requirements is particularly important in consultancy services. Cisco (2012, 3) asserts to build open data platforms for city governments, based on standardized platforms such as the 'Smart+Connected Operations Center', to "enable cities to establish a standard catalog system for recording, measuring, and collating city data, and for making it easily accessible for efficient, effective implementation and management of smart city solutions". For individual cities, the specificities of such a system can vary, depending on local circumstances. Cisco's smart city solutions thus combine proprietary ICT platforms and products based on best practices developed from multiple smart city engagements, with consultancy services that take city-specific characteristics into account in. This provides cities with "real-time, context-specific information intelligence and analytics to address specific local imperatives" (Cisco 2013b, 1), and forms the basis for the firm's positioning as a strategic partner for city governments (Cisco, 2010).

The firm's aspiration to build long-term collaborations with city governments is consistently emphasized in the firm's strategic approach to smart cities. Cisco (2013b, 19) states that "in order to realize the full potential of Smart+Connected Communities in the era of the Internet-of-Everything, a strong public-private partnership approach is necessary". An illustrative example in this respect in one specific context of the GaWC inventory (Amsterdam, the Netherlands) is Cisco's participation in the 'Smart Light' pilot project, developed as part of the Amsterdam Smart City network, in collaboration with Amsterdam's city government and a consortium of other partners (Philips, KPN, and Alliander). The aim of this pilot project was to develop and test a 'smart' and energy-efficient public lighting system, with Wi-Fi and motion sensors integrated into the design, which could be managed based on real-time data on traffic and pedestrian flows[2]. Our interviews highlighted that this provided Cisco with an opportunity to build knowledge on this specific type of solution, as part of its broader portfolio

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[2] A more extensive description and analysis of the Smart Light pilot project is available the report 'Organising smart city projects: lessons from Amsterdam', see: https://amsterdamsmartcity.com/posts/organizing-smart-city-projects-lessons-learned-fr

of IoE solutions for cities, whereby the strategic aim was to develop a solution for public lighting that could be applied in other cities in the firm's network as well. While the impact of this solution on urban energy consumption has remained rather limited to date, given that it has not been scaled up beyond the pilot project, it does illustrates how Cisco has the potential to access knowledge from local smart city engagements.

Accenture

Accenture's activities in the field of smart cities are embedded in the firm's broader portfolio of sustainability-oriented services for public and private clients (Accenture, 2013), and primary build on the concept of 'Intelligent Cities'. A key characteristic of the firm's approach is the adoption of innovative ICT-based solutions by city governments to deliver urban services, which combines a "coherent and specific vision along with the right kind of technology platform to enable the optimal integration, delivery and management of city services over time" (Accenture 2011, 10). The firm identifies several economic, technological, infrastructural, and regulatory factors which facilitate the development of 'Intelligent Cities', in line with this strategic approach. First, cities need a technological foundation able to embed intelligence in city operations, and provide city governments with an open, interoperable platform that facilitates the optimization of resource management in multiple domains. This urban management platform forms the basis for the deployment of smart city technologies to addressing urban sustainability issues. Accenture (2011, 14) notes that "innovations such as machine-to-machine communications, sensors, intelligent software and analytics, enable a range of critical capabilities such as improved efficiency of electricity, water and gas usage". Accenture's 'Intelligent Infrastructure Platform' can provide this such a foundation for cities, which the firm operates for city governments in an 'Infrastructure as a Service' mode (Accenture, 2012). Second, cities need strategic planning to develop a city-specific vision for urban development, which incorporates social, economic, cultural and resource-related components. This strategic vision should take context-specific variables of each individual city into account and be related to its prevalent urban sustainability issues. Third, Accenture identifies that cities should build efficient management and governance mechanisms in line with this strategic vision. They include regulatory and policy frameworks, financial incentives aligned with sustainable development goals, and new forms of partnerships between public and private stakeholders (Accenture, 2011).

Underlying Accenture's sustainability-oriented consulting services are the firm's existing resources and capabilities in strategy consulting and outsourcing services for corporate clients, governments, and international organizations, as well as expert knowledge in data analytics and the implementation, integration, and management of ICT-based solutions (Accenture, 2013). The concept of ‘Intelligent Cities’ is adopted to bundle the firm’s sustainability-oriented consultancy activities and technological solutions for efficient management of urban services, which are embedded in different departments and business units. Hence, it is not a stand-alone business unit, but a label to aggregate the firm’s activities related to sustainable urban development, which are distributed throughout the organization. Accenture positions itself as a strategic partner for city governments in the development strategic and long-term solutions for urban management, based on developing an intelligent urban infrastructure rather than implementing individual technology solutions. It states that “interdependent services can only be optimized if operators and planners in city administrations, transport services, public and private companies, have a holistic view of their operations and the environment in which they are embedded” (Accenture 2012, 3). Thus, combining a city-specific vision for urban development with a technology platform that enables city governments to manage urban services in an efficient and integrative way (i.e. an intelligent infrastructure), is central in the firm’s concept of ‘Intelligent Cities’. In this regard, Accenture (2011, 4) mentions that the ‘Intelligent Cities’ concept is “garnered from our experience working with projects and programmes in this space around the world”, which reflects that their sustainability-oriented consultancy services to city governments build on knowledge which is developed across a multitude of urban contexts. In addition, the firm notes in relation to the ‘High Performing City Operating Model’, which is also part of its smart city offerings, that it “builds upon the experience gained from working with more than 80 global cities”, and was “peer-reviewed by leading smart cities such as Amsterdam and Paris” (Accenture 2017, 3).

Interviews with smart experts at Accenture, Amsterdam’s city government, and the Amsterdam Smart City network provided a particularly illustrative example of how MNEs have the potential to develop non-location-bound FSAs from local smart city engagements. As part of the EU-funded TRANSFORM project, Accenture developed an open data platform which visualizes energy flows in Amsterdam in a highly detailed way (the ‘Energy Atlas’), in collaboration with the city government, utilities, and other data holders (Accenture, 2015; Van Warmerdam and Brinkman, 2015). Complementary to this open data platform, a decision support environment for urban management was developed, to enable the city government to simulate interventions in the energy system, supported by the deployment of smart city technologies, in order to lower urban energy consumption[3]. The potential for building FSAs as an international supplier of smart city technologies are both location-bound and non-location-bound in this example. Context-specific factors of the urban context in which this solution was developed, such as the characteristics of the local urban infrastructure, the energy system, access to data from local stakeholders, and relationship-building

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[3] The empirical section of chapter 6 focuses specifically on smart city pilot projects in Amsterdam, and provides a more extensive description of this example, which was developed as part of the Amsterdam Smart City network.

with the city government, provide the potential to develop location-bound FSAs within this specific context. These are difficult to integrate and leverage throughout the MNE network, due to their level of specificity and sub-national spatial heterogeneity in urban contexts. However, the knowledge which is created in the development and realization of this smart city solution in Amsterdam can be leveraged beyond this specific context as well. The open data platform for managing urban energy flows (i.e. the technological solution itself), as well as insight into the organizational process of accessing data in a standardized format from multiple data holders, can be transferred beyond this specific urban context. It can be integrated with FSAs in firm's sustainability-oriented consulting activities and outsourcing services in other localities, and thus be leveraged through the global MNE network to offer similar smart city solutions to other city governments. Our interviewees underlined that Accenture is exploring opportunities to develop similar solutions in other cities, based on the knowledge developed from their activities in Amsterdam.

2.6 Discussion and conclusions

In the internationalization strategies of firms, locating activities in centres of economic agglomeration rather than in peripheral areas is associated with a lower degree of liability of foreignness (Mehlsen and Wernicke, 2016), leading to the propensity of firms to focus on global cities (Goerzen et al., 2013). The lower degree of liability of foreignness enables firms in leveraging FSAs which have been developed in different urban contexts efficiently throughout the MNE network (Rugman and Verbeke, 2007). Given the global presence of all firms in the sample in prime cities for the spread of smart city technologies, as reflected in table 2.1 based on the GaWC Inventory (Beaverstock et al., 1999; 2000), this creates the potential for ICT MNEs to build and sustain a position as international smart city technology suppliers. The empirical section reflected that the firms in the sample seem to be able to tap into resources and capabilities from smart city engagements in a large number of urban contexts, through their network of subsidiaries. Illustrative in this respect is that IBM (2011a) states that its design model for smart city solutions is based on insights from 'over 2000 smart city engagements worldwide'. Firm-specific programmes, including IBM's Smarter Cities, Cisco's Smart+Connected Communities, and Accenture's Intelligent Cities, have facilitated this process, and have provided a basis for building specialized knowledge in technological solutions for urban management. Related to exploring different types of actors in transitions towards more sustainable modes of energy consumption (Farla et al., 2012; Markard et al., 2012), this provides insight into the strategic approaches of ICT MNEs in addressing energy efficiency in cities and urban areas, as suppliers of smart city technologies.

The empirical section highlighted how both location-bound FSAs (which can be exploited globally, potentially leading to benefits of scale or scope) and non-location-bound FSAs (which benefit the firm in a specific location) are important in the strategic approaches of IBM, Cisco, and Accenture to smart cities. On the one hand, the deployment of non-location-bound FSA throughout the MNE network draws on firm-specific smart city engagements in a wide range of cities. This locally developed knowledge can be accessed by other subsidiaries and business units in the MNE network (McCann and Mudambi, 2005), and thus be applied to develop and market solutions to urban sustainability challenges in other localities. Mechanisms for intra-MNE knowledge transfer, which facilitate the inflow and outflow of knowledge between subsidiaries in different local contexts in the MNE's network (Mudambi, 2002), are an important factor. Interviews with all focal firms confirmed that formal mechanisms for knowledge sharing between locations are in place, which allows subsidiaries in the MNE network to transfer explicit knowledge and leverage capabilities beyond the local context. This includes knowledge sharing through information systems, virtual meetings, and conference calls between locations (which occurred in all firms), as well as more integrative forms of project-based collaboration between employees from different locations. A noteworthy example here is IBM's Smarter City Challenge, for which IBM has deployed hundreds of employees in major cities globally since its commencement in 2008. Teams consist of employees with interdisciplinary backgrounds from different office locations, and are commissioned to work collaboratively on a specific sustainability issue in a city for multiple weeks. The interview with IBM reflected that this facilitates post-project knowledge dissemination throughout locations in the MNE network, and may allow MNEs to leverage FSAs throughout different locations, which can potentially lead to the development of non-location-bound FSAs in this market.

On the other hand, several location-bound FSAs remain important for responsiveness to local sustainability requirements, despite being limited in their deployment to the geographic context in which they are embedded. For smart city technologies in particular, pre-existing collaborations, partnerships, or contractual arrangements between MNEs and city governments within a specific urban environment are important. As the empirical section showed, all three ICT MNEs in the sample aim to position themselves as a strategic partner for city governments, and advocate the development of a holistic and long-term smart city vision, which move beyond technological fixes for isolated sustainability issues. Cisco (2010) claims in this respect that their strategic aim is to build partnerships with cities as part of its Smart+Connected Communities programme, which promotes innovative practices using ICT to develop economic, environmental, and social sustainability. Similarly, IBM (2011a; 2011b) refers to the extensive knowledge and experience in collaborating with city governments, positioning itself as a strategic partner for technology-driven innovation and urban management. Given that city governments are the primary customers for urban management solutions based on smart city technologies, existing relationships are important location-bound FSAs for these firms.

However, the interviews with public actors in Amsterdam highlighted that while these firms play active roles in several smart city pilot projects, the scope of their activities has remained relatively small and experimental to date. The involvement of these firms in Amsterdam Smart City projects, as discussed for two energy efficiency projects in the previous section (i.e. Cisco in the 'Smart Light' project and Accenture in the 'Energy Atlas' project), are illustrative in this regard. Both examples showed that these pilot projects can provide opportunities for firms to build knowledge in developing and deploying smart city solutions, as part of their broader international portfolio of smart city engagements. At the same time, it reflected that the broader environmental and social impact from these projects on sustainable urban development has remained rather limited to date, given that the process of scaling up these solutions beyond a pilot project proved to be challenging. Chapter 6 will therefore focus on the complexities involved in scaling up solutions from smart city pilot project in more detail, with specific attention to the role of MNEs. It should also be noted that the ambition to be 'a (key) strategic partner' will be rather difficult for all three firms concurrently in the same city, so a certain level of competition can be expected, especially when the stakes become higher than they currently are. Moreover, if the amounts involved in smart city projects increase considerably, there will a requirement for public tenders in quite some countries, at least in Europe, so obtaining a privileged position may not be that easy.

The analysis of the strategic responses of MNEs to smart cities has provided a firm-centric perspective to existing studies in this field, rooted in IB literature, which reflects key factors that shape the strategic approaches of international smart city technology suppliers. Table 2.2 provides an overview of location-bound and non-location-bound FSAs that can potentially be developed by ICT firms in relation to smart cities, as described for each focal firm in section 2.5. These factors were identified based on the empirical exploration of their smart city engagements, as well as the interviews conducted in Amsterdam with public and private actors. It shows that there are differences in the labels that these firms use, and to some extent in approaches, but that they also share quite some similarities, predominantly in the nature of the urban management solutions that this firms offer to city governments.

Strategic approaches of smart city technology suppliers			
	IBM	**Cisco**	**Accenture**
Smart city strategy or programme	IBM Smarter Planet; Smarter Cities	Cisco Smart+Connected Communities; Connected Urban Development	Accenture Intelligent Cities
Urban management platforms	‘Actionable Business Architectures for Smarter Cities’; ‘IBM Intelligent Operations Center’	‘Cisco Smart+Connected Operations Center’; ‘Cisco Kinetic for Cities’	‘Accenture Intelligent Infrastructure Platform’; ‘Accenture High Performing City Operating Model'
Main foci	Complex systems and digital infrastructures; Big data and analytics; Optimization/automation of digital services; Hardware and software orientation	Connectivity and Internet-of-Everything solutions; Network and cloud solutions; Optimization and automation of digital services; Hardware and software orientation	Strategy consulting; Outsourcing services; Optimization and automation of digital services; Software orientation
Partner in Amsterdam Smart City network	Yes	Yes	Yes
Creation of potential non-location-bound FSAs			
Building resources and capabilities in management from heterogeneous urban contexts	X	X	X
Building a position as international smart city technology supplier in a potential growth market	X	X	
Building a portfolio of exemplary projects and best practices in smart city solutions	X	X	X
Building expert knowledge of persistent sustainability issues in cities and urban areas	X	X	X
Exploiting complementarities between existing resources and capabilities in ICT and urban domains	X	X	
Optimizing proprietary solutions (products and services) from multitude of smart city engagements	X	X	X
Creation of potential location-bound FSAs			
Building relationships with city governments in prime cities for the spread of smart city technologies	X	X	X
Building expert knowledge of specific urban system and infrastructures in a local context	X	X	X
Gaining access to local knowledge clusters and urban stakeholders in a local context	X	X	X

Table 2.2: Assessment of strategic approaches of smart city technology suppliers

The creation of non-location-bound FSAs from local smart city engagements provides firms with the opportunity to address persistent urban sustainability challenges on a global scale. Interviews with smart city experts within each focal firm underlined that their technological solutions for urban management primarily focus on the common characteristics of urban systems. In the development and spread of smart city solutions, firms are able to exploit these communalities by building standardized urban management platforms, products, and services, which can be customized to fit the local sustainability demands and requirements of each individual city. This is reflected in the proprietary urban management platforms offered by each firm (i.e. IBM’s ‘Actionable Business Architectures for Smarter Cities’, Cisco’s ‘Smart+Connected Operations Center’, and Accenture’s ‘Intelligent Infrastructure Platform’). Interviewees from each firms confirmed that these urban management platforms are largely based on existing their resources and capabilities, rooted in the development of ICT solutions for public and private clients, applied to the smart cities domain. While this standardization in technological solutions contributes to the ability of MNEs to position themselves as international smart city technology suppliers, researchers have also been critical in this respect (Söderström et al., 2014; Townsend, 2014). As the review of studies on smart cities in section 2.2 showed, most scholars in the field of geography/regional studies emphasize the importance of including a much broader set of societal dimensions into the conceptualization of smart cities, related to the overall liveability of cities and urban areas. Chapter 6 will elaborate on this wider perspective, by focusing on multiple smart city pilot projects developed in Amsterdam in a more in-depth manner.

Implications for further research and limitations

Several limitations can be identified for this study. First, the industry-specificity and relatively small sample of ICT MNEs limits the generalizability of the findings presented in section 4 for a broader set of 'firms-in-industries' (Geels, 2014) in response to the emergence of smart cities. Second, the lack of specific firm-level data on revenues and sales for their activities in smart cities makes it difficult to determine the extent of firm-specific investments in this market, and assess its strategic importance for the firm. Similarly, the lack of firm reporting on key figures at the level of specificity of cities and urban areas is a limitation to explore firm strategies at the sub-national level. While the GaWC inventory, which was adopted instead, provides insight into the presence of a firm in a particular city, it does not give an accurate picture of the scope of firm activities at that level. A third limitation stems from the use of documentation published by the focal firms, which is inherently a form of self-representation, often meant for reputational purposes. By triangulating firm information with other sources, including semi-structured interviews and publications from reputable third parties where possible, an attempt was made to redress this limitation. However, lack of possibilities to check company statements is an issue.

For future research, it would be fruitful to explore which intra-MNE knowledge sharing mechanisms are most effective in leveraging non-location-bound FSAs throughout the MNE network. The interviews with IBM, Cisco, and Accenture all confirmed that the transfer of explicit knowledge between locations occurred between subsidiaries, and enabled them to draw on resources and capabilities developed from multiple smart city engagements globally. The transfer of tacit knowledge is far more complex, however, given that it is embedded in the routines of individuals, and therefore difficult to transfer through information systems. Hence, gaining insight into effective mechanisms for knowledge transfer between subsidiaries with the MNE network would be worthwhile. This is intertwined with the capacity of MNEs to leverage non-location-bound FSAs beyond a specific local context, as emerged from the analysis of these MNEs. The spatial heterogeneity of each urban environment (Beugelsdijk and Mudambi, 2013; Beugelsdijk et al., 2010), and the need for local responsiveness on the part of the MNE in relation to environmental and social issues (Kolk, 2010; Kolk and Margineantu, 2009), has made ICT firms and smart city technologies an interesting initial research context at the sub-national level. Nevertheless, there are many questions, related to the actual importance and relevance as well as the implementation, beyond that what is stated by companies verbally and in writing.

In addition, further research should also explore the complexities and dynamics of collaboration between MNEs and other stakeholders within urban contexts, most notably city governments. Collaboration between public and private actors is an integrative part of addressing urban sustainability issues through the spread of smart city technologies (EU, 2014). This firm-centric analysis primarily showed how MNEs (state to be) involved as suppliers of technological solutions for cities. For one particular urban context (Amsterdam, the Netherlands), the interviews showed that IBM, Cisco, and Accenture are all involved in energy-related pilot projects as part of the Amsterdam Smart City network. Given that such city-level collaborations have proliferated in capital cities in recent years, further research on collaboration between MNEs and city governments could shed more light on the actual involvement of MNEs in smart cities. This could complement existing case studies on smart cities (e.g. Amitrano et al., 2014; Bakıcı et al., 2013; Hielkema and Hongisto, 2013; Joss and Molella, 2013), and provide more insight on cities and urban areas as geographic contexts to address persistent sustainability issues in society (Bulkeley et al., 2010; Geels, 2011b). Chapter 6 provides an initial contribution here, by providing a management perspective on the factors which facilitate smart city solutions to be scaled up from pilot projects in the Amsterdam Smart City network.

Given that challenges related to sustainable modes of energy production will intensify in the years to come, it is important to explore the approaches to sustainable energy from MNEs in other industries as well. This could contribute to a more fine-grained analysis of how different types of actors approach transition processes towards more sustainable modes of production and consumption in society (Farla et al., 2012; Markard et al., 2012), and complement insights on the approaches of ICT MNEs at the city-level presented in this study. The next chapter also adopts an international business perspective on the approaches of MNEs to sustainable energy, and explores EU electric utilities and their role in the transformation of the European electricity sector (i.e. supra-national), including their renewable energy investments. This adds to insights from this chapter on the responses of MNEs to sustainable energy in cities and urban areas (i.e. sub-national), as actors in the transition that is seen as necessary.

Appendix A / Table 2.3: Smart city statements of the ICT firms

Firm	Smart city strategy or programme	Exemplary statements and quotes on strategic approach to smart cities
IBM	IBM Smarter Planet; IBM Smarter Cities	"Cities are based on six core systems composed of different networks, infrastructures and environments related to their key functions: people, business, transport, communication, water and energy (…) the six core systems become a 'system of systems' (…) each element of this 'system of systems' faces significant sustainability challenges" (IBM 2009, 1-2). "Smarter cities make their systems instrumented, interconnected and intelligent (…) pervasive information and communication technology means that there is much greater scope for leveraging technology for the benefit of cities" (IBM 2009, 9). "Administrations - at city level and elsewhere - are recognizing the importance of 'perpetual collaboration' (…) city administrations will need to work seamlessly across their own organizational boundaries and partner effectively with other levels of government, as well as with the private and non-profit sectors" (IBM 2009, 12). "Actionable Business Architecture for Smarter Cities consists of a set of operating models, including a model for the city ecosystem (city ecosystem model), models for individual systems of cities, and models for shared functions" (IBM 2011a, 3). "IBM has developed Actionable Business Architecture for Smarter Cities, leveraging decades of experience in partnering with cities and local governments across various domains" (IBM 2011a, 8). "IBM Smarter City Solutions are based on insights drawn from more than 2.000 Smarter City engagements worldwide. By working with inspiring leaders to solve difficult challenges, IBM has developed repeatable best practices that can be applied to cities of all sizes" (IBM 2011b, 4). "IBM intends to expand its Smarter City solution portfolio to fulfill the Smarter Planet vision. By making cities more instrumented, integrated and intelligent, IBM Smarter City Solutions can help city leaders meet and exceed citizen expectations through innovation" (IBM 2011b, 19).
Cisco	Cisco Smart+Connected Communities; Cisco Connected Urban Development	"The internet is making cities more essential than ever through a networked urban infrastructure (…) the Cisco Smart+Connected Communities program seeks to find visionary and practical approaches regarding technology innovation, and for what an urban services platform means for the build-out of sustainable urban infrastructures" (Cisco 2010, 2). "Cisco proof-of-concept projects fit into the wider urban blueprint whereby Cisco ultimately envisions a global urban services platform approach for - and among - cities (…) an urban services platform approach is based on an ecosystem that encompasses an eco-centric set of technologies and standards that allows for interoperability of applications and devices" (Cisco 2010, 16). "Greenhouse Gas emissions are forcing cities to develop sustainability strategies for energy generation and distribution, transportation, water management, urban planning, and eco-friendly (green) buildings (…) These issues, and others, can be mitigated through the adoption of scalable solutions that take advantage of ICT to increase efficiencies, reduce costs, and enhance quality of life" (Cisco 2012, 2). "A Smart City Framework will enable cities to establish a standard 'catalog' system for recording, measuring, and collating city data, and for making it easily accessible for efficient, effective implementation and management of Smart City solutions for economic, social, and environmental gain" (Cisco 2012, 3). "The complexity of cities (multiple parties, stakeholders, and processes) remains the most significant barrier to adopting smart city solutions (…) complexity manifests itself across many areas of local government - regulatory, governance, economic, systemic, policy, and organizational" (Cisco 2012, 4). "In order to realize the full potential of Smart+Connected Communities in the era of the Internet-of-Everything, a strong public-private partnership approach is necessary" (Cisco 2013b, 19).
Accenture	Accenture Intelligent cities	"A city capable of becoming both environmentally sustainable and attractive to citizens and businesses requires a new kind of intelligent infrastructure— an innovative, open platform based on smart technologies that can help forward-looking cities more predictably integrate a complex suite of services cost-effectively, at pace and at scale" (Accenture 2011, 9). "Important characteristic that distinguishes an Intelligent City is the manner in which it delivers services using advanced technologies: an integration of a number of innovations including machine-to-machine communication enabled by telematics, sensors and RFID technologies; smart grid technologies to enable better energy production and delivery; intelligent software and services; and high-speed communications technologies" (Accenture 2011, 10). "The technological foundation of an Intelligent City is an intelligent infrastructure: the ability to embed intelligence in city operations, making the drive toward sustainability" (Accenture 2011a, 14). "Accenture Intelligent Infrastructure Platform is operated in Infrastructure as a Service mode (Accenture 2012, 4). "Accenture can help cities thrive in the emerging low-carbon economy by tailoring solutions that take advantage of innovations in key infrastructure areas including smart grid services, smart metering, transportation, water conservation, waste and pollution" (Accenture 2013, 4). "Accenture can help cities define, develop and implement technology and communications infrastructure based on interoperable and scalable platforms, which leverage open technologies and architectures. These are vital enablers of smart cities" (Accenture 2013, 4). "Accenture's High Performing City Operating Model builds upon the experience gained from working with more than 80 global cities (…) the model defines the key building blocks of a modern city government's capability framework. The model was peer-reviewed by leading smart cities such as Amsterdam and Paris" (Accenture 2017, 3).

Appendix B / Table 2.4: Overview of interviews on smart cities and firm strategies

Actor	Organization	Participant	Date and time
Private	Accenture	Smart City and Sustainability Services Consultant	Semi-structured; 28 June 2017: 80 minutes
Private	Cisco	Smart City and Internet-of-Everything Consultant	Semi-structured; 2 March 2017; 120 minutes
Private	IBM	Sustainability and Corporate Affairs Manager	Semi-structured; 20 April 2017; 80 minutes
Private	KPN	Business Services Consultant	Semi-structured; 15 June 2017; 60 minutes
Private	Philips	CSR and Government Affairs Manager	Semi-structured; 7 June 2017; 45 minutes
Public	Amsterdam Smart City	Communication Manager	Semi-structured; 13 April 2015; 60 minutes
Public	Amsterdam Smart City	Project Manager Internationalization	Semi-structured; 6 May 2015; 50 minutes
Public	Amsterdam Smart City	Project Manager Energy Innovation	Semi-structured; 11 May 2015; 45 minutes
Public	Amsterdam Smart City	Business Development Manager	Semi-structured; 29 April 2015; 80 minutes
Public	City of Amsterdam Municipality Physical Planning Department	Smart City Expert / Programme Manager	Semi-structured; 24 November 2014; 60 minutes
Public	City of Amsterdam Municipality Physical Planning Department	Urban Energy Expert / Urban Planner	Semi-structured; 24 December 2014; 70 minutes
Public	City of Amsterdam Municipality Physical Planning Department	Urban Energy Expert / Urban Planner	Semi-structured; 18 November 2014; 60 minutes
Public	City of Amsterdam Municipality Climate and Energy Office	Urban Energy Expert / Policy Advisor	Semi-structured; 20 January 2015; 50 minutes
Public	City of Amsterdam Municipality Climate and Energy Office	Urban Energy Expert / Policy Advisor	Semi-structured; 26 November 2014; 60 minutes
Public	City of Amsterdam Municipality AEB Amsterdam	Urban Energy Expert / Programme Manager	Semi-structured; 19 November 2014; 90 minutes

CHAPTER 3

REGIONALIZATION STRATEGIES OF EUROPEAN UNION ELECTRIC UTILITIES[4]

3.1 Introduction

In the past decade, a debate has started about regionalization, initiated by Alan Rugman who announced the 'end' of global strategy, calling it a 'myth' (Rugman, 2001; Rugman and Hodgetts, 2001). Presented as a specification of the integration-responsiveness framework (Bartlett and Ghoshal, 1989), particularly to further explore the 'high national responsiveness' dimension (Rugman and Hodgetts, 2001), it has evolved as a firm-level manifestation of semi-globalization, which alludes to the fact that markets show neither complete fragmentation nor perfect integration (Ghemawat, 2003). The region as a relevant unit of expansion for multinational enterprises (MNE) has been developed around an extended notion of Triad power and especially the 'global impasse' phenomenon as noted by Ohmae (1985), pointing at the inability of many firms to be present in all three legs simultaneously to the same extent. As such political and economic regional integration projects such as the North American Free Trade Agreement (NAFTA) and the European Union (EU) are important influences on the regional nature of MNEs, as these both provide more regional institutional coherence. For MNEs in a region, this offers the potential for substantially lower investment costs and/or greater efficiency in the exploitation and development of non-location-bound firm-specific advantages (FSAs) within the region relative to other alternatives (Rugman and Verbeke, 2004, 2005, 2008c).

The EU is the broadest and deepest regional integration project between independent nation states in modern time, including economic, political and social dimensions. Energy is a key EU policy issue area that features the longstanding economic ideal of a single European market, with the internal energy market, and a social dimension in the response to pressing societal challenges, pursued through the 'EU sustainable energy policy' process (EC, 2010). Initially put on the agenda in 1987, the EU internal energy market has seen three policy packages (in 1996, 2003 and 2007) aimed at liberalization of what used to be a "heavily regulated industry in almost all EU countries, dominated by national or regional, vertically integrated monopolies" (Domanico 2007, 5064). In conjunction with energy market liberalization, which has been characterized as incomplete in some EU countries (Joscow, 2008), thus creating major differences between countries within the EU, renewable energy targets have also been set through various EU directives (Jones, 2010). In 2009, a Renewable Energy Directive was adopted

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[4] This chapter was published in *British Journal of Management*, 2014, *25*(1), 77-99, with Ans Kolk and Johan Lindeque as co-authors (for more details, see co-author statements included elsewhere in this dissertation).

by the EU in order to establish concrete policy, to be implemented by all member states, towards achieving the 20/20/20 targets (a 20% cut in carbon dioxide emissions, a 20% share of renewable energy and 20% energy-efficiency improvement by 2020). The steps taken in the EU sustainable energy policy process represent a drive for significant regional harmonization that has shaped the regional institutional environment of energy firms.

A particularly important subset of these energy firms is formed by those that are involved in electricity generation and supply (hereafter labelled electric utilities), in view of their role at the heart of the business-society debate about how to sustainably provide "the life blood of our society" (EC 2010, 2). These firms generate a major energy source for both industrial and domestic consumers, while using a range of natural resources as their primary inputs, with various environmental impacts depending on the types involved. As such these firms are not only key players in the EU sustainable energy policy process but also in the broader transition from state-owned, protected positions to liberalized electricity markets with competition, private ownership and more independent regulatory bodies. This changing context clearly affects the profitability, growth and survival of electric utilities, and speed and degree of internationalization in relation to their home countries/regions is a crucial firm-specific factor in this regard. Incumbent utilities may, for example, benefit from a protected home market, while enjoying the opportunity to enter markets where liberalization has seen more progress. This raises questions about the importance of these utilities' home countries and region in their internationalization processes, in relation to both their 'traditional' fossil-fuel and renewable energy generation.

This paper seeks to answer these questions by exploring the global/regional orientations of the seven major EU electric utilities (EDF, Enel, E.ON, GDF Suez, Iberdrola, RWE, Vattenfall) from five different home countries (Germany, France, Italy, Spain, Sweden), which are active in both fossil-fuel and renewable energy generation. They have leading positions in multiple national markets and existing power generation portfolios largely established in fossil and/or nuclear technologies, with vertically integrated supply chains covering the production to end-consumer value chain including generation, transmission, distribution and retail supply activities (Schülke, 2010). The seven firms are featured by (former) state ownership, are most often based in the largest national energy markets of key EU member states, and have shown serious internationalization since the late 1990s, in the context of regional market liberalization. The unique characteristics of the electric utilities gives the opportunity to further examine the representativeness critique of the original Rugman and Verbeke (2004) MNE sample (Seno-Alday, 2009). The predominance of (former) state ownership of these utilities, and their frequent historic dominance as domestic monopolies, suggests home-country effects are likely to be important features of their regionalization. The EU sustainable energy policy process furthermore offers the opportunity to explore the regionalization of firms in terms of legacy fossil-fuel energy generation and emerging renewable energy operations, thus considering different scope of business units and FSAs.

The paper proceeds by reviewing the regionalization literature and the role of the home country/region in this debate. This is followed by an explanation of the method and sample, a presentation and discussion of findings, and subsequently conclusions, implications and limitations in light of the broader regionalization debate, to which this study aims to contribute.

3.2 The (semi)globalization and regionalization debate

Following Rugman and Verbeke (2004), regionalization issues, covering various locations and industries, have subsequently been addressed by an increasing number of scholars and also received attention in special issues of Management International Review (2005), European Management Journal (2009) and International Marketing Review (2009), and in an edited volume (Rugman, 2007). The emergence of regional MNEs and regionalization can be placed in the context of earlier attention to local-global distinctions, which pointed at the need for MNEs to combine local responsiveness and global integration (Bartlett and Ghoshal, 1989, Prahalad and Doz, 1987), as well as the more recent evidence on the existence of incomplete cross-border integration, labelled as semi-globalization, thus requiring regional strategies (Ghemawat, 2003, 2005). A central argument being that the liability of foreignness that an MNE experiences is less within the home region than outside it, resulting in lower adaptation costs with intra-regional internationalization (regionalization) than those borne in case of inter-regional expansion (Rugman and Verbeke, 2007). Home-region location-specific (linking) investments needed to exploit and develop non-location-bound FSAs can be expected to be less substantial and/or can be deployed more efficiently than outside this region (Rugman and Verbeke, 2004, 2005, 2008c); this can be reinforced by policies that add further coherence at the regional level, such as those taken in the framework of the EU or NAFTA. The result is the phenomenon as recognized by Rugman and Verbeke (2004) that firms are not global, i.e. that there are only a few MNEs amongst the Fortune Global 500 that have a substantial presence in all three regions of the Triad. Instead, if firms internationalize, they do this most often within their home region.

Rugman and Verbeke (2004) developed a four part typology of the regional presence/orientation of MNEs, including (1) global, (2) bi-regional, (3) home-region oriented and (4) host-region oriented MNEs. Classifying MNEs within these categories relies on the specification of the regions themselves and criteria for the value of sales, assets or other relevant measures of MNE presence for measuring regional presence. Each MNE has a home region were their home country is located and two other regions in which they can additionally be present. MNEs that are global have their activities distributed most evenly across the three regions. Bi-regional MNEs have the majority of their business in just two of the regions. MNEs with a host-region orientation have more than half their activities in a region other than their home region. MNEs with a home-region orientation have the majority of their business activities in the region around their home country; they accounted for 84% of the 380 MNEs in the Fortune 500 list included in Rugman and Verbeke (2004). This significance of the home region has emerged as a major theme in the regionalization literature (Rugman and Oh, 2012).

While the regionalization literature has been subject to significant debate, it is less the phenomenon itself and the argumentation that has been contested and discussed, but rather the underlying evidence, especially the conceptualization, measurement and the conclusions drawn from that. Debate has been sparked, inter alia, about limitations of the sample (since the Fortune Global 500 is not equivalent to the largest 500 MNEs, as it was presented initially); the arbitrary nature of the cut-off points between (bi-)regional and global; the coherence of particularly Asia-Pacific as a region; insufficient attention for the size of the (home) market; and the fact that the regionalization 'evidence' may in fact stem from a home-country effect (i.e. the predominance of the domestic market rather than the other countries in the home region) (Aharoni, 2006; Dunning et al., 2007; Osegowitsch and Sammartino, 2008; Stevens and Bird, 2004; Westney, 2006). Subsequent studies have addressed such issues further, and some main findings will be indicated next – not with the objective to be comprehensive and 'settle' the debate, but instead to assess implications that are relevant for the subject of this paper: particularly the importance of the home country (Rugman and Verbeke, 2007, 2008c), of industry (e.g. Li, 2005; Rugman and Verbeke, 2008b) and issue specificity (Kolk, 2005, 2010), and differences between business units (Proff, 2002; Rugman and Verbeke, 2008a).

The importance of the home country has received considerable attention, also in responses by Rugman and Verbeke (2007, 2008c) to two commentaries on their work (Dunning et al., 2007; Osegowitsch and Sammartino, 2008). Interestingly, the data they provide (of sales of UK firms in the Global 500, and sales and assets of the top 500 in the 2001-2005 period) in both articles show that domestic sales (and assets) predominate, although this is not explicitly noted. In the Global 500 panel, percentages for sales/assets in rest of the world (ROW) are a little less than 25%, and those in rest of the region (ROR) around 10% (Rugman and Verbeke, 2008c), which means that the home country accounted for approximately 65% over the years. The largest European MNEs (in the 2000-2006 period) turn out to have close to half of their sales and assets in their home countries (Oh, 2009). The home market is on average even more important for Japanese MNEs (Collinson and Rugman, 2008). So regionalization for these sets of firms, on average, also means a strong domestic presence. A clear home-country effect has been found in further research with additional data and/or other approaches, and other sets of MNEs, both from the Triad and emerging economies (e.g. Asmussen, 2008; Banalieva and Santoro, 2009; Hejazi, 2007; Seno-Alday, 2009; Sethi, 2009). Home-country effects on MNE strategies have also recently (re-)emerged as an important theme in the broader International Business literature. Given the central role of the state in the historical emergence of most of the major EU electric utilities, this study makes a contribution to the regionalization literature by highlighting the importance of political and public policy influences on the regionalization of these MNEs. This complements the regionalization literature that has studied the importance of home market size, regional concentration (Seno-Alday, 2009; Oh, 2009) and conformity to economic predictions of optimal internationalization (Asmussen, 2008; Hejazi, 2007).

While data problems, particularly availability of firm-level regional data, seem to hinder more in-depth study, this phenomenon deserves further attention, especially in the case of (formerly) regulated industries such as electric utilities. At least for analytical purposes, a further distinction of the 'regional' dimension appears necessary to separate that category from those firms that are predominantly local with their international presence furthermore mostly in either rest of region (ROR) or rest of world (ROW). This also means that domestic institutions matter as much, and in some cases more, than regional ones, depending on the type of MNE we talk about. To be fair, the original intention of Rugman and Verbeke (2004) was to emphasize the locus of destination, while not denying the importance of the locus of origin. However, since the data show that regionalization in many cases also implies a strong presence in the home country, a more explicit consideration of the different patterns of regional involvement seems an appropriate addition to allow for a more specific analysis and an improved understanding of the phenomenon, and its implications for MNE strategy. This includes a specification of intra-regional groupings (sub-regions) as proximate (large) markets often appear more interesting in terms of liabilities, adaptation costs and potential benefits of regionalization (cf. Seno-Alday, 2009). This seems particularly relevant in the case of electricity in view of transmission and distribution considerations.

What has also come to the fore in the regionalization debate is the importance of industry-specificity, considering broader categories such as manufacturing versus services, but also more specific, detailed (sub)sectors (e.g. automotive, retail, cosmetics, accounting, financial services, professional services, food and beverages, and soft drinks) (Filippaios and Rama, 2008; Gardner and McGowan, 2010; Grosse, 2005; Kolk and Margineantu, 2009; Oh and Rugman, 2006; Rugman and Collinson, 2004; Rugman and Girod, 2003; Rugman and Verbeke, 2008b). Li and Li (2007) showed that patterns of globalization/regionalization differ depending on whether an industry is more globally integrated or rather multi-domestic. The current study reckons with these concerns by its focus on one specific sector, electric utilities. By concentrating on generation, covering both fossil fuels and renewables, it also takes issue-specifity into account (Kolk, 2010). Finally, Rugman and Verbeke (2008a) noted that regionalization dimensions may not only be relevant at the corporate level, but also for strategic business units, with the possibility of distinct roles in terms of FSA types and also geographic scope, even within one and the same MNE. Given that large electric utilities have generally created separate units for renewable energy, this is something that can be explored in this study. Before moving to the findings, the next section first discusses the method and sample.

3.3 Method and sample

We used a multiple case study design in the same vein as that adopted by Rugman and Collinson (2004). This allows the in-depth study of a set of firms representing the major electricity generators in the European energy market and conclusions to be drawn about the nature of their globalization/regionalization strategies and the role of the home country in their internationalization processes. Regarding the sample, the following leading firms have been identified: EDF (France), Enel (Italy), E.ON (Germany), GDF Suez (France), Iberdrola (Spain), RWE (Germany) and Vattenfall (Sweden) (Schülke, 2010). Four out of the five home countries (Germany, France, Italy, Spain; only Sweden is different) are amongst the largest EU economies by GDP and energy consumption, and the largest markets by final energy consumption, with considerable renewable energy generation activity.

We adopt the approach of Rugman and Verbeke (2004), making use of firm-level data and their criteria for identifying the four regional orientation types MNEs might adopt. In view of limitations in the availability of data, additional criteria were developed for ROR and ROW (see below). The distinction between extended triad regions is followed for the purpose of this study: i.e. NAFTA, Asia and the EU (and rest of world). Additionally, the EU is divided into four major geographic sub-regions to allow intra-region regionalization to be identified if present. While the recognition of intra-EU regions is not novel in itself, we are not aware of its operationalization or use in previous publications on regionalization. We therefore developed a classification inspired by the academic literature including those on the varieties of capitalism (Amable, 2003; Schmidt, 2000, 2002; Rhodes and Van Apeldoorn, 1997) and informed by issues of proximity and integration of EU economies, resulting in four sub-regions that have common coherence in terms of Ghemawat's (2001) geographic, economic, administrative and cultural distance dimensions: Nordic, Northern, Southern, and Central & Eastern Europe.

The Nordic group is defined primarily by the original categorization of Amable (2003), and low geographic distance. The Northern Europe group again takes Amable (2003) as point of departure, with the reduced geographic distance (at least time-wise), as a result of the interconnector between the UK and The Netherlands, as well as common approaches in these countries, justifying the inclusion of the UK in this sub-region. The work of Schmidt (2000, 2002) and Rhodes and Van Apeldoorn (1997) is believed to provide a justification for the exclusion of France from this group, which is instead placed in the Southern European sub-region (cf. Amable's (2003) mediterranean capitalism country grouping), especially in light of the geographic proximity of the countries. Finally, the Central & Eastern European sub-region includes all EU members that have achieved accession since 2004. Austria is also included in this sub-region based on its inclusion in the Central/Eastern regional classification of European energy markets (ENTSOE, 2010), the low geographic distance and the significant integration of economic activity between Austria and the transition economies around it since their accession to the EU (Huber, 2003). The remaining smaller EU members are finally 'assigned' based on their proximity to the large countries in each of the sub-regions.

We first collected data on the seven electric utilities from their annual reports for the years 2000, 2005, 2010 (and also scrutinized the latest reports published). This was done through a systematic reading of the annual reports and manual recording of quantitative and qualitative data on their internationalization strategies and core geographical markets. In a small number of instances (three firms for the year 2000), we took the most nearby year for which data was available (see Table 3.2 as presented and discussed in the findings section). It should be noted that the level of detail in which these firms report on non-home markets is limited; this may be related to the nature of the industry and the state ownership heritage (compared to listed companies). Extracting exact figures on their presence in specific geographical markets has been rather challenging due to the paucity of information in firms' annual reports. Figures for company and business unit performance are usually included in all reports. However, given that business units can be geographical, functional, or geographical-functional in nature, obtaining exact numbers for presence in specific geographical markets (and thereby detailed non-home country figures) proved rather difficult. In addition, business units sometimes changed over time due to restructuring, which makes comparability between periods challenging. Moreover, information on the recent renewable activities is also limited in availability, and characterized by great diversity (e.g. in terms of energy sources). We therefore also analysed qualitative statements from annual reports (included in Appendices A and B as further details and illustration) to better understand how companies portray themselves in terms of geographical presence and international ambitions.

For what is thus by nature an exploratory analysis, we collected data for revenues, employees, generation capacity, and reported presence in countries. While assets are an accepted measure of regional presence in the literature (Hejazi, 2007; Rugman and Verbeke, 2008b), the available data was not sufficient for inclusion. Revenue is an accepted measure for assessing the downstream regional profile of MNEs (Hejazi, 2007; Rugman and Verbeke, 2008b); this also applies to employees for the regional profile of MNEs (Hejazi, 2007; Rugman and Oh, 2008; Rugman and Verbeke, 2004, 2008). Generation capacity, measured in mega-watts (MW), is a sector-specific measure of MNE presence related to the firm's core electricity generation activities and provides a substitute for the asset measure that could not be used. This is in a similar vein to the use of production capacity by Rugman and Collinson (2004) for the study of the automotive sector, Sethi's (2009) counting of the number of mergers and acquisitions (M&A) deals by country of acquiring and region of acquired firms, and the counting of stores in countries by Rugman and Girod (2003). Finally, we also counted reported presence in a country. While this is a relatively crude measure of the regional presence of a MNE, it does provide some indication of scope and was particularly important for this study as a mechanism for capturing the within-region distribution of the electric utilities in the EU home region. It provided a reliable discriminator between the within-region profiles of the firms; similar approaches have been used in the literature on regionalization. For renewables, we worked with the data that could be found (see Appendix B).

To obtain some further insight into developments and strategies, we also did a search of the Financial Times reporting on the seven firms between 2000 and 2012, using the name of the firm as key search term as a first step. This resulted in a very broad range of articles being returned, which were then systematically reviewed to identify articles providing significant commentary on the strategies of the focal firms. The results of this search where as follows for each firm (the first number is the earliest year for inclusion of an article, the second the total articles returned and the third the articles considered most relevant to firm strategy); RWE (2001; 643/34), E.ON (2001; 498/64), EDF (2001; 1964/143), GDF Suez (2005; 1142/61), Enel (2001; 493/63), Iberdrola (2001; 753/49) and Vattenfall (2001; 185/29). These articles were scrutinized through systematic reading on relevant strategic and policy developments.

The exploration of this firm-specific information proceeded similar to Maguire and Hardy (2009). We developed a narrative account of the key strategic decisions/events for each firm and constructed a history of key events drawing on the newspaper sources and annual accounts independently to provide a picture of its strategic evolution. This approach allows for data triangulation, which we complimented by investigator triangulation, as all three authors considered the data and provided an analysis. Limits on the scope of the work however did not allow a design of the study to accommodate theoretical and methodological triangulation (Denzin, 1978). The case analysis was completed through a within-case analysis for each firm independently and then cross-case analysis of these firm-specific accounts to compare and contrast findings to illuminate themes unique to specific cases and those that were common to a majority of the firms (Yin, 2003). The work of Miles and Huberman (1994) is reflected in the use of tables to present our data and findings.

3.4 Internationalization of EU electric utilities

Developments in regional orientations

Table 3.1 contains the available internationalization data for revenues, employees and generation capacity, with an indication of basic regional orientations on these dimensions for 2000, 2005 and 2010. We collected additional information on the firms and their renewable activities (summarized in the Appendices), which were used to assess the regionalization strategy and sub-regional orientations for 2010, differentiating utilities' core, 'traditional' generation activity from their renewable-energy business (Table 3.2). We first discuss broader patterns of regionalization, followed, in the next sub-section, by an exploration of utility-specific dimensions/patterns, in the context of the (historic) role of respective home governments, derived from the different sources specified above.

The overall development is one of considerable internationalization since the late 1990s, considering revenues, employees and generation capacity, reflecting accompanying EU energy liberalization. Although Table 3.1 only distinguishes between home market (country) and non-home market, the vast majority of the available data covers European business activities, as qualitative analyses confirmed (see e.g. Appendix A). The majority of this internationalization is therefore argued to be home-region oriented, reflecting regionalization patterns identified by Rugman and Verbeke (2004). The relative importance of non-home markets has clearly increased, except for GDF Suez (see firm-specific analyses below).

Interestingly, firms' reports show that none present themselves as home-country oriented, instead emphasizing their geographical spread and international ambitions. They often link internationalization and growth ambitions: i.e. seeking opportunities outside the home country and diminishing risks through diversification of geographical portfolios to depend less on one specific market. Concurrently, most utilities still concentrate on a small number of core markets in Europe, which seems to reflect the phenomenon that Europe has one grid (physically), whereas commercial strategies start from sub-regions that are interconnected through transmission agreements and national system operators (ENTSOE, 2010).

For renewables the international spread is much greater than for core generation, often beyond Europe (see Table 3.2 and Appendix B). Utilities' renewable business is relatively new, influenced by recent EU policy developments, so indicating specific patterns over time is hard; also due to limited data availability (this is most notable for GDF Suez, which only mentions activities in Europe and the Americas). Current renewables regional orientations show home-region foci for Enel, RWE and Vattenfall; EDF and Iberdrola are close to bi-regionalization and E.ON is host-region oriented, all three with a clear presence in North America.

Electric utilities by geographic location (home-country; non-home country), years (2000, 2005, 2010) and regional orientation (home-country; home-region)

PART A: Electric utilities home and non-home revenues (in € mln and % of total), and orientation (HC, HR)*								
MNE	**Home country**	**Total 2010**	**Home market**			**Non-home market**		
			2000	**2005**	**2010**	**2000**	**2005**	**2010**
RWE	Germany	53,320	39,058 (62%) (HC)	23,038 (55%) (HC)	27,283[7] (53%) (HC)	23,820 (38%)	18,781 (45%)	23,439[7] (47%)
E.ON	Germany	92,863	42,050[3] (51%) (HC)	33,557 (59%) (HC)	49,824 (54%) (HC)	40,933[3] (49%)	22,842 (41%)	43,039 (46%)
EDF[1]	France	65,200	26,400 (77%) (HC)	30,126[3] (59%) (HC)	36,200[3] (56%) (HC)	8,024 (23%)	20,925[3] (41%)	29,000[3] (44%)
GDF Suez[2]	France	84,478	9,500 (21%) (HR)	9,720 (23%) (HR)	31,502 (37%) (HR)	39,700 (79%)	31,769 (77%)	52,976 (63%)
Enel	Italy	73,377	25,109 (100%) (HC)	33,146[4] (97%) (HC)	30,767 (43%) (HR)	-	913[4] (3%)	42,610 (57%)
Iberdola[2]	Spain	30,431	8,511 (90%) (HC)	9,707 (83%) (HC)	14,629 (48%) (HR)	978 (10%)	2,031 (17%)	15,802 (52%)
Vattenfall	Sweden	-	2,565[34] (73%) (HC)	- (HR)	- (HR)	949[34] (27%);	-	-
	Nordic	23,725	3,127[34] (89%)	4,522[34] (32%)	6,300[34] (27%)	387[34] (11%)	9,825[34] (68%)	17,425[34] (73%)
PART B: Electric utilities home and non-home employees for 2000, 2005 and 2010								
RWE	Germany	70,856	100,996 (59%) (HC)	43,579 (51%) (HC)	34,184 (48%) (HR)	68,983 (41%)	42,349 (49%)	36,672 (52%)
E.ON	Germany	85,105	103,450 (55%) (HC)	43,219 (54%) (HC)	35,116 (41%) (HR)	83,338 (45%)	36,728 (46%)	49,989 (59%)
EDF[1]	France	158,842	110,089[2] (66%) (HC)	108,557 (67%) (HC)	105,393 (66%) (HC)	57,220[2] (34%)	53,003 (33%)	53,499 (34%)
GDF Suez[2]	France	236,116	60,550 (32%) (HR)	-	103, 865 (44%) (HR)	127,500 (68%)	-	132,251 (56%)
Enel	Italy	78,313	72,647 (100%) (HC)	46,663 (86%) (HC)	37,383 (48%) (HR)	-	5,115 (14%)	40,930 (52%)
Iberdola[2]	Spain	29,641	9,422 (79%) (HC)	9,955 (58%) (HC)	11,899 (40%) (HR)	2,463 (21%)	7,229[4] (42%)	17,742 (60%)
Vattenfall	Sweden	38,179	8,086 (62%) (HC)	8,350 (26%) (HR)	9,000 (24%) (HR)	5,037 (38%)	23,881 (74%)	29,179 (76%)
PARTC: Electric utilities home and non-home generating capacity (MW) for 2000, 2005 and 2010								
RWE	Germany	52,214	-	33,418 (77%) (HC)	34,028 (65%) (HC)	-	9,851 (23%)	18,186 (35%)
E.ON	Germany	68,475	-	25,623 (48%) (HR)	23,345 (34%) (HR)	-	27,990 (52%)	45,130 (66%)
EDF[1]	France	133,900	99,890 (84%) (HC)	98,922 (76%) (HC)	99,100 (74%) (HC)	18,835 (16%)	31,854 (24%)	34,800 (26%)
GDF Suez[2]	France	78,200	-	4,818[2] (9%) (HR)	9,384 (12%) (HR)	-	48,804[2] (91%)	68,816 (88%)
Enel	Italy	97,281	56,609 (100%) (HC)	42,216 (92%) (HC)	40,522 (42%) (HR)	-	3,786 (8%)	56,759 (58%)
Iberdola[2]	Spain	44,991	18,915 (93%) (HC)	24,502 (88%) (HC)	25,590 (57%) (HC)	1,403 (7%)	3,289 (12%)	19,401 (43%)
Vattenfall	Sweden/ Nordic	39,932	-	16,355 (50%) (HR)	16,951 (42%) (HR)	-	16,093 (50%)	22,981 (58%)

Sources: Companies' annual accounts

Notes: 1) Values for either 2000 or 2001; 2) Values for 2002 or 2003; 3) Sales values; 4) Estimated value; 5) Income before taxes; 6) Operating income; 7) home and non-home-market figures based on external sales figure (€50.722)

*HC: Home-country orientation; HR: Home-region orientation. The orientations per year are assessed based on the assumption that the vast majority of these firms' activities is still home-region based.

Table 3.1: Overview of the electric utilities by geographic location, years, and regional orientations

Regional (and EU sub-regional) orientations of the electric utilities in 2010		
	Core energy business[9]	**Renewable energy business**[10]
RWE	*home-country orientation*[1] *(bi-sub-regional in EU*[6]*)*	*home-region orientation*[1] *(bi-sub-regional in EU*[6]*)*
E.ON	*home-region orientation*[1] *(trans-European*[8]*)*	*host-region orientation*[3] *(tri-sub-regional in EU*[7]*)*
EDF	*home-country orientation*[2] *(tri-sub-regional in EU*[7]*)*	*home-region*[1] */ (home) bi-regional orientation*[4] *(*bi-sub-regional *in EU*[6,11]*)*
GDF Suez	*home-region orientation*[1] *(tri-sub-regional in EU*[7]*)*	- [12]
Enel	*home-region orientation*[1] *(uni-sub-regional in EU*[5]*)*	*home-region orientation*[1] *(*uni-sub-regional *in EU*[5]*)*
Iberdrola	*home-region orientation*[1] *(tri-sub-regional in EU*[7]*)*	*home-region*[1] */ (home) bi-regional orientation*[4] *(*bi-sub-regional *in EU*[6]*)*
Vattenfall	*home-region orientation*[1] *(tri-sub-regional in EU*[7]*)*	*Home-region orientation*[1] *(bi-sub-regional in EU*[6]*)*

Source: Table 3.1 and Appendices

Notes: 1) Rugman and Verbeke (2004) define a home-region orientation as when at least 50% of sales are in the home region of the MNE, we assess our measures against this criteria; 2) Home-country orientation is a special case of the home-region orientation where the home country presence alone is enough to meet criteria for a home-region orientation; 3) Rugman and Verbeke (2004) define a host-region orientation as when more than 50% of sales are in a host region of the MNE, we assess our measures against this criteria; 4) Rugman and Verbeke (2004) define a bi-regional orientation as when between 20% and 50% of sales are in each of two regions. EDF and Iberdola both meet the criteria for home-region orientation in renewables and only marginally fail to meet the criteria for a bi-regional profile. We identify the firms as (home) bi-regional oriented firms as a secondary categorization to recognize how much more they are internationalized in renewables compared to their traditional generation business, and competitors, but still with a dominant home-region presence. This avoids the possibility of them mistakenly being considered bi-regional oriented firms in two host regions; 5) Uni-sub-region orientation refers to an electric utility having a presence in one of the four EU sub-regions; 6) Bi-sub-region orientation refers to an electric utility having a presence in two of the four EU sub-regions; 7) Tri-sub-region orientation refers to an electric utility having a presence in three of the four EU sub-regions; 8) Trans-European orientation refers to an electric utility having a presence in all of the four EU sub-regions; 9) Sub-regional presences for the core business of electric utilities is assessed based on their presence in major EU energy markets, as more detailed data was not available; 10) Sub-regional presences for the renewable business of electric utility is recognized when the region accounts for 5% or more of the overall renewable business activity and / or is emphasized in the annual accounts of a firm; 11) The renewable business sub-regional presence of EDF is made using presence in the large EU energy markets as the data available is limited and the approach is consistent with that adopted for the core business column; 12) Insufficient data to make an assessment.

Table 3.2: Regional (and EU sub-regional) orientations of the electric utilities

Early government support for renewables, particularly in Germany, Spain and Denmark, has been said to have played a role in this development (Gan et al., 2007; Saidur et al., 2010). When US stimulus programmes emerged later, European firms could leverage their (non-location bound) FSAs built up before at home (Pinkse and Kolk, 2012). For example, of the US$1 billion 2009 clean-energy grants of the Obama government, Iberdrola obtained 57% and E.ON almost 13% (Choma, 2009). Almost 90% of these grants went to wind, which reflects its overall dominance in utilities' renewables portfolios. Wind has grown fastest in installed capacity (Saidur et al., 2010), is most developed economically and technologically (Jacobsson and Johnson, 2000), and seems to suit utilities' FSAs in larger-scale investments best.

Utility-specific regionalization dimensions

The seven electric utilities are featured by diverse historical trajectories in specific domestic contexts, which has coloured current peculiarities (see Table 3.3 and the Appendices). Government influence/protection has varied, and so has ownership; Vattenfall being the only fully state-owned utility. Both EDF and Enel were established as dominant domestic utilities through government-driven industry consolidation (in respectively the 1940s in France and the 1960s in Italy), with nuclear-energy giant EDF receiving consistent state protection in its home market, much more than Enel (see below). Also in France, GDF Suez emerged only towards the end of the EU energy liberalization process as government-promoted defensive merger to protect Suez as diversified utility from foreign takeover, which required the hasty privatisation of the previously state-owned gas monopoly GDF. In Germany, RWE is a century-old private diversified utility with strong local government ties, while E.ON results from the merger of two privatised conglomerates, influenced by the national government in anticipation of EU energy policy. Iberdrola was created through a merger of two existing private electric utilities in the early 1990s. It is worth noting that EDF and RWE, each as the dominant national utility benefiting from consistent government support, have also been the only home-country oriented firms (for core generation) in our sample (see below). In addition to background information on formation, privatization and the relation to government, Table 3.3 also includes detailed information on key mergers, acquisitions, joint ventures and disposals, which reflect each utility's unique strategic path. Below we will provide brief utility-specific case analyses in the context of EU energy liberalization processes and a consolidation wave in the industry. This is followed by a discussion of the implications of the case analyses for the broader regionalization debate to which this study aims to contribute.

Background information on the electric utilities

Dimensions	**RWE**	**E.ON**	**EDF**	**GDF Suez**	**Enel**	**Iberdrola**	**Vattenfall**
Home Country	Germany	Germany	France	France	Italy	Spain	Sweden
Formation Year	1898	2000	1946	2008	1962	1992	1909
Privatization Year	Private Firm	Private Firm	2005 (partial)	GDF (partial 2004)	1999 (partial)	Private Firm	State Owned
Ownership	Listed	Listed	Listed	Listed	Listed	Listed	Listed
Private	85%	100%	15%	64%	~ 69%	100%	-
Public	15%	-	85%	36% (golden share)	~ 31%	-	100%
Emerged from a merger?	No	Yes	Government driven industry consolidation	Yes	Government driven industry consolidation	Yes	Government Owned
Political influence on / support for firm emergence	Yes (Local)	Yes (National)	Yes (National)	Yes (National)	Yes (National)	No	Yes (National)
Strategy in 2000	Diversified Utility	VEBA (Conglomerate) VIAG (Conglomerate)	Focused Integrated Electric Utility	GDF (SOE gas monopoly) SUEZ (diversified utility)	Integrated Electric Utility	Hidrola (Private Electric) Iberduero (Private Elec.)	Integrated Electric Utility
Strategy in 2010	Integrated Electric Integrated Gas	Integrated Electric Integrated Gas	Integrated Electric (Some Gas)	Integrated Electric Integrated Gas	Integrated Electric (Some Gas)	Integrated Electric (Some Gas)	Integrated Electric (Some Gas)
Primary mode of growth	Acquisition	Merger / Acquisition	Acquisition	Merger / Acquisition	Acquisition / Joint Ventures	Acquisition	Acquisition
Primary Electricity Generation Fuel	Coal / Gas	Coal / Gas / Nuclear	Nuclear	Gas/Hydro	Gas/Hydro	Gas/Renewables/Hydro	Coal/Hydro/Nuclear
Key events for Mergers & Acquisitions, Joint Ventures and alliances	Thames Water (UK, 2000) American Water (US, 2001) Innogy (UK, 2002) Essent (NL, 2009)	Suez Lyonnaise des Eaux (FR, failed 2000) PowerGen (UK, 2002) Ruhrgas (DE, 2002-2003) Graninge (SE, 2003) Stake in Gazprom (RU, 2004) Talks with Scottish Power (Failed 2005) Endesa Assets (ES, 2006-2007) OGK-4 (RU, 2007)	EnBW (25%) (DE, 2001) Hidroelectrica del Cantbrico via EnBW 60% stake (ES, 2001) SPE (10%) (BE, 2001) Edenor (Controling stake) (AR, 2001) Seeboard (UK, 1998-2002) Edison (80.7%) (IT, 2001-2011) Constellation Energy (US, 2008-2010) British Energy (UK, 2008)	Gas Natural (11.3% by Suez) (ES, 2007) International Power (UK, 2010-2012)	Gruppo Camuzzi (40%) (IT, 2001) Viesgo (ES, 2001) Slovenske Elektrarne (SK, 2004-2006) Suez (BE, failed 2006-2008) Electrica Muntenia Sud (67.5%) (RO, 2006) OGK-5 (RU, 2007) Endesa (ES, 2007-2009)	Endesa (ES, failed 2001) Gamesa (ES, strategic alliance, 2002) Gas Natural bid for Iberdrola (ES, rejected by regulator 2003) Rokas (49.9%) (GR, 2005) Scottish Power (UK, 2006) CPV Wind Ventures (US, 2007) EDF Approach (Rejected 2008) Elektro (BR, 2011) Possible merger with RWE (Not pursued 2011)	HEW (DE, 1999-2001) EW (75%) (PL, 2000-2006) Bewag (DE, 2001) GZE (75%) (PL, 2001-2006) VEAG (DE, 2002) Elsam Asset Share (DK, 2005) Amec wind business (UK, 2008) Nuon (NL, 2009)
Key Disposals	Hochtief (DE, 2004) Heidelberger Druckmaschinen (DE, 2004) Thames Water (UK, 2006) American Water (US, 2008) Apirion Distribution Network (79.4%) (DE, 2011)	Gelsenwasser (DE, 2003) Thuega Network of Municipal Holdings (DE, 2009) Long-distance Distribution Network (DE, 2009) US Electric / Gas Assets (2010)	Sale of South American Assets (BR/AR, 2005-2006) British Energy (20%) (2009) Network Business (UK, 2010) EnBW (25%) (DE, 2010)	Italian natural gas transmission network (IT, 2011)	Regulatory mandated generating capacity, market share falls from 68% to 41% (IT, 2001-2005)	Gas business (US, 2010)	50Hertz Transmission (DE, 2010) Polish/Belgian/some Finnish Assets (2011)

Sources: Schulke (2010), Company annual accounts, Company websites; Financial Times articles (see methodology section for explanation) [Given the large number of sources for the findings presented here, we do not provide detailed references; full referencing is available from the authors upon request].
Notes: ISO 3166 Standard Country Codes used between brackets: Argentina (AR), Belgium (BE), Brazil (BR), Denmark (DK), Greece (GR), France (FR), Germany (DE), Italy (IT), The Netherlands (NL), Poland (PL), Romania (RO), Russian Federation (RU) Slovenia (SK), Spain (ES), Sweden (SE), United Kingdom (UK), United States of America (US).

Table 3.3: Background information on the electric utilities

Vattenfall

Vattenfall is peculiar for being the only state-owned utility, and for its specific regionalization trajectory. The early integration of energy markets in the Nordic region allowed Vattenfall to establish a strong ‘home’ base. Concurrently, limits to growth in this relatively small market drove expansion abroad to the largest CEE market (Poland) and the main Northern markets through various acquisitions and joint ventures. This internationalization, however, changed Vattenfall from having low-fossil fuel-based FSAs into one with an energy mix containing significant coal generation, particularly in Germany. This change became an issue for home-market stakeholders, which in conjunction with broader questions over the purpose of the firm brought its internationalization strategy into question. As the only state-owned firm in the sample, Vattenfall has been most susceptible to home-country pressure, which by 2010 drove a consolidation in its key European markets and withdrawal from many other markets. Vattenfall now explicitly emphasizes a stronger focus on its three core Northern European markets (Sweden, the Netherlands, Germany), which accounted for 85% of the firm’s cash flow in 2010, as central to corporate strategy. Vattenfall’s renewables generation capacity is equally concentrated in the core Nordic and Northern European markets, particularly Denmark (27%), Sweden (23%), the UK (23%) and the Netherlands (17%), with offshore wind power in countries in the North Sea region standing out as key for further expansion. The search for renewables can be placed in the context of its changed energy mix, as opportunities to offset fossil-fuel emissions are sought. Vattenfall intends to expand its power-plant investments in low-emitting technologies from 33% of plant investments in 2012 to 66% in 2016, with proportionally the fastest growth in wind energy, which underlines the importance of renewables, but clearly restricted to the nearby home region.

Iberdrola

Iberdrola’s ties to the government seem relatively weak as it prevented the firm’s attempt to achieve European scale via the domestic acquisition of Endesa. The failure to gain scale leaves Iberdrola subject to repeated threats of being acquired (e.g. by EDF), and it invests significant effort in avoiding this outcome, resulting in a more regional profile. Deals include a strategic alliance with domestic wind turbine manufacturer Gamesa and a 2006 acquisition of Scottish Power, which provides the scale needed to stay independent and helps to build Iberdrola’s unique FSAs in renewables. These FSAs play an important part in the internationalization of the firm, and allows the most to be made of renewable-energy incentives that governments put in place. Iberdrola is the largest wind power company in the world, and it claims ‘global leadership in clean energy’. Spain (43%) and the UK (8%) are the largest European renewables markets in terms of installed capacity, while the US (39%) is a core market as well, indicating that Iberdrola almost classifies for a bi-regional focus in renewables. Deeper geographical diversification in renewables outside the home market, thereby building on the strong

FSAs in renewables, is a clear focus for Iberdrola given that 84% of newly installed renewable capacity in 2010 occurred outside Spain, with 56% in the US. Overall, for its core business, Iberdrola remains home-region oriented, with 2010 figures for the geographical spread of electricity production showing Spain as main market with 47%, followed by Latin America (25%), the UK (18%), and the US (9%).

Enel

Enel's home market has presented considerable challenges because the Italian government started energy-market liberalization in 1999. Enel faced a regulator that actively sought to reduce its dominance via mandated sales of generation capacity throughout the first half of the period. Enel abandons its initial multi-utility strategy, with the disposal of non-core assets raising funds for potential expansion, but due to the reduced home-market dominance, it lacks sufficient scale, and without unique assets struggles to participate in the first wave of European consolidation. Although some acquisitions are made (including Eastern Europe and later Russia, as first mover), no major deals are completed. The early years of the second half of the period see Enel bid for Suez, to which the French government responds by sponsoring the GDF-Suez merger (see below). Shortly afterwards, however, Enel emerges as preferred alternative to E.ON in the eyes of the Spanish government for acquiring Endesa. This results in the European scale sought, also in defence against unwelcome interest from other utilities, and provides Enel with a strong position in Southern Europe and Latin America, although Italy is still the main market with 43% of generation capacity in 2010. For renewables, primarily developed through Enel Green Power, its spread is consistent with the generic profile in terms of focus regions, but with a geographically more diverse portfolio, a presence in more different countries within each (sub-)region, and also in North America. Italy is most prominent for renewables as well, followed by Iberia (Spain and Portugal), and then North America, Latin America, and other European countries. Overall, for both core generation and renewables, the large presence in Southern Europe indicates expansion to proximate markets.

GDF Suez

When Enel makes a hostile bid for water and power group Suez in 2006, the French government actively promotes the merger with Gas de France (GDF) to create an integrated European energy utility. Even in the context of EU energy liberalization, the French government retains its distinctive 'dirigiste' tradition, in a state-led model of market coordination (cf. Bohne, 2011), sometimes leading to contradictions and only incremental changes to existing policies; this is most notable in the EDF case presented next. Throughout the later part of the period of investigation, the integration of GDF and Suez takes place and, seemingly as a result, no major acquisitions are made before 2010. Although the firm has a considerable gas market share, the French government effectively prevents GDF Suez from establishing major electricity generation in the home country by supporting EDF (see below), also for nuclear assets for which EDF is preferred in 2009. GDF Suez therefore continues to look internationally for growth. For 2010, electricity generation capacity per geographical region reflects this strong international focus, with 57% of installed capacity in Europe (of which 45% outside France), 20% in Asia, Pacific and Middle East, 14% in Latin America, and 9% in North America. This outward-looking strategy appears to draw on FSAs in managing global operations; the expansion to the UK via International Power in 2010, which pursued a comparable strategy is seen as a natural match. The European and North American markets dominate the firm's core activities, but at the end of the decade, it indicates a clear intention to broaden further, with a third of investments between 2012 and 2017 aimed at pursuing growth in emerging markets. Europe remains by far the strongest contributor to revenues in 2011 (80%), with the Asia, Pacific and Middle East region; North America; and South America contributing with 8%, 6% and 5%, respectively. GDF Suez has an equally global renewable-energy strategy, with presence in Europe, North America, and South America, but specific data is not available as noted above already.

EDF

Benefiting from considerable home-government support, including (in)direct protection from domestic and foreign competition, EDF retains monopoly-like home market shares throughout the period studied, with a clear home-country orientation in core generation. As the EU energy market liberalizes and consolidation begins, EDF makes a number of acquisitions in key markets; but the strong domestic political support appears to affect the degree to which some markets are open to EDF. EDF faces little resistance when removing a competitor on the German border by taking a stake in EnBW, growing its business in the UK by acquiring Seeboard, acquiring a direct stake in SPE in Belgium or an indirect one in gas supplier GVS via EnBW. Acquisitions in Southern Europe are more challenging, however, with significant resistance from the Italian government resulting in new laws to restrict voting rights for state-owned enterprises, a move that attract attention of the European Commission. The indirect acquisition of Hidroelectrica del Cantabrico in Spain via EnBW (in cooperation with Electricidade de Portugal) again leads to temporary blocking of voting rights while state ownership is probed. State ownership clearly has an effect on the degree to which EDF experiences a liability of foreignness in Southern Europe. As further illustration of the influence of the home country on firm strategy, EDF faces strong criticism from the French government in 2003 for risking public money with its internationalization strategy, and the European Commission orders it to repay €1 billion of (in)direct state aid and guarantees.

In 2005, EDF is partially privatised and focuses attention on Europe; by 2008 it has leading positions in UK, Italy and Germany in core generation. Unique FSAs in nuclear energy provide EDF with significant strengths in the acquisition of British Energy and US Constellation Energy. It initially entered the US nuclear sector via a strategic alliance, but his proved challenging, and ultimately requires EDF to buy out its partner. Furthermore, EDF sells the stake in EnBW towards the end of the period, when gaining control seems increasingly unlikely, and acquires Edison in Italy. The 2010 sales figures reflect the developments towards three core markets, which include France, the UK and Italy with 56%, 16% and 9%, respectively. EDF grows renewable energy in both Europe and North America during the period, emphasizing a clear strategic choice to "embark on diversified international expansion drive from the very outset". Contrary to the home-country dominance for EDF as a whole, France is only of marginal importance with 15% of installed renewable capacity, while North America accounts for 34%, and nine other European countries jointly for 51%.

RWE

The German setting is somewhat specific for its overall corporatist model of social market coordination and the federal structure with decentralized (partial) ownership by sub-national governments (Bohne, 2011). This is most notable in the case of RWE, with the German home market and its local political stakeholders providing a secure and supportive environment for its internationalization. Throughout the period studied RWE pursues a strategy of investment in core businesses and divestment of non-core assets reflecting its abandoned multi-utility strategy to focus on electricity and gas. Divestments also take place in Germany, where some of the retained assets are 'rationalized', including efficiency improvements in operations in former Eastern Germany, facilitated by domestic energy policy reforms in the late 1990s. UK Innogy and Essent in the Netherlands are the two major energy acquisitions which reflect a Northern European focus, although Germany is still the dominant market. In the later part of the period, the legacy of coal-powered generation in the context of emerging regulatory pressure for emission reductions is an important driver for RWE's move into renewables. In 2008, renewable-energy activities in the RWE Group are bundled into RWE Innogy, for which the primary purpose is defined to expand generation capacity in mature renewable-energy technologies and focus R&D efforts and venture capital investments to develop emerging renewable-energy technologies. RWE has built on its existing core markets for installed renewable energy capacity in terms of geographical presence, with 81% of its installed capacity in its three main markets of Germany (32%), the UK (35%), and The Netherlands (14%), complemented with Spain (12%) as crucial for especially wind energy.

E.ON

The German home government plays an instrumental role in the establishment of E.ON through the merger of two formerly state-owned conglomerates in anticipation of EU energy market liberalization and facilitating the acquisition of domestic gas assets to establish the firm as an integrated energy utility. Pursuing a multi-utility strategy including electricity, gas and water, E.ON communicates a clear European and North American focus in the early years. The integration of the German gas assets in the home market, however, delay an intended North American expansion and initial internationalization is directed at the UK, Eastern and Nordic Europe. E.ON generates funds for internationalization through the sales of legacy non-core assets and then through regulator-mandated divestments in Germany, including water assets, and is perceived to have pursued a very successful strategy of acquisitions, although expansion into Southern European markets was initially difficult. E.ON is the only utility with a significant trans-European home-region orientation, with a presence in all four sub-regions. Its German home market is still dominant in terms of revenues with 54%, but this is much less the case for employees (41%) and generation capacity (34%). Towards the end of the period, E.ON sells US assets and pursues growth opportunities in Europe, Latin America and Asia.

Since 2007, when E.ON Climate & Renewables came into existence, renewable investments have been rather significant with approximately €7 billion between 2007 and 2011, and another €7 billion planned for 2011 to 2016. Wind energy accounts for 96% of its installed renewable capacity. E.ON meets the criteria for a host-region oriented strategy in renewables with 53% of activities in the US; its European presence includes two of the major Northern European markets (Germany, UK) and all three major Southern European markets, as well as the main market in both the Nordic (Sweden) and CEE (Poland) sub-regions. It explicitly states a focus on the most attractive Western markets as identified in the Country Attractiveness Index Renewables (E&Y, 2012), which in addition to the US includes six European countries. Installed renewable capacity outside its German home market amounts to 95%, indicating that the geographic diversification in renewables is much deeper than for core generation. E.ON identifies dependence on political support as a key risk for sustainable market growth in renewables, emphasizing that "support frameworks are diverse and highly volatile". Most recently E.ON has exited the UK nuclear sector in line with home-market institutional changes away from this energy source that will affect the utility's future internationalization strategy as well.

3.5 Discussion and conclusions

As discussed in the theory section, core assumptions supporting the regionalization literature are that home-region internationalization is associated with lower liability of foreignness than expansion into other regions, which can be reinforced by regional policy coherence, with most MNEs thus likely to have a home-region profile. Two additional observations identify possible nuances: first, there may be distinct regionalization patterns for different FSAs and scope of business units; second, home-region orientations may in fact stem from a considerable home-country effect or predominance of the MNE presence in its home market. This study explored these aspects for the main EU electric utilities, and confirmed a home-region orientation for core generation, with two firms having a strong home-country focus. Policy harmonization and market integration at the regional level appears to have played a role in promoting regionalization of these formerly domestic utilities. Their renewables business units show a different pattern, however, for the six firms with sufficient data: three utilities are home-region oriented, two are close to bi-regionalization and one is host-region oriented.

Hence, while core generation confirms home-region orientations and home-market effects, suggesting much greater liability of foreignness is experienced when internationalizing outside the home region, this differs for renewables, supporting the argument of different FSAs and scope of this relatively new business. Here, utilities appeared able to leverage FSAs built up at home first, supported by renewable-policy incentives, also outside the region. The subsequent drive for renewables (as part of 'green-growth' plans) in the US was an important dimension in the host-region orientation of E.ON and the bi-regional tendency of EDF and Iberdrola. Whether such a 'regulation drives innovation' argument in a new shape, i.e. considering the peculiarities of MNEs (cf. Rugman and Verbeke, 1998), holds more generally is an interesting area for further investigation, with wider relevance, beyond the specific industry; renewable energy could well serve as possible case. There is also the question of whether the more international orientation of renewables might affect the future development of the other fuels and utilities' predominant generation focus. Our study pointed at strategic expansion opportunities based on unique FSA positions for some utilities (EDF for nuclear energy, Iberdrola for renewable energy, for example). Additionally, it seemed that (legacy) non-core assets were central to utilities' ability to generate funds through disposals, for subsequent acquisitions in this asset-intensive industry.

Our study also identified EU sub-regions (Table 3.2), which in conjunction with the accounts of individual firm strategies, points to the potential role of home-region/country differences in the liability of foreignness experienced by utilities, reflecting Asmussen's (2008, 1202) observation that "regional integration may be less effective than previously believed, and that significant barriers to international expansion remain also within regions". Some utilities found expanding into a EU sub-region that did not include their home market challenging as commercial approaches often start in nearby sub-regions. In core generation, only E.ON was present in all four sub-regions, while in renewables, within-region expansion was also incomplete, with only E.ON present in three sub-regions, the others in less.

Different responses of home-country governments to regional integration influenced the position of domestic utilities, as some governments supported the emergence of a national champion, while others did not. Furthermore, some governments 'pushed' utilities abroad through a considerable liberalization of their domestic markets, while others provided a safe home market to allow utilities' successful internationalization. These choices then shaped the degree to which other home-region markets were open to firms to enter during the two phases of consolidation in the industry. Our study thus highlights the effect of home-country public policy on utilities' inward and outward investment decisions, using firm-level data, providing a refinement of the macro level work by Dunning et al. (2007). Towards the end of the period of study we also observed home-country governments with significant stakes in the home utility reigning in their expansion to concentrate on the European region, a finding that provides further insight into the role of residual state ownership in MNE strategy, complementing the work of Vaaler and Schrage (2009).

These forces almost certainly played an important role in utilities' incomplete home-region internationalization. The influence of home-country institutions is reminiscent of the larger-scale work by Thomas and Waring (1999) on the institutional influence in key Triad countries (US, Japan and Germany). Our study adds an exploratory single-sector, within-region account of home-government effects on the international strategies of the seven electric utilities, within a regional institutional policy process. Interestingly, Thomas and Waring's competing capitalisms approach is mirrored in the EU sub-regions that we identified, suggesting that different degrees of liberalization within national markets influenced utilities' strategy, causing friction in internationalization and liabilities faced by utilities from more protected markets versus those from more liberalized markets. However, this deserves further investigation with a larger sample. It would also be interesting to analyse utilities in the UK and the Netherlands, as these countries are most advanced in energy liberalization, but their home-country incumbents have been taken over by foreign utilities. Whereas some of the aspects are idiosyncratic for utilities, others have wider relevance, for sectors and firms confronted with government protection/intervention and/or market liberalization; such complexities related to corporate strategy and FSAs in the context of regionalization are not only faced by utilities.

Finally, it would also be worthwhile to explore possible differences between upstream and downstream internationalization patterns. While we collected data on generation capacity and employees (which can be seen as upstream) as well as revenues (downstream), this was too limited for an analysis; the information available did not suggest differences. However, with proceeding internationalization of the industry as well as further liberalization of the EU electricity market, including separation of generation and sales, it may well become possible to collect better data and thus contribute to the broader debate as to different types of FSAs and liabilities related to upstream versus downstream (cf. Kolk and Pinkse, 2008; Li and Li, 2007; Rugman and Verbeke, 2008c). Another phenomenon that might be further examined is the different path of internationalization in case of two domestic electric utilities, as our preliminary findings, based on a small number of firms, suggest that the more dominant and protected the largest player, the earlier the internationalization/ regionalization by the other. While the limited sample is a clear limitation of our paper more generally, its findings provide insight into an industry type that has not received much attention in the regionalization literature and thus also contributed to the ongoing debate by suggesting areas and directions for follow-up research.

Appendix A / Table 3.4: Main geographic markets for the utilities in 2010

Triad Regions	**Europe (EU)**					**NAFTA**	**Asia**	**Rest of World**	**Statements on main markets from 2010 annual report**
Company	**Northern Europe**	**Nordic**	**Southern Europe**	**Central and Eastern Europe**	**Other**	-	-	-	
RWE	**Germany (HC)** United Kingdom Netherlands Belgium	-	-	Poland Czech Republic Hungary Slovakia	Turkey	-	-	-	"Among our core markets are Germany, the United Kingdom, the Benelux countries as well as Central Eastern and South Eastern Europe" "The markets of North Western Europe continue to be attractive for us, although they still harbour weak growth potential in terms of electricity and gas consumption" "In particular, the Central Eastern European countries and Turkey distinguish themselves through good growth prospects"
E.ON	**Germany (HC)** United Kingdom Netherlands Belgium	Sweden Finland	France Italy Spain	Czech Republic Romania Hungary Slovakia Bulgaria	Russia	-	-	-	"Europe is and will remain our home market and the main focus of our business operations" "The Central Europe business unit has significant operations in Germany, Belgium, France, the Netherlands, Hungary, Czech Republic, Slovakia, Romania, and Bulgaria" "The UK business unit has significant operations in the United Kingdom" "The Nordic business unit has significant operations in Sweden and Finland" "The New Markets business unit has solid market positions in Russia, Italy and Spain"
EDF	United Kingdom Netherlands Belgium Switzerland	-	**France (HC)** Italy Spain	Poland Austria Hungary Slovenia	-	United States	China Vietnam Laos	Brazil	"The EDF Group is active in more than 30 countries. Its global operations focus on three core businesses: generation, networks and sales and trading" Sales (% of total) per business unit (BU): France (55%), United Kingdom (15%), Italy (9%), and Other International Activities (11%), so around 85%-90% of sales are generated in Europe with France, the UK and Italy as main markets Other International activities (11%) includes activities in Europe (Poland, Belgium, Austria, the Netherlands, Slovakia, Switzerland, Hungary, Germany), North America (United States), Latin America (Brazil), and Asia (China, Vietnam, and Laos)
GDF Suez	Germany United Kingdom Netherlands Belgium Luxembourg	-	**France (HC)** Italy Spain Greece Portugal	Poland Romania Hungary Slovakia	Turkey	United States Canada Mexico	Thailand Laos Singapore	Brazil, Argentina Chile, Peru, Panama, Costa Rica, United Arab Emirates, Bahrain Oman, Saudi Arabia, Qatar	For electricity generation the geographical spread is: 27% Benelux & Germany, 21% Middle East, Asia & Africa, 17% Europe (other), 11% France, and 8% North America; so 55% of electricity is generated in Europe Geographical region Benelux & Germany includes Germany, the Netherlands, Belgium, and Luxembourg Geographical region Europe includes Italy, Spain, Portugal, United Kingdom, Greece, Poland, Hungary, Romania, Slovakia Geographical region North America includes United States, Canada, and Mexico; South America includes Brazil, Argentina, Chile, Peru, Panama and Costa Rica Geographical region Middle East, Asia & Africa includes United Arab Emirates, Bahrain, Oman, Qatar, Saudi Arabia), Turkey, Thailand, Laos, and Singapore.

Appendix A / Table 3.4: Main geographic markets for the utilities in 2010

Triad Regions	**Europe (EU)**					**NAFTA**	**Asia**	**Rest of World**	**Statements on main markets from 2010 annual report**
Company	**Northern Europe**	**Nordic**	**Southern Europe**	**Central and Eastern Europe**	**Other**	-	-	-	
Iberdrola	Germany United Kingdom Netherlands Belgium Switzerland	-	France Italy **Spain (HC)** Greece Portugal	Poland Austria Czech Republic	-	United States Mexico	-	Brazil Bolivia Guatemala	"The Group is present in the electricity markets of 13 countries: Spain, France, Germany, Italy, the Netherlands, Belgium, Austria, Portugal, Switzerland, United Kingdom, Greece, Poland and the Czech Republic" "Iberdrola is now the leading Spanish energy group, the 5th largest company on the Ibex 35 by market capitalization, the world leader in the wind sector, and one of the five largest global power companies" Revenues (% of total) per geographical area: Spain 48%, United Kingdom 27%, Rest of Europe 1%, United States 13%, and South America 11%
Enel	Belgium	-	France **Italy (HC)** Spain Greece Portugal	Romania Slovakia Bulgaria	Russia	-	-	Brazil Argentina Chile Colombia Peru	"Significant results were also achieved in the Iberia and Latin America Division in 2010. Division's revenues grew 15% to €31.3 billion about 25 million customers served in Iberia and Latin America in the electricity sector and about 1 million in Iberia in the gas sector" "The foreign companies in the International Division have contributed to the Group's result with their excellent performance" (International Division includes Slovakia, Russia, Romania, France, Belgium, Bulgaria) Revenues (from third parties, % of total): Italy 50%*, Iberia 42% (of which Spain/Portugal 68%; and Latin America 32%), and International 8% *(BUs for Italy includes Sales, Generation/Management, Infrastructure/Networks, Engineering, and Services) The Iberia and Latin America division of Enel was established through the takeover of Endesa (home market: Spain) in 2009
Vattenfall	Germany Netherlands Belgium	**Sweden (HC)** Finland Denmark	-	Poland	-	-	-	-	"The core markets are Sweden, Germany and the Netherlands. In 2010 operations were also conducted in Belgium, Denmark, Finland, Poland and the UK" "Vattenfall's core markets – Germany, Sweden and the Netherlands – together account for 85%–90% of the Group's cash flow. In these three countries' Vattenfall has advanced market positions" "Vattenfall's other markets are Denmark, Finland, Poland and Belgium. The UK is not a core market, however, it is considered to have a special role as a growth market – particularly in offshore wind power"

Source: Annual Accounts
Notes: HC = Home Country

Appendix B / Table 3.5: Renewable energy activities for the utilities in 2010

Company	**Main subsidiary / business unit**	**Established**	**Installed capacity (MW)**	**Capacity by geographical region (MW)**	**Capacity by technology (MW)**	**Additional statements and information**
RWE *(2012 report)*	RWE Innogy	2008	3,744 MW	32% Germany 35% United Kingdom 14% Netherlands 12% Spain 3% Poland 4% Other countries	30% Biomass 44% Wind Onshore 4% Wind Offshore 21% Hydro 1% Other renewables	RWE Innogy: "Bundling renewables activities and competencies across RWE Group" "Focus on capacity growth in commercially mature renewable technologies, i.e. wind, biomass and hydro" "Research & Development and Venture Capital to drive the development of emerging technologies, e.g. solar, geothermal, marine" "European focus" "RWE Innogy operates 2,430 MW of the total 3,744 MW of installed capacity of the RWE Group" "Has approximately 1.450 employees in 5 European countries" RWE has 797 MW in hydro-electric generation capacity (2012) which is included in the reporting for RWE in this section
E.ON *(2011 Report)*	E.ON Climate & Renewables	2007	4,190 MW	53% United States 12% Iberia (Spain / Portugal) 11% United Kingdom 9% Italy 6% Nordic (Sweden / Denmark) 5% Germany 2% France 2% Poland	85% Wind Onshore 11% Wind Offshore 4% Other renewables	E.ON C&R: "We focus on what we do best and where we can add the most value: Making and marketing energy in competitive, converging international markets" E.ON C&R: "Responsible for E.ON's global activities in industrial-scale renewable power generation" E.ON C&R: "Operating a geographically balanced portfolio with 4,190 MW capacity across Europe (47%) and North America (53%)" E.ON C&R: "We are implementing a new strategy to transform our company into a global provider of specialized energy solutions" E.ON C&R: "Wind onshore focus regions: United States, United Kingdom, Poland, Nordic countries, Spain, Italy" E.ON C&R: "Has 804 employees of 36 nationalities in 11 countries, and is the global #3 in offshore wind and global #8 in onshore wind" E.ON has 5,548 MW in hydro-electric generation capacity (2010) which is not included in the reporting for E.ON in this section
EDF *(2011 Report)*	EDF Energies Nouvelles	2004	3,486 MW	51% Europe (Ex. France) (United Kingdom, Spain, Portugal, Italy, Germany, Greece, Bulgaria, Belgium, Turkey) 34% North America (United States, Canada, Mexico) 15% France	86% Wind 9% Solar PV 5% Other renewables	EDF EN: "The EDF Energies Nouvelles group operates in 13 countries in Europe and in North America, and has around 3,000 employees" EDF EN: "From the very outset, EDF Energies Nouvelles focused on expanding outside France as market conditions were not very favourable in its domestic market at the time" EDF EN: "From a base in several European countries and the United States, the Group gradually broadened its sights to the whole of Europe and North America" EDF EN: "Onshore wind, the core segment, is driving and will drive future growth thanks to the Group's diversified portfolio of high-quality projects in ten countries" EDF EN: "In the space of ten years, EDF Energies Nouvelles has become a major player in the global wind energy industry" EDF EN: "Growth is based on diversified geographical presence and a multi-field expertise" EDF has 21,500 MW in hydro-electric generation capacity (2010) which is not included in the reporting for EDF in this section

Appendix B / Table 3.5: Renewable energy activities for the utilities in 2010

Company	Main subsidiary / business unit	Established	Installed capacity (MW)	Capacity by geographical region (MW)	Capacity by technology (MW)	Additional statements and information
GDF Suez *(2010 Report)*	n/s	n/s	3,198 MW	n/s	69% Wind 30% Biomass 1% Other renewables	GDF Suez: “GDF Suez has a production capacity of 963 MW in the biomass and biogas in Europe, where it is the leader, in the United States and South America” “There is a particular focus on wind turbines with a capacity of 2,205 MW, making the Group the leading operator on the Belgian and French markets and number two in Portugal (…) several projects are also being run in Europe, Canada, Latin America and Morocco” “GDF Suez is also present in the solar energy sector, including the production of photovoltaic cells and modules in France and Belgium and investments of several dozen MW in France and Portugal” GDF Suez has 10,744 MW in hydro-electric generation capacity (2010) which is not included in the reporting for GDF Suez in this section
Iberdrola *(2011 Report)*	Iberdrola Renovables	2001	13,690 MW	43% Spain 39% United States 8% United Kingdom 10% Other Countries (Brazil, Mexico, Germany, Hungary, France, Portugal, Italy, Poland, Romania, Greece)	97% Wind 3% Other renewables	Iberdrola Renovables: “Installed capacity rose 9.2% to 13,690 megawatts (MW) across the Group (…) approximately 57% of total installed capacity is now located outside of Spain” “With a presence in 23 countries, it has the largest project portfolio in the industry (62,613 MW) which increased by 4,197 MW in 2010” “assets in operation in the most important markets of the world (Spain, United States, United Kingdom, Republic of Ireland, Greece, France, Poland, Portugal, Mexico, Germany, Brazil, Italy and Hungary)” “84% of new capacity in 2010 was installed outside of Spain (with 56% in the United States), thus strengthening the process of geographic diversification. The international area represents 57% of installed capacity.” Iberdrola has 9,898 MW in hydro-electric generation capacity (2010) which is not included in the reporting for Iberdrola in this section
Enel *(2010 Report)*	Enel Green Power	2008	6,102 MW	45% Italy 25 % Iberia (Spain / Portugal) 13% North America (United States / Canada) 11% Latin America (Mexico, Costa Rica, Guatemala, Nicaragua, Panama, El Salvador, Chile and Brazil) 6% Europe excluding Italy, Spain, Portugal (Greece, France, Bulgaria, Romania)	44% Wind 42% Hydroelectric 12% Geothermal 2% Other renewables	Enel GP: “With more than 600 plants operating in Europe and the Americas in a total of 16 countries to date, the Group’s net output in 2010 amounted to 21.8 TWh” “In Europe, Enel Green Power is present in Italy, Spain, Portugal, Greece, France, Romania and Bulgaria” “In North America, Enel Green Power is present in 20 US states and 2 Canadian provinces through Enel Green Power North America” “In Latin America, Enel Green Power Latin America operates 33 plants in Mexico, Costa Rica, Guatemala, Nicaragua, Panama, El Salvador, Chile and Brazil” “Has 2,955 employees of which 62% work in ‘Italy and Europe’ and 24% in ‘Latin America and Iberia’” Enel has 31,034 MW in hydro-electric generation capacity (2010), of which 2,539 MW is included and 28,495 MW is not included in the reporting for Enel in this section. Excluding hydro from Enel Green Power, Italy accounts for 36%, Iberia and Latin America for 42%, Europe (non-Italy, non-Iberia) for 9% and North America for 13%.

Appendix B / Table 3.5: Renewable energy activities for the utilities in 2010

Company	Main subsidiary / business unit	Established	Installed capacity (MW)	Capacity by geographical region (MW)	Capacity by technology (MW)	Additional statements and information
Vattenfall *(2010 Report)*	n/s	n/s	1,896 MW	27% Denmark 23% Sweden 23% United Kingdom 17% Netherlands 7% Germany 3% Other Countries	76% Wind 24% Biomass	Vattenfall: "Vattenfall will continue to expand in offshore wind power in the North Sea countries – the UK, Germany and the Netherlands – and onshore in prioritised markets" "Vattenfall is one of the world's leading wind power developers and operators and is currently building nine wind farms in six countries" "900 turbines operating in Sweden, Denmark, Germany, Poland, the Netherlands, Belgium and the UK" Vattenfall has 11,516 MW in hydro-electric generation capacity (2010) which is not included in the reporting for Vattenfall in this section

Source: Annual Accounts

Notes: n/s = not specified

CHAPTER 4

THE DEVELOPMENT AND COMMERCIALIZATION OF SOLAR PV TECHNOLOGY IN THE OIL INDUSTRY[5]

4.1 Introduction

The path towards achieving sustainability in energy supply on a global scale is one of the key challenges for the twenty-first century. Since the industrial revolution, industrialized societies worldwide have had a consistent dependence on fossil energy sources to achieve economic growth. This dependence on fossil energy sources is still reflected in the global energy market at present. However, concerns about global climate change and energy security, particularly due to a high dependence on oil, have put pressure on governments to diversify their energy supply. In diversifying energy supply, the transformation of the energy industry has been identified as a key challenge for a sustainable energy future (Holdren, 2006; Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000; Unruh, 2000). This suggests that incumbent firms in this industry have a vital role in the development and commercialization process of renewable energy technologies.

When looking at the key high-potential renewable technologies for widespread diffusion, wind energy is the most developed renewable technology. With an average annual growth rate in installed wind power capacity between 1980 and 1998 of 55% (Jacobsson and Johnson, 2000), and an average annual growth rate of 25% from 2002 to 2006 (REN21, 2008), wind energy has reached a cost-competitive level with fossil fuel-based energy technologies, and is the most widespread renewable energy technology (Gross et al., 2003). Contrary to the mature development stage of wind power, solar photovoltaic (PV) technology is an emerging technology, which grew relatively slow in the 1990s, i.e. 22% annually (Jacobsson and Johnson, 2000). However, from 2000 onwards, investments in solar PV capacity have increased considerably, even leading up to an annual growth rate of 70% in grid-connected solar PV instalments in 2008 (REN21, 2009), and has thus become the fastest growing energy technology worldwide.

With this global momentum in the growth of solar PV technology, a major avenue emerges to analyse the strategic approach of incumbent firms in the energy industry towards the development and commercialization of solar PV technology, as their powerful position in the industry might give

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[5] This chapter was published in *Energy Policy*, 2012, *40*, 11-20, with Johan Pinkse as co-author (for more details, see co-author statements included elsewhere in this dissertation).

them a pivotal position in the diffusion process of solar PV. The main aim of this paper is therefore to provide a comparative analysis of oil incumbents' strategies regarding the development and commercialization of solar PV technology. To investigate this, we have conducted a multiple case study within the European oil industry to compare and contrast the three largest oil firms – British Petroleum (BP), Shell, and Total – with regard to their perception of renewable energy technologies in the context of future energy supply as well as their investment behaviour in solar PV technology from the mid-1990s onwards. Before exploring these aspects empirically, however, we will first briefly provide a background on the diffusion process of renewable energy technologies.

4.2 Towards the diffusion of renewable energy technologies

Renewable energy has the potential to replace conventional fuels in four distinct sectors: power generation (grid-connected), transport fuels, water and space heating, and rural (off-grid) energy (REN21, 2008). As each of these energy sectors has its own characteristics, a renewable energy future is unlikely to depend on a single prevailing 'silver bullet' technology ending fossil fuel dependence. Instead, a wide spectrum of various renewable technologies will be more suitable for meeting the diverging demands of each of these four sectors. As Gross et al. (2003) identify, one of the most notable features of renewable forms of energy is the diversity of technologies, thereby indicating that renewable energy diffusion will lead to diversification in energy sources making energy markets less dependent on fossil fuels as a single source of energy.

Experimentation with various renewable energy sources on a non-commercial basis commenced around 1973, when governments started investing considerable amounts of money on renewable energy research and development (R&D) as a reaction to the first major oil crisis in that same year (Jacobsson and Johnson, 2000). Since the early 1990s, commercial development of various forms of renewable sources has occurred, resulting in a range of modern renewable technologies of which solar PV, wind power, concentrating solar power (thermal and PV), marine power (wave and tidal), and modern biomass offer the best opportunities for widespread diffusion. Conventional renewable sources, predominantly traditional biomass and large hydroelectric installations, supplied around 17% of the world's energy demand around the start of the century, but do not offer significant sustainable growth opportunities towards the future (Gross et al., 2003). Although modern renewable technologies currently account for only 1% of the world's energy demand, projections of their contribution in meeting the world's energy demand around 2050 range from 20% to 50% (World Energy Assessment, 2000).

Embedded in the larger development of moving from fossil fuels to renewable technologies, solar PV has emerged as the fastest-growing technology in recent years with huge diffusion potential towards the future. The first commercial efforts to develop solar PV technology were initiated by the oil crises of the early 1970s, with governments investing in R&D to develop a solar alternative to fossil fuels (Tsur et al., 2000). However, these policies for stimulating solar investments lacked a long-term perspective and were strongly correlated with fossil-fuel price fluctuations. With fossil-fuel prices decreasing in the mid-1970s, investments in solar R&D decreased tremendously, with technological development only continuing for several smaller niche markets. From the mid-1980s to mid-1990s solar PV capacity started to grow with a modest growth rate of 15% (Gross et al, 2003), with an increasing importance for grid-connected systems after 1995 (World Energy Assessment, 2000). Influenced by an increasing awareness of issues such as energy independence and negative environmental consequences (e.g. climate change) of fossil fuel combustion in the early 1990s, R&D investments became more centred on developing a long-term-oriented alternative to fossil fuels compared to the 1970s. Investments in solar PV increased extensively after 2000 due to increased cell efficiency, reduced capital costs, and favourable policy, leading to annual growth in grid-connected solar capacity of 60% from 2002 onwards (REN21, 2008).

The most vital component of solar PV technology is the solar cell, as the solar cell establishes the photovoltaic effect and therefore determines the conversion efficiency. Growth potential of solar PV essentially depends on two aspects: the achieved conversion ratio in the solar cell and the capital costs (installation and materials) associated with solar cell production. Solar cell types currently being commercialized are single-crystal cells (17% efficiency in 2007), polycrystalline (15% efficiency in 2007) and amorphous silicon (10% efficiency in 2007), which all are considered to be the first generation PV technologies. These technologies require major energy and labour inputs, which prevent significant production costs reductions, but are currently the most-installed type of solar cells (REN21, 2008). Second generation solar cells offer much greater potential for cost reductions and efficiency enhancement. These are thin-film cells that currently offer only 9-12% efficiency, but are in an early development stage with extraordinarily high potential for conversion ratios up to 60%, compared to 30% for first generation cells. In 2007, only 7% of solar cell production was thin-film cells, but they gained acceptance as a mainstream solar cell due to manufacturing maturity and decreased production costs. Despite this acceptance, conversion ratios are far from their potential, making it more viable to further invest in R&D before large-scale commercialization will take place (REN21, 2008). Goetzberger et al. (2002) define three scenarios for cell efficiency enhancement and cost reductions: (1) the continued dominance of present single-crystal and polycrystalline cells, (2) the introduction of new crystalline thin-film materials of medium thickness, and (3) the breakthrough of true thin-film materials that could potentially dramatically increase cell efficiency. All scenarios are equally plausible on the long term, although the first and second generation solar cells are more short-term oriented and currently visible in the market, while third generation is more likely to occur in a longer timeframe (Gross et al., 2003).

From an industry life cycle perspective, two main phases in industry evolution can be identified: a formative period and a market expansion period (Jacobsson and Bergek, 2004; Klepper, 1997; Utterback and Abernathy, 1975). The formative period is characterized by uncertainty in technologies, markets, and regulations, whereby a range of competing technology designs exist. Within this formative period, Jacobsson and Bergek (2004) identify four process features: market formation, entry of firms and organizations, institutional change, and the formation of technology-specific advocacy networks. All four features are beginning to emerge in the solar PV industry, whereby the first two are especially interesting in the light of this paper. Market formation is characterized by growth in multiple niche markets for which the technology is superior, usually also involving favourable government policy and investment incentives. It appears that the solar PV industry entered its market formation stage around 2004, when favourable policy towards solar PV became more widespread and solar PV was developed for multiple grid-connected and off-grid niche applications. This phenomenon is referred to as ‘protected spaces’ or niches, where technological learning process can take place, and where price of performance of the technology can be improved (Jacobsson and Bergek, 2004; Kemp et al., 1998).

Three factors are particularly important in this industry’s formative period. First, solar cell efficiency and capital cost reduction for large-scale diffusion need to be achieved (Goetzberger et al., 2002; Gross et al., 2003; REN21, 2008). Second, policy should be developed to allow development in solar PV niche markets to support the learning effect from ‘learning by doing’, which positively influences large-scale diffusion of solar PV technology (Gross et al., 2003). Tsur et al. (2000) suggest that this diffusion process should be evolutionary rather than revolutionary in nature, also emphasizing that government-funded stimulating R&D programmes should be adopted that are substantial and persistent in nature. Third, firm entry is essential in shaping the development path of an emerging technology, predominantly due to the resources and competences they bring into the industry (Jacobsson and Bergek, 2004). With solar PV growing tremendously, and huge opportunities for firms from various backgrounds to enter this growing market, assessing the impact of businesses on solar PV development is therefore essential.

4.3 Solar PV diffusion in the oil industry: a research model

To investigate the behaviour of incumbent firms in the oil industry regarding solar PV development and commercialization, we applied a multiple case study methodology. This methodology facilitates gaining rich understanding of the context in which the phenomenon is embedded (Yin, 1994). In this paper, the unique phenomenon is the emergence of a renewable energy technology in the oil industry, which is fundamentally different from the fossil fuel-based technologies that are currently widely diffused in the supply chains of large oil incumbents. As our sample we chose three major players in the European oil industry, which have made ‘substantial’ investments in solar PV in the recent past: BP, Shell, and Total. We collected data about corporate behaviour on solar PV development and commercialization from both corporate and independent third-party sources, thereby assessing whether the articulated corporate position of these firms on the importance of solar PV technology was in line with perceptions from outside. Data collection included corporate publications (i.e. firm annual reports and CSR/sustainability reports), publications of trade associations (i.e. the European PV Industry Association, the Energy, Solar Energy Industries Association, and the Solar Electric Power Association), and newspaper and magazine articles (i.e. New York Times, Wall Street Journal, Washington Post, Guardian, Economist, and Time magazine).

To guide the analysis of the data, we first developed a research model (see figure 1). Our starting point was the assumption that the emergence of solar PV technology in the established oil industry presents incumbent firms with a fairly disruptive technological innovation. Literature on the emergence of disruptive innovations shows that small entrepreneurial ventures provide the more heterodox, breakthrough innovations, while incumbent firms generally engage in incremental, sustaining innovations to optimize technology performance (Baumol, 2002; Bower and Christensen, 1995). At the same time, however, the bulk of expenditures in R&D and related innovative activities, are not carried out by small entrepreneurial ventures but by large oligopolistic firms (Ahuja and Lampert, 2001; Baumol, 2002). With the model we therefore envisaged gaining understanding of how incumbent firms can stimulate the development and commercialization of disruptive technological innovations, including the use of acquisitions and joint ventures as ways to gain control over disruptive innovations, rather than gaining insight into how small entrepreneurial ventures introduce new innovations and organically grow into larger corporations.

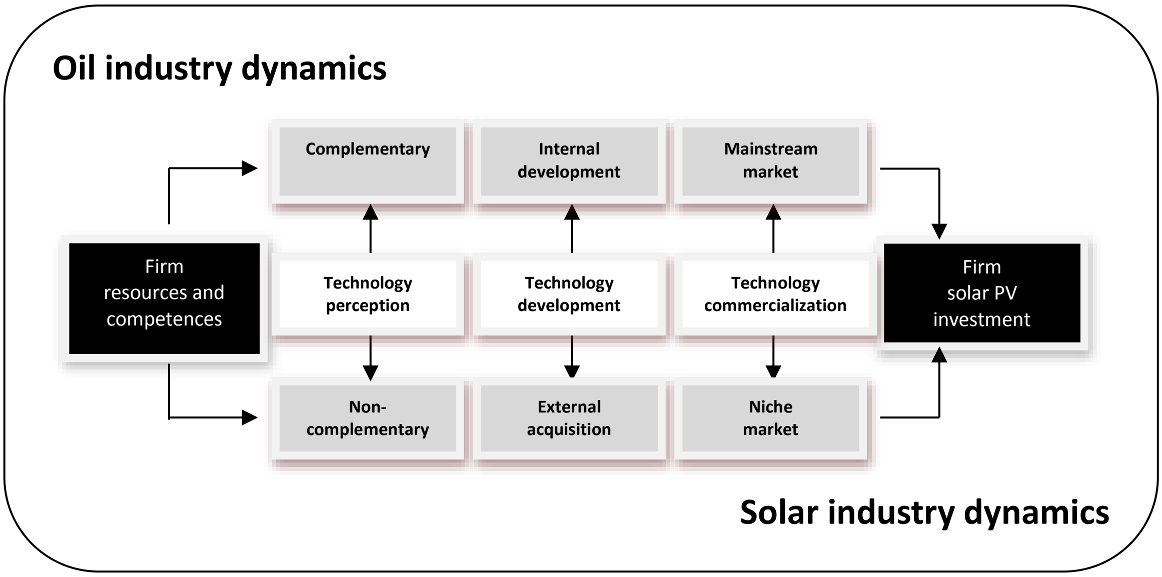

Figure 4.1: Solar PV technology diffusion: a research model

The model is built around the innovation process of firms, which comprises the invention and development of a technology as well as the commercialization in the market. This process requires various resources and competences such as technology accumulation, strategic networking through alliance formation, and being responsive to market needs (Rothwell, 1994). The central notion in the innovation process is that firms make strategic decisions and position themselves on renewables taking account of *firm-specific factors* to leverage internal resources and competences as well as *contextual factors* to anticipate external industry dynamics (Kolk and Levy, 2004). We considered firm-specific factors related to development and commercialization decisions along the following steps in the innovation process: (1) what is the strategic nature of solar PV technology in relation to firms' core business goals; (2) what is the incumbent's strategy towards the development of the emerging technology; and (3) what is the incumbent's approach for commercializing the emerging technology? In answering these questions, we also reckoned with *contextual factors* related to industry dynamics, where we made a distinction between oil industry dynamics and solar industry dynamics. The motivation behind this is that oil firms investing in solar technology operate at the intersection of both industries. Therefore, contextual factors not only concern those affecting market formation in the solar industry, but also factors shaping the oil industry's market structure. While some factors such as oil price changes or the global financial crisis have an effect on dynamics in both industries, other factors such as renewable energy policy or firm entry/exit are more industry-specific.

Technology perception: complementary vs. non-complementary

Firstly, the model posits that the strategy of oil firms in solar PV diffusion depends on oil incumbents' perception of solar PV technology in terms of degree of *complementarity* to core business activities (Davis, 2006; Milgrom and Roberts, 1990). The concept of complementarity refers to the relation between different business activities such as R&D, manufacturing and marketing which firms pursue, implying that a fit between activities leads to higher economic returns (Milgrom and Roberts, 1990; Jacobides et al., 2006). Whether the development, manufacturing and marketing of solar PV have many complementarities with core business activities of oil firms is contestable. Throughout the vertically integrated supply chain of oil firms, the resources and competences needed to operate both upstream and downstream activities are related to fossil-fuel supply (Davis, 2006). Therefore, on the face of it, a disruptive technology such as solar PV cannot build on existing attributes related to upstream extraction activities and downstream refining, which are (still) crucial for the oil industry, but introduce a new set of attributes that potentially depreciate the value of the attributes historically valued by mainstream customers (Bower and Christensen, 1995). The main problem is that solar PV requires much corporate R&D to achieve cost-effectiveness of the technology. However, R&D investments in the oil industry have predominantly been aimed at refining and petrochemicals; R&D budgets have decreased considerably; and these investments have exhibited relatively low rates of return (Davis, 2006). Solar PV technology would thus mean that activities throughout the whole supply chain have to change fundamentally, which would require different resources and competences than currently owned by oil firms (Kolk and Pinkse, 2008).

Nonetheless, it is not uncommon either for firms to invest in technologies, which are not complementary to core business activities. Besides investing in sustaining technologies, incumbents also invest in disruptive technologies for reasons of diversification and exploration of potential future growth markets (Bower and Christensen, 1995). Whether the oil industry considers renewable energy as a future growth market has differed considerably across firms (Levy and Kolk, 2002), and even within firms the outlook changed over time, depending on how various scenarios on the stake of renewables in global energy supply evolved (Backer and Clark, 2008). To what extent oil firms are willing to diversify into solar also depends on the general corporate strategy, which in the case of oil firms has changed considerably over the past decades (Grant, 2005; Grant and Cibin, 1996). After the oil crises of the 1970s, which led to a decline in demand for oil and an emergence of state-owned enterprises, the oil industry has become very turbulent and competitive. In response, oil firms pursued diversification in related and unrelated activities on a massive scale, including solar PV. In the period from the mid-1980s to mid-1990s, however, this trend reversed from diversification to massive restructuring and a focus on core business (Grant, 2005). Due to declining oil prices and increased emphasis on short-term profitability, most non-core activities were divested during this period, but remarkably solar technology was maintained in most large oil firms (Davis, 2006; Grant and Cibin, 1996). In other words, while non-complementarity seemed no real obstacle during the 1980s, in the 1990s this became more of an issue. Yet, it must be noted that the perception of what core business constitutes also changed during the 1990s, as some companies broadened their mission from 'oil' to 'energy' firms (Kolk and Levy, 2001). Still, when a technology is perceived strategically significant but non-complementary, firms will most likely locate the initial market for introducing the disruptive technology outside existing mainstream markets that incumbents serve and set up an independent organization, isolated from core activities (Bower and Christensen, 1995).

Technology development: internal development vs. external acquisition

Secondly, the strategy of oil firms for solar PV diffusion depends on the way the technology development is organized, that is, whether they opt for *internal development* or *external acquisition*. As mentioned above, in the technological development of solar PV, solar cell development is the key element where innovation takes place and two elements are crucial for the potential for large-scale diffusion: solar cell efficiency and capital cost reduction (Goetzberger et al., 2002; Gross et al., 2003). But, how do oil firms achieve such scale effects when solar PV lies outside oil firms' major innovation activities? The fact that solar PV seemingly lacks complementarity with core oil activities means that oil firms face the challenge of developing new resources and competences, as they cannot rely on earlier investments in this area. Not surprisingly, in the past, the oil industry has expressed different views on technology development paths for solar PV (Levy and Kolk, 2002). It has been posited, for example, that competences in solar PV take time to develop and early investments are necessary to develop scale, learning and complementarities, which corresponds to preference for internal development, enabling these effects to materialize. Alternatively, it has been argued that, since they lack the required competences for solar PV, oil firms should only invest in this technology when the external environment for renewables has become less risky. This view has mainly been fuelled by past experiences in the industry of failed diversification – also in renewable energy – thus leading to preference for external acquisition when the 'time is right' (Davis, 2006; Levy and Kolk, 2002).

There are also potential other reasons for deciding on internal growth versus external acquisition, which are related to the high vertical integration that has traditionally characterized the organization of oil firms (Grant and Cibin, 1996). In the past, oil firms have owed most of their success to controlling the whole value chain. And, even though there was a trend towards vertical disintegration in the 1980s and 1990s, recent expansion in natural gas has again been carried out by covering the complete chain from exploration to marketing (Grant, 2005). However, the vertically integrated firm tends to be equated with a view of incumbent-led technological development devoted to routinized innovation processes for increasing product and process reliability, based on a conservative approach with bureaucratic control (Baumol, 2002, 6). Moreover, this way of organizing has been portrayed as ‘closed innovation’, where incumbents generate, develop, and commercialize their own ideas and innovations, based on a philosophy of self-reliance in which innovation activities are based on control and substantial investments in internal R&D (Chesbrough, 2003). Recently, however, a fundamental shift has been observed in the process of how firms generate ideas, develop innovations, and commercialize these ideas and innovations to the market from closed to open innovation. In ‘open innovation’, an organization ‘commercializes both internally and externally developed innovations, by deploying both outside and in-house pathways to the market’ (Chesbrough 2003, 37).

For the development and commercialization of solar PV technologies, the philosophy of self-reliance underlying the closed innovation model will be complex; oil firms cannot rely on historical R&D investments in this area, and achieving intra-firm complementarities between solar PV and oil activities is intricate. In contrast, applying the concept of open innovation to solar PV technology development and commercialization seems sensible as incumbent firms can commercialize solar PV technology outside their own supply chain, and develop inter-firm complementarities instead (Davis, 2006). Even so, what will be crucial, then, in determining how oil firms develop solar PV technology, is a firm’s financial investment power. If, therefore, financial investment power through generated income is exceptionally strong, which is usually so when oil prices are high, they will most likely use this to externally acquire solar technology and knowledge, rather than develop it internally.

Technology commercialization: mainstream market vs. niche market

Thirdly, when it comes to commercialization of solar PV technology, the focus is on downstream activities in the supply chain, particularly the distribution, marketing and sales activities to deliver energy to customers. The main question is whether market penetration in mainstream markets is possible or firms can merely establish one or more market niches (Raven, 2007). For oil firms, all end-product categories (light, medium, and heavy distillates) are fully based on fossil fuel supply. Both end-users in the industrial market and consumer market rely on the supply of fossil fuels which are currently non-substitutable, as this would require a major technological shift in various fossil fuel-based industries, such as steel, chemicals, and construction as well as in consumer behaviour regarding transportation. In other words, the fossil fuel dependence of end-users also enforces the carbon lock-in of this industry (Unruh, 2000). Therefore, key downstream activities of oil firms do not really fit solar energy supply. Then again, solar PV does give oil firms the opportunity to enter new niche markets, which is enhanced by the fact that solar PV is a modular technology that can be fairly easily integrated into final consumer products (Davis, 2006).

Moreover, comparing the emerging solar market with the mature oil market provides a false picture of the commercialization potential of solar PV. To assess the potential for large-scale commercialization, it is more useful to consider the solar PV market in isolation and compare different niches within this market. For example, there are important differences between grid-connected and off-grid solar systems in their potential for mass production. Grid-connected systems are more suitable for mass production compared to off-grid applications, because the latter often require on-site customization and alternative business models to reach the customer (Shum and Watanabe, 2007). Nevertheless, grid-connected solar systems have the disadvantage that they have to compete directly with other electricity generation technologies, whereas off-grid applications are more often implemented in developing countries with inadequate of lacking electricity infrastructures (Davis, 2006). Another case in point regarding large-scale commercialization of solar PV is the role of government-initiated investment stimulation for solar PV technology. Feed-in tariffs implemented during the 2000s, which have particularly been successful in Germany and Spain, have stimulated the creation of markets for solar PV (Jäger-Waldau, 2009). Still, whether oil firms could benefit from these energy policy measures depends much on the precise their provisions (Reiche and Bechberger, 2004).

4.4 Solar PV in the oil industry

BP

In comparison to other oil firms, BP has the longest history in the development and commercialization of solar energy, with BP's first solar activities dating back to 1980, and BP's establishment as the world's largest vertically integrated solar PV firm in 1999. Within BP, PV technology was built as a separate product class from 1980 onwards, which eventually led to the establishment of a separate BP Alternative Energy division in 2005. The growth process of BP Solar towards its current position as one of the larger solar companies worldwide has thus been achieved by setting up a separate solar division outside existing fossil fuel-based activities to cope with a technology that is potentially disruptive. Nevertheless, the fact that BP entered the solar industry at such an early point in time, and has consistently built its position in the market, indicates that BP perceived the technology as strategically important.

The first milestone in BP's solar activities was in 1980, when BP entered the solar market through the acquisition of solar company Lucas Energy Systems. This step was part of a broader diversification strategy (BP for example also entered the coal business, minerals and information technology), then common in the oil industry, as it was a response to the 1970s oil crises and slowing growth (Grant and Cibin, 1996). A second milestone was the speech of BP chief executive John Browne at Stanford University in May 1997, where he pledged to increase investments in solar from US$100 million to US$1 billion a year. Interestingly, this commitment to solar was no longer considered as diversification, but part of a strategy to be responsive to the issue of climate change (Levy and Kolk, 2002; Sæverud and Skjærseth, 2007). This pledge was followed up in 1999, when BP Solar established itself as the largest vertically integrated solar company in the world, through the acquisition of all of shares in Solarex (a company made up of former solar activities of Exxon, Enron and Amoco), creating BP Solar as it exists at present. Although BP perceived solar technology as disruptive, at this time it was not necessarily considered as non-complementary. In 2000, BP repositioned its mission from an exclusive focus on oil towards a broader focus on energy, which was accompanied by a rebranding campaign with the Helios logo and the 'Beyond Petroleum' slogan as main outcomes (Kolk and Levy, 2001).

What is remarkable about BP Solar is the different perception of crystalline solar technology in comparison to thin-film technology. Until 2002, BP had a strong position in crystalline technology in both manufacturing and sales, but simultaneously engaged in innovation of thin-film technology. In 2002, BP decided to abandon further developing thin-film technology and focus solely on crystalline-based technology, based on the rationale that thin-film in its 2002 development stage was economically uninteresting. BP Solar's consistent commitment to crystalline-based technology was enforced in 2006 when BP invested US$5 million to a five-year research project on The California Institute of Technology, to develop a more efficient way of producing crystalline solar cells making solar manufacturing costs more competitive. BP Solar's decision to consistently build a position in crystalline solar cells and not engage in thin-film technology is noteworthy, because crystalline-based technology has limited possibilities for radical performance enhancement (Goetzberger et al., 2002; Gross et al., 2003).

A consistent and crucial factor for BP's development of solar technology has been its engagement in acquisitions and joint ventures. BP achieved growth in its solar business in the 1980s and 1990s by building a global network of manufacturing facilities, mainly through acquisitions of existing solar manufacturing plants, and sales offices in multiple countries, most notably the above-mentioned acquisitions of Lucas Energy Systems and Solarex. Besides acquisitions, BP also engaged in joint ventures to gain access to specific geographical markets. In 1989, BP entered a joint venture with Tata Energy to establish its position in the Indian market, while in 2005 BP Solar partnered with China-based solar company SunOasis to build its position in the Chinese market. A key observation regarding technology development is BP's consistent focus on achieving scale advantages to reach cost-competitiveness with widely diffused energy technologies, both in manufacturing activities and solar power plants. For manufacturing, this already started in 1997, when BP announced investing US$20 million to establish one centralized manufacturing plant for the US market, and was continued until 2008, when BP decided to focus manufacturing activities on the four largest plants in the US, Spain, China and India. Regarding solar power plants the focus on scale is illustrated by BP's projects in Portugal and Spain in 2005 where it profited from feed-in tariffs: in Portugal BP Solar constructed a large 62 MW power plant of 350.000 solar panels delivering electricity to 22.000 homes, while in Spain BP built 278 small power plants across Spain with a joined capacity of 18 to 25 MW, thereby providing electricity to 12.500 homes.

When assessing commercialization, the acquisitions and joint ventures also point at BP's external focus in the context of marketing solar products. In building its position in the solar market, BP followed a strategy of entering multiple niche markets while simultaneously improving crystalline technology. In the context of BP Solar's leading position in the global solar industry and the vertically integrated nature of the company's solar activities since the 1999 takeover of Solarex, BP Solar has become a mainstream player in the solar industry. To illustrate, in 2001 BP had become the second largest solar PV firm with annual sales of 58 mega-watts (MW). Nevertheless, even though BP Solar's sales climbed steadily over the years its leading position declined from being number 2 in 2002 (73.8 MW) to number 7 in 2005 (90 MW) and number 16 in 2008 (156 MW), as it was surpassed by specialized solar firms including Q-Cells, Suntech and First Solar (Jäger-Waldau, 2002, 2003, 2006, 2009).

The focus on controlling costs seems crucial when looking at the most recent developments in BP Solar. The financial crisis and economic recession negatively affected the position of BP Solar, which translated into major cost reductions through cutting 28% of BP Solar's workforce, predominantly in the US and Spain. Not surprisingly, BP recently decided to subcontract solar panel manufacturing to China and India, dismantling the vertically integrated solar firm, and only retain those activities where value can be created. In addition, with BP Alternative Energy making a loss of US$800 million in 2008, while BP as a whole was profitable, the announced budget cuts in BP Alternative Energy of at least US$400 million for 2009, and BP's recent investment in upstream activities that include winning oil from Canadian tar sands (BP 2008, 5), it is of vital importance to reach cost-competitiveness for solar PV technologies within a limited timeframe. Within BP a lack of profitability of renewable energy technologies could thus be a strong driver for divestiture decisions.

Shell

In its approach towards solar technology, not only has Shell long been a follower of BP, but also more modest, applying a lower public profile (Levy and Kolk, 2002). Shell also started investing in solar in the

1980s as part of a diversification strategy (Eikeland et al., 2004; Grant and Cibin, 1996), but on a much smaller scale. The first real milestone for Shell was in October 1997, when it committed to investing US$250 million in its solar manufacturing over the next five years. This was considered a way of repositioning the firm on climate change as well as a response to BP's recent shift on the issue (Levy and Kolk, 2002). What is particularly noteworthy about this commitment is that investments in renewable energy were heralded as Shell's 'fifth core business' (Boulton, 1997). However, over the past years Shell's stance towards solar PV has become more reserved and the firm has recently reiterated that the primary focus is upon sustaining reliable and responsible fossil energy supply (Shell, 2008). According to former Shell CEO Van der Veer, Shell expected around 80% of all the firm's capital investments to be in upstream projects (Shell, 2008). With respect to the importance of renewable energy technologies for Shell, CEO Van der Veer stated in the 2008 sustainability report (2008, 1): "While our primary focus continues to be delivering oil and natural gas responsibly, we also made progress developing renewable energy."

Compared to BP, Shell's investment and divestiture decisions in solar PV have been poised in uncertainty and exhibited a rather erratic pattern with sudden changes in perceived prospects of solar as a future growth market (Backer and Clark, 2008). However, already when Shell started showing a renewed interest in the solar business in 1997, the firm was relatively cautious in its statements about the future outlook of solar, emphasizing that it would position it as a supplement to its oil business, not as a substitute. In other words, Shell has always perceived solar technology as potentially disruptive and non-complementary to mainstream oil activities, as reflected by the fact that Shell's renewables division was neither embedded in the fossil fuel-based supply chain nor focused on serving Shell's mainstream customers in Shell's oil business. From its conception, Shell Solar was integrated in the Shell Renewables division, which in turn was as a separate division outside existing divisions of upstream (exploration and production and gas and power) and downstream (oil products, oil sands, and chemicals) divisions.

Reticence towards investing in solar PV has culminated in a series of divestitures, which started with selling all crystalline activities in 2006 to Solar World, as Shell perceived this technology as economically uninteresting for large-scale diffusion. This continued until the final decision in 2009 to divest all renewable technologies including solar, wind and hydrogen. A statement of Shell on the rationale for divesting most renewable energy technologies while investing in biofuels is a case in point: 'Shell will be stepping up efforts in sustainable sourced transport biofuels as the area of focus for renewable energy activities, as biofuels are closest to our fuel business, which means Shell can add real value' (Shell 2008, 10). The fact that biofuels can be integrated into the supply chain is a key determinant for Shell to further invest in this form of renewable energy. Despite pulling out of renewable technologies, Shell not only announced to increase investments in its bio-fuels activities, but also to concentrate on developing cleaner ways of using fossil fuels through carbon capture and storage (CCS). In other words, as a way of coping with climate change, CCS is more attractive than other renewables including solar because it allows continuation of fossil fuel supply with lower emissions (Pinkse and Kolk, 2010), but was not yet available when climate change became salient to the oil industry in the 1990s.

Moving to Shell's strategy for developing solar PV technology, the joint venture structure that Shell Solar adopted for technology development between 2001 and 2006 shows that Shell focused on the external acquisition of complementary resources and competences for solar PV development; reasonable since Shell's innovation capacity is in fossil fuel technologies, with 80% of all technology innovation expenditures going to fossil fuel-based upstream technology development (Shell, 2008). First, in 2001, Shell Solar (33%) entered a joint venture with Siemens (34%) and E.ON (33%) for technological innovation in crystalline-based cell technologies. In 2002, through the acquisition of 100% of the shares in the Shell-Siemens-E.ON joint venture, Shell established access to both mono-crystalline and multi-crystalline cell technologies, then mainstream solar technologies, and thin-film technology, which was in an early development stage in 2002. After this acquisition, Shell had transformed Shell Solar into a vertically integrated solar company, which included R&D, manufacturing and marketing of solar PV (Jäger-Waldau, 2004). Second, in 2006, after selling all its crystalline-based activities to Solar World, Shell again entered a joint venture with Saint-Gobain, to develop the next generation thin-film based solar cell in AVENCIS. Although both joint ventures were with incumbent firms and cross-industry in nature, an interesting difference between the Shell-Saint-Gobain joint venture in 2006 and Shell-E.ON-Siemens joint venture in 2002 is the difference in industry of Shell's joint venture partners. However, a more important observation in this context remains Shell's engagement in joint ventures with incumbent firms instead of small technology-based entrepreneurial ventures.

Looking at the commercialization of solar PV, in the initial growth phase between 1997 and 2001, Shell Solar served two distinct markets: grid-connected solar systems and rural electrification. In the context of energy supply, both markets were niche markets compared to other technologies for electricity generation, and both markets were outside Shell's existing oil business, yet becoming mainstream within the solar industry. Simultaneously, as of the Shell-Siemens-E.ON joint venture, focus has come on innovating in crystalline solar PV technology; the most widely diffused solar technology at that time. With Shell's acquisition of all shares in that joint venture in 2002, Shell gained access to a global network consisting of professional distributors and sales partners with sales offices worldwide for mono-crystalline, multi-crystalline cell and thin-film technologies; thus steadily building its position in multiple niche markets. The growth in multiple niche markets led Shell Solar to become the second largest solar company in the world in 2003 with 73 MW in sales (Jäger-Waldau, 2004). Initially Shell appeared to be on a path of commercializing solar PV beyond niche markets to larger and broader mass markets. With the 2006 Shell-Saint-Gobain joint venture for the development of thin-film based CIS technology, and the divestiture of crystalline-based activities in that same year, Shell appeared to be seriously building its position in solar PV technology even further through developing a new generation solar cell suited for large-scale diffusion. However, with the 2009 decision to abandon all solar activities, it has become clear that at present Shell has no intention to further develop solar PV technology into mainstream markets.

Total

In contrast to BP and Shell, Total has only become a 'supermajor' quite recently, after it merged with PetroFina in 1999 and Elf Aquitaine in 2000, which was part of the wave of mergers occurring in 1995-2002 period (Grant, 2005). Moreover, for a long time, Total was a state-owned enterprise and even after the French government reduced its stake; it has maintained close relations with Total (Buchan and Mallet, 2001; Van de Wateringen, 2005). Presumably, due to Total's distinct history of becoming one of the largest oil firms while being state-owned first, it has been a relative latecomer in the solar business. At any rate, at the end of the 1990s, when BP and Shell renewed their investments in solar, Total was not under the same kind of pressure from non-governmental organizations to deal with climate change, because it was still fairly small and to some measure sheltered by the French government (Buchan and Mallet, 2001). Nevertheless, although Total had made some small investments in solar in the 1980s, it entered the solar market in a significant way in 2001, but on a smaller scale than BP and Shell (Eikeland et al., 2004), and has stayed active ever since. Total has built its position in solar energy consistently through subsidiaries by engaging in joint ventures and acquisitions. Total has also perceived solar PV technology as disruptive and lacked the resources and competences to build its position in solar energy through internal development, and thus opted for 'open innovation' and the creation of inter-firm complementarities instead (Davis, 2006). However, contrary to Shell and BP, Total does not have a separate renewable/alternative energy division as an autonomous business unit in the company.

For the establishment of Total's subsidiaries in the solar PV industry, joint ventures and acquisitions have been Total's consistent investment strategy. In 2001, Total entered the solar industry with the €14m joint venture Photovoltech – Total (47.8%), GDF Suez (47.8%), IMEC (4.4%) – aimed at R&D and production on multi-crystalline silicon solar cells, which has shown consistent growth over the years towards revenues of €67m (48 MW) in 2008. Subsequently, in 2005 Total together with EDF invested in the acquisition of 50% of the shares each in Tenesol, thereby gaining shared control of the solar joint venture. Tenesol is a vertically integrated solar company founded in 1983 with main solar activities in design, manufacturing, installing and operating solar PV systems related to grid-connected applications, electrification of remote sites, and electrification in developing countries. In 2004, Tenesol had sales of €115m (25 MW), but has achieved major growth over the years towards projected revenues in 2009 of €300m (85 MW). Furthermore, Total invested in a 25% interest in Novacis in 2007, which conducts R&D in thin-film photovoltaic cells, and in 2008 made a €45m investment in Konarka, a world's leading company in organic photovoltaic technology. While Photovoltech and Tenesol focus on manufacturing and sales of crystalline technology, which is in a mature phase of technology development, Novacis and Konarka focus more on R&D of a thin-film-based and organic-photovoltaic-based new generation solar cell, indicating that Total focuses both on commercializing current solar cell technologies and developing future solar cell technologies.

The latter illustrates Total's strategy on the development of solar PV, and is consistent with the following quote of Total scientist Minster, who states that 'with respect to new energy technologies, Total believes these solutions are a long way from maturity. That means Total has to actively pursue a host of technological options, so that when the time comes Total is ready to industrialize the ones that do reach maturity' (Total 2007, 15). When looking at the type of firms in which Total has acquired shares to develop solar PV – Novacis and Konarka – these are both small-technology driven ventures with a scientific background. Konarka is illustrative in this context, as the company was established in 2001 by a team of scientists, and technical innovations of the venture have led to investments of over US$150 million in private capital and US$20 million in government research funding until 2009. This strategy of Total of acquiring small-scale business ventures for developing future solar PV technology is also reflected in Total's strategy for commercializing proven solar PV technology.

Total pursues a strategy in solar commercialization of aiming at several niche markets simultaneously through co-ownership in several small ventures by way of joint venture: Photovoltech, which started as a spin-off of IMEC, one of the world's leading research institutes with a strong knowledge-base in photovoltaic research, and Tenesol, which was founded as a solar energy start-up in 1983. For the near future, Total's stake in Photovoltech is most ambitious in trying to achieve scale effects from mass production, as expansion plans encompass a total production capacity of 500MW in 2012. Nevertheless, even when this production capacity will be used to its full effect, Photovoltech will not be a major player, as the leading solar firms had already surpassed 500MW boundary in 2008 (Jäger-Waldau, 2009). Interestingly, the joint venture partners Total has co-ownership with in managing these ventures are incumbent firms from electric utilities (GDF Suez in Photovoltech, EDF in

Tenesol). This cross-industry collaboration between an oil firm and electric utilities illustrates that incumbents from both industries not only perceive their investments in solar ventures as mutually beneficial, but are also uncertain about the prospects of the solar business and therefore prefer a form of risk sharing.

Year	**BP**		**Shell**		**Total**	
	Investment	**Divestiture**	**Investment**	**Divestiture**	**Investment**	**Divestiture**
1980	Purchase of Lucas Energy Systems					
1989	Joint venture with Tata forming Tata BP Solar					
1997	US$20m investment in US-based solar PV manufacturing plant		Establishment of Shell Renewables			
1999	US$45m investment in remaining 50% of Solarex and merging into BP Solarex (later renamed BP Solar)					
2001			Joint venture with Siemens and E.ON for crystalline technology.		Joint venture with GDF Suez and IMEC forming Photovoltech	
2002		Disinvesting thin-film solar cell development and manufacturing	Acquisition of 100% share in the Shell-Siemens-E.ON joint venture			
2003			Start of crystalline and thin-film solar panel production			
2004			Shell Solar and GEOSOL establish the world largest solar PV power station in Germany			
2005	Joint venture with the China-based SunOasis; Establishment of BP Alternative Energy		Rural electrification and solar divisions in Asia		Acquisition of 50% of shares in Tenesol gaining shared control with EDF	
2006	US$5m investment in 5-year research project of Caltech		Joint venture with Saint-Gobain forming AVENCIS	Selling crystalline operations to Solar World		
2007				Selling Asian rural electrification operations	Acquisition of 25% interest in Swiss-based Novacis	
2008				Freezing all investments in solar, wind and hydrogen	Acquisition of 20% share in Konarka	
2009		Selling Australian solar PV production plant to Silex Solar Systems	Announcement to increase investments in biofuels and carbon capture and storage	Announcement to divest all wind, solar and hydro technologies.	€70m investment of Photovoltech in silicon wafers fabrication plant	

Table 4.1: Oil firms’ investments and divestitures in solar PV

4.5 The uncertain outlook of the oil industry's commitment to solar PV: a discussion

As confirmed by previous research, the major oil firms tend to be fairly similar in the general strategy they follow (Levy and Kolk, 2002), due to the fact that oil industry dynamics are largely determined by geopolitical turbulence, including fluctuating oil prices, energy security issues, climate change, and nationalization of assets. As a consequence, a constant drive for finding new oil reserves has dominated oil firm strategies. Moreover, as the three case firms are currently all 'supermajors' – the outcome of an industry which went from large-scale diversification in the 1980s, to a focus on core business in the 1990s, and massive consolidation moving into the 2000s (Grant, 2005) – they share a structure of the vertically integrated firm with divisions in exploration, extraction, refinery, distribution and marketing, indicating that resources and competences are all embedded in supplying fossil fuels. However, although the solar PV investments of these firms over the past decades have exhibited important similarities, there are also clear differences, pointing at divergent views of the future outlook of solar and potential oil industry involvement (see table 4.1).

Regarding technology perception of solar, Shell, BP, and Total shared the view that solar technology is disruptive and lacks intra-firm complementarities to oil activities. Therefore, these firms built their renewable divisions outside core business activities (Bower and Christensen, 1995), either through separate business divisions detached from the fossil fuel supply chain (Shell Renewables and BP Alternative Energy) or by shared ownership in multiple subsidiaries (Total). Nonetheless, isolating solar activities from core business might also have planted the seed of eventual failure and/or divestiture in Shell and BP. As a separate business unit, it seems difficult for solar to survive in an oil firm when subdued to the same performance targets as highly profitable fossil fuel-oriented business units, operating in a mature market. This problem has become larger over time, because a solar business involves investing in a relatively R&D intensive emerging technology, while performance targets in the oil industry have increasingly emphasized short-term shareholder returns (Grant, 2003). Notably, diversification efforts in the 1980s also revealed problems of non-oil businesses keeping up with profitability targets and they were cross-subsidized to keep them afloat (Davis, 2006). Furthermore, what this implies is that Total's solar activities are not necessarily heading for disaster as well. Total does not have a separate renewable energy division, but invests through multiple subsidiaries co-owned with other firms. In other words, it might be argued that Total, by allowing for interfirm complementarities with electric utilities to evolve (Davis, 2006), has developed solar PV activities which better stand the competition with other business units.

For commercializing solar PV, two distinct markets outside the oil business have been most important: grid-connected solar systems and rural electrification. While both are niche markets in relation to oil markets, they have become mainstream markets within the solar business. To enter these markets and access specific solar knowledge, all three firms relied on financial investment power, using joint venture agreements and acquisitions. However, there are clear differences in the type of firms they acquired or collaborate with, which is related to the fact that there are competing ways to achieve a low-cost, high-efficiency solar cell (Goetzberger et al., 2002; Gross et al., 2003). BP has predominantly focused on acquiring established solar companies, because it made the choice to achieve scale economies based on solar cells using crystalline technology and abandoned its commitment to further develop thin-film technology. At first Shell was following a similar trajectory to achieve scale in crystalline technology, but sold all crystalline activities in 2006 and decided focussing on joint venture agreements with the incumbent Saint-Gobain to further develop thin-film technology. Finally, Total has preferred to keep betting on two horses – crystalline and thin-film – inter alia by setting up joint ventures with large electric utilities and acquiring shares in small technology-driven ventures with specialized knowledge in future generation of solar cells, thus applying open innovation logic (Chesbrough, 2003). However, regardless of whether they have chosen to develop the next generation solar cell with superior performance before investing in commercialization (thin-film technology), or commercialize what was most viable for mainstream markets but limited possibilities for future performance enhancement (crystalline technology), over the past five years oil firms have been outpaced by specialized solar cell producers such as Q-Cells, First Solar, Suntech and Sharp (REN21, 2009). While in 2002 BP and Shell could still be leaders in the solar market with revenues of around 73 MW, the solar industry has expanded at an unprecedented pace; in 2008, for example, sales of European leader Q-cells amounted to 570 MW, although this firm is now challenged by new entrants from China (Jäger-Waldau, 2009).

4.6 Conclusion and policy implications

This paper has provided a comparative analysis of oil firms' strategies regarding solar PV technology investments. Our findings show that oil incumbents have experienced difficulties in integrating solar technology in their supply chain and therefore established fairly independent business units, serving niche markets outside mainstream markets for oil. While, on the face of it, it was striking that Shell and BP decided on divestitures of solar at a moment when the technology was on a path towards grid parity, these decisions coincided with a high level of firm entry which led to higher competition in the solar industry. Based on the most recent developments in solar investments, it is nevertheless uncertain whether all oil firms will abandon solar completely, as it depends to what extent they are able to generate profits with these activities.

Furthermore, the findings suggest that the competitive dynamics of oil firms are to a large extent determined outside the market for renewables. However, the competitive strain and increased turbulence in the oil industry have led to erratic investment behaviour of oil firms, as various geopolitical factors and short-term performance targets govern the industry. As a consequence, renewable energy projects in which incumbents are engaged might be cancelled for reasons which have nothing to do with the market viability of renewable energy. Nevertheless, due to the economic importance of the industry, oil firms tend to have quite some leverage in advising high-level policy makers on market development for renewables (Backer and Clark, 2008; Jacobsson and Bergek, 2004). This raises the question to what extent it is desirable that policy makers pay lip service to and create incentives for these firms in designing renewable energy policy instruments. An issue for further investigation would thus be a larger study on the influence of oil firms on the emergence and maturing of the renewables industry over time.

In addition, it would also be of interest to study other incumbents with regard to their role in the solar PV industry. For example, while large firms from electronics have already played a role in the development of the solar PV industry, utilities are starting to become more important as well. Firms from these industries might have fewer difficulties creating intrafirm complementarities, but an interesting direction for further inquiry is whether and/or how they are able to create these or face problems similar to oil firms. Finally, while oil industry dynamics affected firm entry in the 1980s and renewed interest in the solar market in the 1990s, currently it seems that solar industry dynamics in terms of increased competition from new entrants affect further expansion plans and/or exit strategies. However, how these solar industry dynamics unfold and which role new entrants play in the emergence of the solar PV industry would be another area for further research.

To conclude, then, the recent investments of Shell and BP in unconventional oil reserves such as tar sands point at a ‘recarbonization’ trend in the industry, which was stimulated by the record-high oil prices just prior to the global financial crisis. The oil firms seemingly stopped worrying about their public profile on climate change (Levy, 2009). What might have caused this change is the fact that in dealing with climate change, investments in renewables are no longer the main option for oil firms. Other mitigation measures including energy efficiency, emissions trading, biofuels and CCS have become more widespread (Pinkse and Kolk, 2009), which enable oil firms to stay closer to their oil activities. Regrettably, policy makers might have incentivized this behaviour, because they have focused on the implementation of climate policy instruments to achieve near-term carbon targets (Sandén and Azar, 2005). Whereas emissions trading, due to relatively low allowance prices, has not yet provided an incentive strong enough to induce radical mitigation measures, it is particularly governments subsidizing CCS, which might have stimulated oil firms not to switch away from fossil fuels. Findings of this study therefore corroborate the call made earlier that policymakers need to put in place technology-specific instruments to stimulate market entry of more disruptive renewable energy technologies (Sandén and Azar, 2005).

CHAPTER 5

IN SEARCH OF VIABLE BUSINESS MODELS FOR DEVELOPMENT: SUSTAINABLE ENERGY IN DEVELOPING COUNTRIES[6]

5.1 Introduction

In the past decade, international interest in the role of business in furthering development has increased, and from a growing number of perspectives. Be it the policy debate in the framework of the Millennium Development Goals or the literature on bottom of the pyramid, subsistence markets or partnerships, involvement of the private sector has been emphasised. As such, attention for economic, entrepreneurial activity in developing countries, including the impact of foreign investment on development, is not new at all (for overviews see Fortanier and Kolk, 2007; Meyer, 2004). What has changed in more recent years is that multinationals in particular are increasingly called upon to help alleviate poverty (Kolk et al., 2006), and are thus seen as 'part of the solution' – no longer as only 'part of the problem'. In addition, they are not just asked to contribute to economic development 'per se', but also to address social and environmental issues. In this way, business is expected to take on roles and responsibilities that were previously regarded as belonging to the domain of government, and/or of non-governmental organizations (NGOs).

Especially multinationals have become very active in a variety of fields, ranging from mere philanthropy to more strategic corporate social responsibility efforts, sometimes even linked to their core business, as can be seen in some business-NGO partnerships or supply-chain activities (Kolk et al., 2008). Since the early 2000s, attention has even shifted to the possibility to make a profit out of poverty-oriented approaches, as put forward by the Bottom/Base of the Pyramid (BOP) thesis as initially launched by Prahalad and Hart in 1999. While there is no evidence for a systematic 'Fortune at the BOP' for multinationals beyond a limited number of high-profile, oft-cited cases – as the poorest of the poor do not have sufficient purchasing power to generate huge market opportunities (e.g. Garrette and Karnani, 2010; Ireland, 2008; Kolk et al., 2010; Pitta et al., 2008) – the BOP idea has put poverty strongly on the international business agenda. Interestingly, the recent emergence of BOP 2.0 (Simanis and Hart, 2008), in which the poor stand much more central, as co-creators of BOP initiatives, has meant a certain convergence with the subsistence market(place)s approach (Viswanathan et al., 2009; Viswanathan and Sridharan, 2009).

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[6] This chapter was published in *Corporate Governance: Int. Journal of Business in Society*, 2012, *12*(4), 551-567, with Ans Kolk as co-author (for more details, see co-author statements included elsewhere in this dissertation).

In line with that bottom-up, micro-level perspective, the overall debate has moved towards the role of smaller, local companies, and to a broader interest in reconciling the ‘social good’ with economic objectives, i.e. beyond corporate social responsibility or philanthropy only, and in such a way that it can reach sufficient scale to address the urgent and huge unmet needs of the poor. However, although the crucial role of business, and of business-based approaches, in development is thus frequently underlined by academics and practitioners, we lack insight into the ‘whether and how’ of viable business models, in environmental, social as well as economic terms. Despite generic calls at the macro level and statements that business can help to alleviate poverty, how this might work from a business perspective that considers firm-specific factors, is not so clear. This article aims to contribute by analysing private-sector involvement in development, taking the case of sustainable energy in developing countries. This is highly relevant as energy is often seen as a crucial lever for development, as the next section will explain in more detail. We also examine the ‘state of the art’ on sustainable energy and business involvement, and subsequently present our own research on illustrative cases from local companies involved in renewable rural electrification. This includes a discussion of implications, viewed from the broader perspective of business models for development as well.

5.2 The crucial role of energy in development

Energy is important for social and economic development, and crucial for individuals and communities in developing countries to meet their basic needs. The essential role of access to clean and reliable sources of energy for realizing sustainable development has been widely recognized, as reflected in the UN’s decision to label 2012 as the international year of ‘Sustainable Energy for All’. It is estimated that almost one fifth of the world population does not have access to electricity, and this situation is expected to still hold for 1.2 billion people in 2030 (IEA, 2010). Energy is directly linked to increased income and productivity, and indirectly to better health, education, quality of life, and human development in general. Access to energy can act as an incubator of economic activity and have an important impact on long-term poverty reduction, as it can increase livelihood options by allowing households to engage in a more diverse range of income-generating activities and make pre-existing activities more efficient (Biswas et al., 2001; Davis, 1998; Sagar, 2005; Sharma, 2006). Besides domestic use, electricity can improve healthcare: it enables the possibility of providing clean water and lighting, of conserving medicines, vaccines, and blood storage, as well as access to usage of modern medical equipment. In terms of education, learning conditions could be dramatically improved as electricity means lighting during the evening, and facilitates access to internet, and thus to knowledge and information beyond the local community.

Considering that approximately 80% of the people in developing countries who lack access to electricity live in rural areas beyond the reach of the electricity grid (ARE, 2008), rural electrification is a crucial issue in access to energy. The conventional approach to electrification has been to extend the electricity grid powered by centralized fossil fuel-based power plants operated by the national utility. This is based on the model adopted in developed countries, where national governments had traditionally created such systems. The reality in many developing countries, however, is very different, because it is financially, technologically and organizationally almost impossible to extend the central grid to all remote and rural parts of the country. Grid-connected electricity is often only available in urban areas, because of high costs for connection and subsequent power transmission losses resulting from the large distances that need to be bridged (ARE, 2008). This thus calls for off-grid, decentralized solutions for energy provision, either based on existing technologies such as diesel generators or emerging renewable energy technologies (RETs), which provide access to energy beyond the public electricity grid. A diverse range of such RETs that are relevant for developing countries has emerged over the years (see Box 5.1). RETs in fact relate to two of the three (interlinked) objectives adopted in the framework of Sustainable Energy for All: i.e. to "ensure universal access to modern energy services" and "double the share of renewable energy in the global energy mix".[7]

A broad range of RET-based applications for decentralized off-grid electrification including solar, wind, hydro and hybrid systems has become available in recent years. For the main applications in domestic use, such as lighting and usage of electrical appliances (e.g. television, radio, mobile phones), REN21 (2010) states that the main options include the following: solar home systems (SHS) applied to individual homes, schools or hospitals; village-scale mini-grids powered by solar, wind or hybrid technologies; small-scale biomass gasifiers with gas engines; and hydropower installations on a pico-scale, micro-scale or small-scale. In addition to utilizing solar energy through SHS, ARE (2008) also mentions two options for solar photovoltaic (PV) which create high flexibility in usage as they are easy to move and share: small solar PV applications, consisting of solar PV modules attached to a specific application, and energy boxes, consisting of a portable loading station with power outlets for creating a connection to specific applications.

When considering appropriate RETs for electrification in developing countries, it is important to define dimensions on which the choice for a specific energy system can be made, as a broad spectrum of stand-alone and mini-grid based RET applications has emerged in recent years. Selecting the best technological configuration for rural electrification from the diverse range of available options mentioned above should be done on a case-to-case basis, as the specific conditions in a geographical area determine the most effective technology solution (ARE, 2008). O'Brien et al. (2007) identify several general characteristics for selecting the appropriate RET-based solution for electrification, including the efficiency, adaptability, reparability, and ease of use of the technology, which are rather context-specific and dependent on the needs of the end-consumer. Reliability and affordability are also often mentioned as crucial aspects (e.g. Umree and Harris, 2006).

Box 5.1: Renewable energy technologies for developing countries

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[7] See Energy for All: http://www.sustainableenergyforall.org/about-us.

While decentralized RET-based electrification offers clear benefits from an environmental and social perspective (e.g. by avoiding emissions from fossil fuels and negative health effects from using traditional biomass fuels such as charcoal and wood for cooking and heating inside), achieving economic viability has been problematic. In addition to challenges related to financing and upscaling beyond pilot projects, Mohiuddin (2006) mentions that RETs are not yet widely adopted in developing countries due to a lack of available infrastructure for RETs, which creates high initial capital costs for RET-based electrification projects, and limits the possibilities for a wider, sustained market development. The main challenge is to achieve broad access to affordable, modern energy services in countries that lack them, and to find a mix of energy sources, technologies, policies and behaviours that avoid the negative environmental impact related to fossil fuels (Spalding-Fecher, 2005; Spalding-Fecher et al., 2005).

However, as RETs involve local solutions, frequently for remote communities only, national governments in developing countries might often not (be able to) play an active role in their provision at affordable price levels for poor people. This is one of the reasons that many other (non-)governmental organizations have become engaged in stimulating investments in off-grid solutions in those parts of the world that would be neglected otherwise. Through different kinds of partnerships and financing schemes, such organizations have often tried to attract the interest of the private sector while keeping costs for electricity users low. However, creating the right kind of incentives to step up investments in off-grid energy solutions and designing long-term viable business models to sustain rural electrification has been very difficult for for-profit companies. Academic research including work by Chesbrough et al. (2006) has also shown that many technologies developed with the intention to be implemented in developing countries did not achieve commercial viability, or remained limited to charitable distribution programmes by donor organizations.

In the next section, we pay attention to financing and delivery models in RET-based electrification as they have come to the fore in the literature, and compare the options that have emerged. We subsequently present our own research on some illustrative cases from local companies involved in RET-based electrification in developing countries, which represent a market-based bottom-up approach, and characterise the issues at play. Given that the importance of private sector involvement to establish energy markets in developing countries for long-term sustainability is increasingly recognised, the viability of the underlying business models of these initiatives is considered. We also discuss the implications, viewed from the broader perspective of business models, for research and practice in sustainable development.

5.3 Financing and delivery models for renewable energy technologies

While the importance of access to energy for sustainable development in developing countries is widely recognized, the issue has not yet received mainstream attention in the academic business and management literature. Publications have included a range of case studies, covering sub-Saharan Africa (e.g. Jacobson, 2007; Nygaard, 2009; Wamukonya and Davis, 2001), South-East Asia (e.g. Byrne et al., 1998; Ling et al., 2002; Miller and Hope, 1999; Nguyen, 2007; Umree and Harries, 2006), Oceania (e.g. Umree et al., 2008; 2009), and the Indian subcontinent (e.g. Biswas et al., 2001; Chakrabarti and Chakrabarti, 2002; Rao et al., 2009; Sharma, 2007). However, they have focused on concrete (technical) issues, usually taking a more macro-economic and/or policy-oriented approach, including the identification of success factors and the implications for (donor) investment policies in terms of delivery and financing mechanisms. Research that examines private-sector involvement from a business perspective, including the factors at the level of the firm that influence the viability of business models for RET-based electrification, has been lacking.

If we consider the existing macro/policy studies, they have predominantly consisted of two types: empirical papers based on case studies on rural electrification in specific (sets of) developing countries using RET as an energy source, and policy-oriented papers looking at the existing policies and financing mechanisms for stimulating investments in RETs and energy-efficiency technologies. Particularly publications in the latter category, which sometimes contain insights on emerging delivery models on how sustainable energy projects are developed and implemented, are potentially interesting for the purpose of this article; that also applies to financing schemes that address funding mechanisms within a project. The models and schemes identified by different authors and multi-stakeholder organizations such as the Alliance for Rural Electrification (ARE) and Renewable Energy Policy Network for the 21st Century (REN21) overlap in multiple ways, and share important characteristics that we will briefly summarize next.

Figure 5.1 positions the various delivery and financing models as included in four main recent studies, based on two basic dimensions that come to the fore in each decentralized off-grid solution to access to energy in developing countries: the extent to which subsidies are included in the model in question, ranging from fully subsidized to non-subsidized, on the one hand; and the nature of the actors involved, public or private, on the other hand. While this overview is indicative only (with sometimes dotted lines if there is a range and not just one point), it gives insight into the different options distinguished, and shows their variety, as well as similarities. We will not discuss all four studies in detail, but focus on evolution of thinking over the years, in which the desirability of models carried out by private actors without subsidies is the most recent phenomenon in a field that has traditionally relied on donation-based, donor-driven projects.

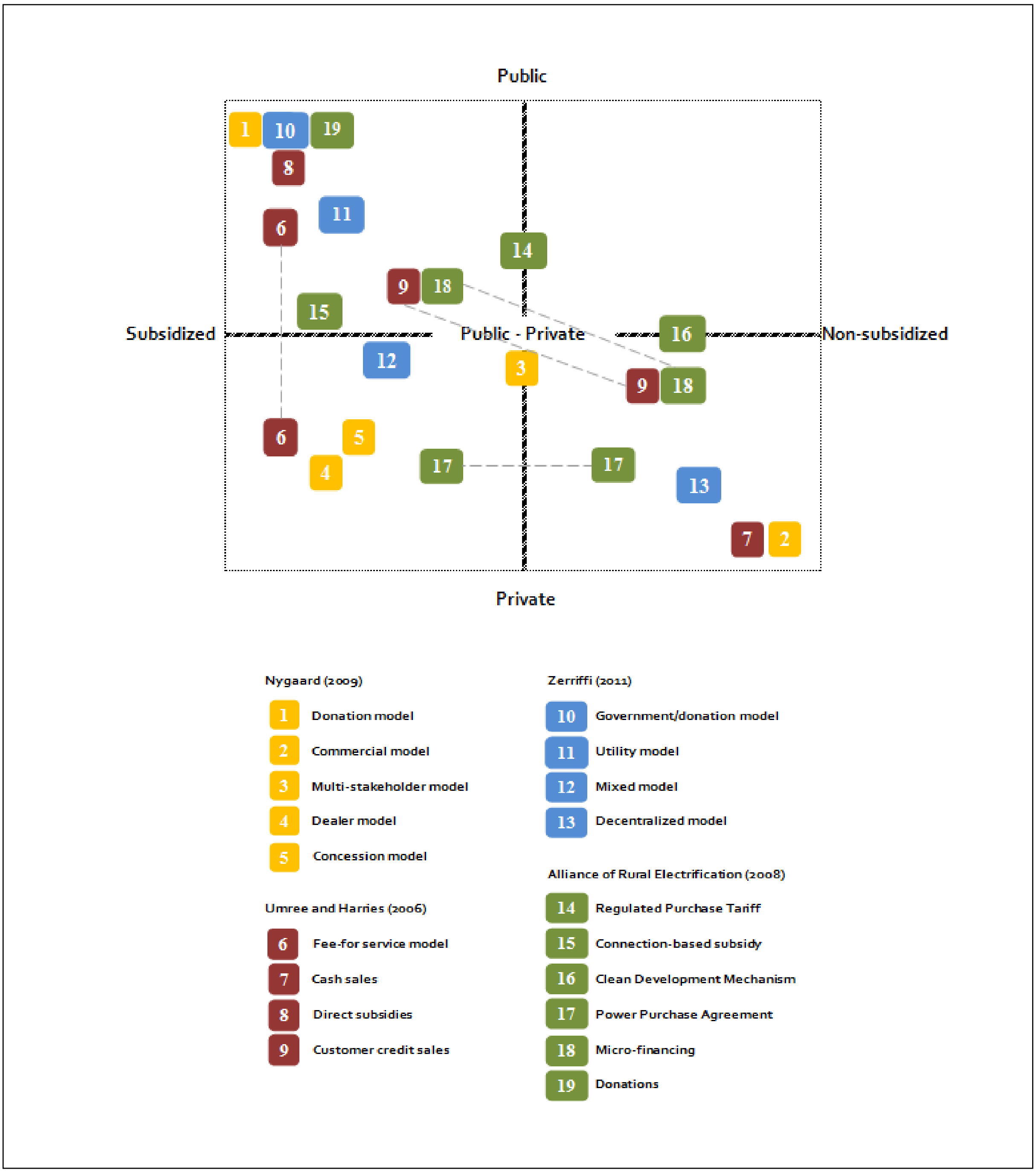

Figure 5.1: Indicative positioning of some off-grid delivery and financing models

Based on his study on rural electrification using solar technology in Sub-Saharan Africa, Nygaard (2009) identifies delivery models that cover the whole range. At one extreme, there is the traditional philanthropic model (#1 in Figure 5.1), a 'donor-driven' approach in which developed countries provide funding to developing countries on a project basis, and government organizations are fully in charge of all aspects related to the RET-based electrification system. This does not provide a basis for establishing a viable market, and large organizations such as the World Bank are trying to move beyond this model (e.g. Martinot, 2001). The other end of the spectrum consists of a commercially-led delivery model (#2 in Figure 5.1) based on cash sales, with zero subsidies. This resembles a classic market-based model in which private organizations and/or individuals are end-users of the electricity, own and finance the system and are fully responsible for installation and maintenance – roles all fulfilled by a government organization in the previous model. In between these two, we find a multi-stakeholder model (#3) in which private entities are still end-user of the electricity and have ownership over the installation, but financing in is provided by a donor, financing institution or dealer through a low to medium-size investment in the overall project. This approach is broad by definition and can involve a variety of different actors, and is relevant as a possible alternative to the two other models mentioned earlier. Based on research in Brazil, Cambodia and China, Zerriffi (2011) suggests comparable models, although his most 'extreme' private model (#13 in Figure 5.1) is one that focuses on decentralization which can cover both established (fossil-based) mini-grids and solar systems. While highly interesting for this context, Zerriffi (2011, 144) notes that this has "not been around long enough to have significant impact and allow evaluation of sustainability and replicability".

The literature also contains various financing models, as discussed most specifically by Umree and Harris (2006) and ARE (2008), and included in Figure 5.1 as well. This again ranges from donations/subsidies on the one hand (#8 and #19) and more or less fully private funding, such as those based on cash sales (#7), on the other. The latter variant only works for households with sufficient purchasing power, which excludes the (poorest of the) poor (Jacobson, 2007). In this context, micro-financing is sometimes mentioned as a possibility (#18). While this instrument in general has not been without criticism, a debate beyond the scope of this article[8], several authors adjusted it to the energy context to support both RET supply and demand (Mohiuddin, 2006; O'Brien et al., 2007; Rao et al., 2009). Rao et al. (2009) most specifically proposed an 'energy-microfinance framework' to pool energy expertise and financial management skills. Figure 5.1 also contains fee-for-service models (#4, #5 and

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[8] For recent insights into the broader micro-finance debate that often rely on empirical results from randomized controlled field experiments in the framework of MIT's Poverty Action Lab, see Banerjee and Duflo (2010), Chu (2007) and Karlan and Murdoch (2010). For several short practice-oriented articles on micro-finance, see e.g. *Stanford Social Innovation Review*, particularly in the 2007 and 2008 volumes.

#6), in which a national utility or energy service company owns, finances and maintains the installation, and is responsible for maintenance while periodically charging a fee to households based on usage. An affordability payment scheme or specific subsidy can be part of such an arrangement. ARE (2008) distinguishes several models in which subsidies are integrated, such as a regulated purchase tariff (#14), with subsidies that complement tariffs paid by consumers, or fund electricity producers either for the number of connections established (#15) or via power purchase agreements (#17) that guarantee producers a specific price and a minimum purchase to stimulate investments.

As shown in Figure 5.1, the number of market-based models that operate without subsidies is fairly limited, despite persistent calls for private investment for more than a decade, particularly by international development organizations such as the World Bank. This has been accompanied by the identification of a range of key demand and supply factors to be addressed by policies for infrastructure, investments, institutions, entrepreneurial and consumer behaviour (Martinot, 2001; Miller and Hope, 2000, World Bank, 2008a, 2008b). However, as noted by Mohiuddin (2006, 122), “the majority of support for RETs in developing countries still comes from local and state governments or from foreign donors, which is not sustainable because government funds fluctuate as priorities shift and as national and regional crises spring up from time to time and aid flows from foreign donors can ebb at times”. A 2012 UN document on Sustainable Energy for All urges all stakeholders to take steps, and suggests many possibilities for action. It mentions, “by way of illustration” that “private sector stakeholders could commit to”, inter alia, “develop and deploy business models that deliver and build value from sustainable energy solutions” (UN 2012, 14).

Interesting is the unequivocal statement in that same “Framework for Action” (UN 2012, 19) that “In many off-grid situations, small-scale sustainable energy solutions for productive uses of energy are not only affordable under the right business models, but cheaper than current sources of energy. This creates opportunities for local business development consistent with all the objectives of Sustainable Energy for All. There are numerous recent success stories involving innovation in energy access by small-scale businesses and civil society organizations. Replicating and scaling up successful community-based delivery models could have a significant impact, both as stand-alone efforts and as part of national efforts described in the previous example”. These national activities comprise joint activities funded by the private, public and non-profit sectors. The emphasis on collaboration also comes to the fore in the quotation “Private sector stakeholders can make a significant contribution toward achieving the Sustainable Energy for All objectives, both on their own and – more importantly – through partnerships” (UN 2012, 14).

It is not clear whether the terms ‘affordability’, ‘cheaper’ and ‘success stories’, as cited above, refer only to reaching poor populations or also to the economic viability for business. The request to companies, cited above, to make a commitment to develop business models suggests that the focus is more on access to energy and the impact for developing countries. While understandable, this still leaves open the question how and to what extent RET business models can become viable and thus sustainable in both economic and social/environmental terms. To shed some light on these aspects, we examined four illustrative cases of bottom-up business initiatives of local companies. Below first the methodology and approach will be explained, followed by a presentation of findings, embedded in a broader discussion of business models.

5.4 Methodology

Sample and method

We analysed four local companies that have developed innovative business models for providing RET-based off-grid energy solutions to households and villages living beyond the reach of the electricity grid. These are illustrative cases originating from four countries in Asia: Kamworks (Cambodia), Sunlabob (Laos), Husk Power Systems (India) and Grameen Shakti (Bangladesh). We selected these companies after a web-based search for examples of entrepreneurial, local activity in RET-based rural electrification in developing countries as they show different aspects and technologies used in developing countries, and positioned themselves as market-oriented organizations. Other examples could have been taken, for example in Africa, although the number of for-profit ventures seems to be smaller in reality than it looks at first sight as many appear private but turn out to be non-governmental or hybrid at best. The number of local companies active in RETs appears to be rather limited, at least when doing a selection via internet sources.

Primary and secondary data was collected from public sources, particularly websites and reports, supplemented with nine semi-structured interviews with experts in the field, held by the second author in the first half of 2011, to gain insight into emerging RET business models in developing countries. Interviewees were three directors of small local companies (including two of the Asian companies included in this study and one active in Africa), four senior staff members of international governmental and non-governmental (development) organizations, and two other experts in the field of energy in developing countries (see appendix A for an overview). Based on insights from the literature, questions focused on main challenges of RETs for access to energy, the role of the private sector and the emergence of market-based business models, and the (possible) role of collaboration with partners from the public, private and/or non-profit sectors in this regard.

Of the four companies, Grameen Shakti is somewhat exceptional in view of its explicit positioning as a not-for-profit company. Furthermore, it is part of the broader Grameen family of organizations which contains an umbrella of non-profit and for-profit ventures, all related to the initial

Grameen Bank set up to provide micro-credit. At the same time, it is a relatively large renewable energy company that has focused on offering RETs in rural areas for many years already and therefore interesting to consider as well. In addition, like the other three (Husk Power Systems, Kamworks and Sunlabob), it operates according to a market-oriented approach, and can thus be found in the lower half of Figure 5.1 as presented in the previous section. Issues related to levels of subsidization will be discussed in the next section when we explore their respective business models, in the context of the literature on this topic.

Business model perspectives

In the past few years, business models have received growing attention in the management literature[9], but the number of articles that reckons with the situation in developing countries has been very limited, except for a few that focus on business-NGO collaboration in this context (Chesbrough et al., 2006; Dahan et al., 2010) or on opportunities for (Western) multinationals in emerging markets (e.g. Eyring et al., 2011). Yunus et al. (2010) describe first-hand experiences with a few Grameen companies from a ‘social business model’ perspective, but this is less linked to the generic literature on the topic and several details (for example on funding and profitability) are far from clear. We therefore searched for additional, older publications as well for frameworks that might be helpful to discuss the type of companies, issues and locations covered in this study, which also included Morris et al. (2005) and Shafer et al. (2005).

Eyring et al. (2011) turned out to be less applicable in view of its starting point of competition on either differentiation or price. Given the early stage of the market for RETs with commercial viability still being explored and companies emerging only recently, the model appears not so relevant for the purpose. Its components (customer value proposition, key resources and processes, and profit/cost structure) bear resemblance to other models though, such as Shafer et al. (2005). The framework of Shafer et al. (2005, 202) consists of strategic choices, value creation, value network and value capture, with several subcategories, following from their definition of a business model as “a representation of a firm’s underlying core logic and strategic choices for creating and capturing value within a value network”. However, the elements are too specific given the nascent state of the market and the companies, the limited information available for the local companies and their lack of formalization compared to large (Western) companies.

The most appropriate model for the purpose of this article appears to be Morris et al.’s (2005) more open set of questions at the foundation level as summarized in Table 5.1, coupled with a

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[9] See a special issue with 19 articles on business models in *Long Range Planning*, Vol. 43 (2010), which included an introductory reflective piece by Baden-Fuller and Morgan (2010); and Zott et al.’s overview as published in the 2011 annual review issue of *Journal of Management*.

proprietary level that considers the unique innovation of the specific venture. We will discuss these aspects in more detail below, using the findings of our research on the four companies.

Question	**Some sub-components**
How will the firm create value?	Peculiarities of the offering
For whom will the firm create value?	Market factors such as business-to-business or business-to-consumer, local-international, value-chain position of customer, market segments
What is the firm's internal source of competitive advantage?	Internal capability factors including production, sales, technology, finance, supply chain management, leveraging of networks and resources
How will the firm position itself in the marketplace?	Competitive strategy factors such as operational excellence, product/service quality, innovation/cost leadership, customer relationship/experience
How will the firm make money?	Economic factors such as pricing and revenue sources, operating leverage, volumes and margins
What are the entrepreneur's time, scope, and size ambitions?	Type of investment model (e.g. subsistence, income, growth, speculation)

Table 5.1: Six questions that underlie a business model, based on Morris et al. (2005, 729-730)

5.5 Emergent RET business models

Table 5.2 contains some key characteristics of Grameen Shakti (GS), Husk Power Systems (HPS), Kamworks and Sunlabob, particularly location, main products/services and customers, relationships, and key achievements as presented by the companies themselves and as honoured by external parties via awards. It also includes references to the most applicable delivery/financing models as discussed earlier in this article (see Figure 5.1). The Table gives fairly detailed information regarding the activities of the companies, also in terms of technologies (cf. Box 5.1) and the specific organizations with which they partner. In our discussion below we will not pay much attention to the technicalities but rather aim to generate insight into broader implications for sustainable energy and development considering the (im)possibilities of market-based, private-sector involvement. Components of Table 5.1 will be used to characterize the (unique) features of the companies, as well as the sector more generally. The first subsection addresses the first four questions of Table 5.1 as well as the proprietary level, followed by the last two questions to explore the economic viability and (future) investment models.

	Grameen Shakti (GS)	Husk Power Systems (HSP)	Kamworks	Sunlabob
Year of creation	1996	2008	2006	2000
Country of origin	Bangladesh	India	Cambodia	Laos
Countries/(sub) regions of activity	Main market is Bangladesh	Main market is India's Bihar state	Main market is Cambodia	Main market is Laos, also international activities on project basis in Thailand, Cambodia, Uganda, Sierra Leone, Mozambique, Liberia, and Afghanistan (some starting from 2012 onwards)
Main products /technologies (cf. Box 5.1)	Solar home systems, improved cooking stoves , biogas plants. All include a programme incorporating credit schemes and microfinance options	Biomass gasifier running on rice husk, distributed by village grid	Grid-connected and off-grid solar systems, water systems (pump), solar home systems (sizes 20W to 320W), Moonlight solar lantern, solar-powered cooling	Grid-connected solar systems, village grid systems (technologies: hybrid, solar, hydro, wind), solar home systems (sizes 20W to 150W), solar lanterns, water systems (pump, purification, treatment, heater), solar-powered cooling
Main services	Installation and maintenance , awareness raising and demonstration, training programmes. Entrepreneur development through Grameen Technology Centres, credit schemes	Installation and maintenance, training programmes through Husk Power University	Installation and maintenance, awareness raising and demonstration, rental scheme on solar lantern	Installation and maintenance, consultancy on electrification and energy efficiency, project management, training programmes, awareness raising and demonstration, rental schemes on energy systems and solar lanterns
Types of customers	b-to-c, predominantly low-income customers in rural Bangladesh	b-to-c, predominantly low-income customers in rural India	B-to-b and b-to-c, broad customer base from organizations/business to middle- and low-income customers in rural Cambodia	B-to-b and b-to-c, broad customer base from organizations/business to middle- and low-income customers in rural/urban Laos
Key achievements / statements	(1) "Grameen Shakti has developed one of the most successful market based programmes with a social objective for popularizing Solar Home Systems (SHSs) including other	(1) "The company designs, installs and operates biomass-based power plants. Each plant uses proprietary gasification technology to convert abundant agricultural residue (procured from local farmers) into	(1) "Kamworks tries to introduce the so-called energy ladder: for the lowest income household we have the Moonlight (a solar-powered lantern), and for the medium and higher income households we have	(1) "Sunlabob operates as a profitable, full-service renewable energy provider, providing commercially-viable energy services"

	Grameen Shakti (GS)	Husk Power Systems (HSP)	Kamworks	Sunlabob
	renewable energy technologies to millions of rural villagers” (2) Since its inception, Grameen Shakti achieved a total of 815,528 of installed Solar Home Systems, a total of 463,842 distributed ICS, and a total of 22.096 installed Biogas Plants. It has 1217 branch offices throughout all 64 districts in Bangladesh, with a total of 1445 offices including regional and divisional offices, with a total of around 5 million beneficiaries (figures for May 2012). (3) “GS used its Grameen Bank's experience to evolve a financial package based of installment payment which reduced costs and helped it reach economy of scale”	electricity, which is then distributed to rural households and micro-enterprises through a micro-grid system - providing a better quality, cheaper way to meet their need for energy” (2) “Consumers pre-pay a fixed monthly fee ranging from US$2 to US$2.50 to light up two fluorescent lamps and one mobile charging station. This offers consumers savings of at least 30% over competing kerosene and diesel energy sources” (3) ”Since 2008, HPS has successfully installed more than 80 plants in Bihar, providing electricity to over 200,000 people across 300 villages”	a SHS systems in 20 watt, 40 watt and 80 watt” (2) “In the first place Kamworks sells and installs solar electricity systems for professional end-users that have a need for electricity in the rural areas (high-end). In the second place, the company imports, develops, produces and sells products based on solar electricity for the consumer market (low end)” (3) ”International experience shows that the biggest problems with battery operated solar systems are usually related to the quality of the product and lack of a functioning local service network”.	(2) “Sunlabob believes that responsible, long-term oriented entrepreneurship is the driving force for sustainable economic development and for providing managerial, technical, and financial resources needed to meet social and environmental challenges” (3) “Sunlabob installed more than 10,000 systems in over 500 villages and locations in Laos” (4) “Sunlabob has successfully initiated a rental service for energy systems and a Solar Lantern Rental System that allows households and villages to afford electricity”
Awards	Awards include: SolarWorld Einstein Award (2010), International Microfinance Award (2009), Ashden Outstanding Achievement Award (2008), Energy Globe Award (2008), and the Ashden Award (2006)	Awards include: Ashden Award for Sustainable Energy (2011), Africa Enterprise Challenge Fund Award (2011), and Real Heroes Award – Social Welfare for founder Gynesh Pandey	Awards include: Clean Energy Marketplace Award by USAID, ADB, and RWI (2010), Development Marketplace Award by the World Bank (2006)	Awards include: Development Marketplace Award by the World Bank (2005), Ashden Award for Sustainable Energy (2007), Energy Globe Award – Laos (2007 / 2008 / 2009), Cleantech National Competition in Singapore Award (2010), and Best Practice in CSR Award (2012)
Size	10.341 employees (7 executive management)	350 employees (6 executive management)	Not specified (estimated 15-25 employees)	Around 70 employees

	Grameen Shakti (GS)	Husk Power Systems (HSP)	Kamworks	Sunlabob
Subsidies obtained	States to get 'no direct subsidies', focus on micro-credit financing in collaboration with Grameen Bank (no mention of subsidies by this company)	Investments from a number of organizations including international organizations, foundations, venture capital firms, and non-profit venture funds	From international (development) organizations for supplying and installing RET-based energy solutions on project-basis, which includes the World Bank and Energy & Environmental Partnership Mekong	From international (development) organizations for supplying and installing RET-based energy solutions on project-basis, which includes the World Bank, Asian Development Bank, and United Nations/UNIDO
Partnerships within private sector	Not specified	Investors include Shell Foundation, Draper Fisher Jurvetson (DFJ), LGT Venture Philanthropy, Bamboo Finance (Oasis Capital), and Cisco	Includes private sector partners for supply of products (organizations not specified)	Includes private sector partners for supply of products (21 organizations), projects & implementation (11 organizations), and business strategy development (3 organizations)
Partnerships with governmental actors	Not specified	Includes The Ministry of New and Renewable Energy (MNRE), Govt. of India and World Bank/IFC	Includes Agentschap NL (Netherlands) and GIZ (Germany)	Includes United Nations/UNESCAP, World Bank/IFC, GIZ (Germany), SES (Germany), Lao Institute for Renewable Energy (LIRE)
Partnerships with NGOs	Not specified	Includes the Acumen Fund	Includes Energy & Environmental Partnership (EEP) Mekong, PicoSol Cambodia, CICM/Crédit Mutuel Kampuchea, the Delft University of Technology (Netherlands), the University Twente (Netherlands), and Kofi Annan Business School (Netherlands)	Includes The Asia Foundation, Engineers Without Borders Australia, FK Norway, Cambodia Rural Development Team, World Volunteer
Most applicable model(s) (Figure 5.1)	#9, #18	#2, #7, #13	#2, #7, #13	#2, #5, #6, #13

Table 5.2: Some characteristics of the four companies, based on company websites, reports, and interviews

Offerings, markets, positioning and capabilities

Overall, local companies in off-grid rural electrification offer a portfolio of energy 'solutions', generally consisting of different renewable-energy technologies to various customers: business-to-business and/or business-to-consumer, in a range from individual-level to village-level products and services. End-consumers vary in their ability to pay as many are poor which means that there is often financial support via donor organizations, in which case these organizations can be argued to resemble, in a sense, a 'business' customer (as end-consumers are beneficiaries). Business-to-business activities are commercial if they cater to the needs of local companies. It is possible to buy RET-products as a single item, but also in combination with other products and/or services such as installation, maintenance, training, project management, and sometimes financing and rental schemes. The local companies usually do not manufacture RET-products but focus on value-added reselling of standardized solutions that are customized and locally-adapted where needed so as to ensure a reliable electricity supply. This is a challenge as it requires a network of maintenance and repair as well as stable quality products all delivered in distant rural areas. RET-applications are currently still niche markets, but with a potential to become much larger in view of the large number of people in developing countries without access to energy.

Within this overall sector framework, the four local companies also exhibit some differences in terms of size, product-service solutions and customers, as Table 5.2 shows. All four are locally-focused in their respective home countries; only Sunlabob has started some activities on a project basis in other countries as an outflow of their international recognition and contacts. Husk Power Systems is unique for its cost-effective electricity generation through a biomass gasifier running on discarded rice husk, abundantly available in rural India, which is subsequently distributed through a village grid. This is a specific business model and technology developed by HPS aligned to local conditions. The other three companies have a broader RET-portfolio, with Grameen Shakti standing out for its much larger size. Peculiar to GS is that its RET-based solutions come with a micro-financing 'soft credit' scheme developed in collaboration with the Grameen Bank. The company is locally embedded in Bangladesh through more than 1200 branch offices, which provides a clear infrastructure.

Although based in two different countries, Kamworks and Sunlabob are rather similar in many respects, considering their main products/services, types of consumers and the fact that they are run by an entrepreneur strongly embedded in the local/regional context. One dissimilarity is Kamworks' primary orientation at solar energy, which means that it is more focused in the type of renewable energy than Sunlabob. Different from GS and HPS, which predominantly cater to low-income (end) consumers only, Kamworks and Sunlabob serve a broader mix of customers, including local business on a fully commercial basis as well as end-consumers, villages and/or individuals, who pay themselves or are (partly) funded via international donor projects. This relates directly to the economic factors and types of investment models of the local companies.

Economic viability and (future) models

Although it proved impossible to obtain hard revenue and profit data from the companies, our research confirms that building a viable business model in this sector in the present situation is rather difficult. While circumstances differ and so do the companies we studied, subsistence appears to be the key current focus, even though the aim is to move towards a stable income and subsequently growth model. Particularly Husk Power Systems has an innovative and relatively simple approach, but this requires the abundant availability of husk material. Even in such unique conditions, however, financing for pilots and start-up costs are required. This is all the more the case for other locations, where only other RETs can be used and where rural electrification is not viable on its own as upfront costs for installation, infrastructure and material as well as operating and service-network costs are difficult to fund. In the absence of sufficient collateral, banks and investors are generally not willing to provide loans (at affordable interest rates) to companies in view of long payback periods and problems with cost recovery in general. End-consumers face the same type of problems, in a context where poverty reigns and even micro-credit tariffs are too high.

The four companies that we studied are set up and function as private entities, and strongly advocate market-oriented approaches and entrepreneurship. At the same time, they generally have a variety of (non-)governmental partners with which they collaborate. Often these serve to gain, for example, access to subsidies or other types of support from international organizations to service the real poor and/or start up a business in renewable off-grid energy. There are differences in the degree to which the local companies rely on such external sources. Kamworks and Sunlabob have a mixture of self-sustaining commercial activities alongside subsidized projects based on donor funding. The latter type is focused at reaching the poorest consumers while commercial activities target business markets or middle-class consumers. GS explicitly mentions to get “no direct subsidies” but, interestingly, the company does not aim for profit, perhaps because it is part of the broader Grameen family of organizations, which has the provision of micro-credit as cornerstone of the overall business model. So indirect support may be obtained this way or otherwise, but information about this could not be found. HPS has designed an innovative for-profit model based on specific local circumstances which has potential to be scaled up. Still, the company has several socially-oriented investors, including the Shell Foundation.

The variety shows that several models may be needed to address local demands, adjusted to the specific context. The emergence of market-based approaches generally does not diminish the role of other (non-)governmental actors as the challenges of 'sustainable energy for all' are tremendous. In the final section, we will draw conclusions and discuss the implications for the role of business in sustainable development.

5.6 Discussion and conclusions

While renewable, off-grid electrification in developing countries offers clear benefits in environmental and social terms, and is needed in view of the international objective to realise 'Sustainable Energy for All', the economic viability has been a real issue. As a clear illustration of the complexities related to large-scale involvement of business in furthering development, this article examined sustainable energy, and explored how innovative market-based models for RET-based rural electrification are emerging as part of a move away from more traditional, purely donor-funded projects. In line with the importance of the private sector-based solutions in establishing access to energy in developing countries, as emphasized by academics and practitioners, the cases of Sunlabob, Husk Power Systems, Kamworks and Grameen Shakti provided more insight into various business models in rural electrification. They also show the organizational, financial, regulatory, and technological challenges, and raise questions as to possible roles that remain or (re-)emerge for governmental and non-governmental actors.

In comparing these local-level market-based models to international-level donor-driven approaches, a major strength of the former is the companies' adaptability to local conditions as opposed to more generic one-size-fits-all electrification solutions. As these companies are, almost by nature, embedded in local communities and possess in-depth knowledge of the distinct characteristics of markets and consumers, they seem better able to develop context-specific solutions which also creates legitimacy for their approach. Kamworks in Cambodia and Sunlabob in Laos follow a mixed model with segmentation based on income levels and energy needs, thereby providing the appropriate technological solution that suits consumers best. Taking Kamworks as an example, the company emphasizes its commitment to introducing an energy ladder based on this need- and income-segmentation, whereby the lowest-income households have the opportunity to purchase a Moonlight solar-powered lantern (through a rental scheme, which reduces the upfront costs of buying a Moonlight and makes it more accessible), while those with higher purchasing power (individuals or companies) can buy somewhat more expensive systems.

Still, there needs to be funding for poor people to be able to get access to energy either via an arrangement like this or another type of (external) support, with a clear role for governments, international organizations, NGOs, corporate philanthropy or social venture capital. Or, as in the case of Grameen Shakti, a reliance on micro-finance 'soft credit' schemes for instalment payments for solar home systems that is offered via its relationship with the Grameen Bank. Sunlabob and Kamworks developed rental schemes in conjunction with micro-finance institutions and donors. Funding is also necessary for covering upfront investment and operating costs because it is relatively expensive to set up and maintain a stable system of electricity provision in remote rural areas – those locations where the true challenge of 'sustainable energy for all' lies. In many places, the situation is comparable to Cambodia and Laos, with similar issues as those faced by respectively Kamworks and Sunlabob. Until the moment that local, village-based systems can be connected to a regional or national grid in collaboration with a domestic utility, costly models will have to be set up and kept running. Even then, however, the problem may remain that (remote) rural consumers pay a higher price for electricity than those in traditionally grid-connected urban areas, which is likely to raise questions about equity (at the national level) at some point.

There may be locations where cheaper solutions are available, as the Indian case with electricity generation from discarded husk rice shows. Even there, however, funding for pilots and the start and set-up of the whole system is needed, requiring donors and/or socially-oriented investors with a longer-term orientation. With declining (relative) costs of renewable energy (see, for example, the price development of solar panels), possibilities to undertake more activities for less funding might increase, depending on local weather and geographical conditions, but a long-run commitment to a specific approach is necessary given the complexities of operating and building networks of suppliers. These types of support often run counter to donor approaches of funding for larger-scale one-off projects, competitive 'bidding' for grants, or shifting from one location/partner to another to cover multiple countries, satisfy diverse constituencies or jump on the bandwagon of a successful venture elsewhere.

There is also the issue, raised by interviewees, that 'theoretically' the role of the private sector is widely accepted, also by international (development) organizations, but that an understanding of the practical side of how business operates and what it requires to realise a profitable approach is something different. It is, for example in the case of sustainable energy, relatively easy to underline the importance of the "right" business models, but the road to building and then supporting such bottom-up entrepreneurial activity to sufficient scale is complex and protracted. Large, stand-alone donor programmes can distort local markets if they do not relate to local companies that need to play a role in longer-term solutions – especially in the case of rural electrification, small-scale rather than large business (let alone multinationals) will be actively involved. These are concerns that are worthwhile to consider in shaping the (future) involvement of companies in establishing long-term sustainable markets in combination with support from governments and donor organizations, where applicable. Some issues, such as renewable, rural off-grid electrification, may need a form of collaboration by public, private and non-profit actors who subscribe to trajectories that become economically viable in the longer run or that rely on mixed forms of funding or partnership arrangements. The specifics may differ depending on local circumstances, as some business models seem to have the potential for economic viability, provided that there is sustained commitment based on in-depth, local knowledge of markets, consumers and products/services. Further in-depth research on the peculiarities and dynamics would be very useful.

Related to the difficulties and limitations of collecting information about local companies active in remote rural settings, our article contained only a relatively small number of illustrative cases. While we covered a variety of technologies and approaches, embedded in a thorough examination of the available literature, follow-up studies that include more companies and from other countries would be helpful to shed more light on the topic. For the selection of a sample it should be noted, however, that small entrepreneurial ventures tend to be little formalized and often rather locally-oriented, and may thus be less or not visible on the internet, especially if they operate in poor regions where access is limited. This means that only those (larger ones) that already have international connections may show up through a web-based search. A second point is that many initiatives in, for example, sustainable energy, appear to be (predominantly) run by NGOs or supported by donors to such an extent that one cannot really speak of a private-sector activity.

Finally, although sustainable energy is a crucial lever for development, research on other important social and/or environmental issues could generate additional insight, also to extend our initial exploration in relation to the business model literature. Despite a growing interest in business models, academic publications hardly reckon with the specificities of developing countries, as we indicated in our article. As an initial contribution, we discussed our findings against a generic framework that we deemed most appropriate for the purpose, but this is something that deserves further careful attention as well.

Appendix A / Table 5.3: Overview of interviews on business models for sustainable energy

Actor	Organization	Participant role	Date and time
Public	Energy and Environmental Partnership (EEP) Mekong	Chief Technical Advisor	Semi-structured; 20 April 2011; 45 minutes
Public	SNV Dutch Development Organization	Senior Advisor Laos	Semi-structured; 7 May 2011; 60 minutes
Public	SNV Dutch Development Organization	Senior Advisor Cambodia	Semi-structured; 23 June 2011; 45 minutes
Public	United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP)	Chief Energy Security and Water Resources	Semi-structured; 6 June 2011; 45 minutes
Private	Nollen Group / Green Ventures	Portfolio and Sustainability Director	Semi-structured; 27 June 2011; 45 minutes
Private	JanSun Renewable Energy	Founder and Managing Director	Semi-structured; 20 June 2011; 60 minutes
Private	Kamworks	Founder and Managing Director	Semi-structured; 4 May 2011; 80 minutes
Private	Lao Intergro	Energy Consultant and Managing Director	Semi-structured; 22 June 2011; 45 minutes
Private	Sunlabob Renewable Energy	Founder and Managing Director	Semi-structured; 6 May 2011; 75 minutes

CHAPTER 6

SMART CITY PILOT PROJECTS: EXPLORING THE DIMENSIONS AND CONDITIONS OF SCALING UP[10]

6.1. Introduction

In recent years, many cities around the world have witnessed a proliferation of pilot projects that aim to test or develop new solutions to address urban sustainability issues, improve the effectiveness of urban services, and enhance the quality of life of citizens. These projects, often labelled as 'smart city' projects, come in many forms, sizes, and types and vary in their degree of technical and organizational complexity. Helped by a growing supply of (inter)national funding opportunities, city administrations have been actively initiating, promoting, and supporting these projects, reflecting the belief of urban policymakers and other stakeholders that technology might help to make the city more liveable, sustainable, competitive, and inclusive while improving public services (Hollands, 2008; Townsend, 2014).

A wealth of funding opportunities for smart city projects has become available in recent years. Europe's Horizon 2020 programme provides €18.5 billion in subsidies for clean energy, green transport and climate actions, implying significant funding opportunities for smart city-related research (most of it to be conducted in collaboration with local authorities and companies). Also, the European Regional Development Fund (ERDF) regulation requires that a minimum of 5% of the funds is allocated to sustainable urban development, which amounts to a minimum of €16 billion between 2014 and 2020. The smart city equally appeals to the private sector. Multinational enterprises (MNEs) in the information and communication technology (ICT) industry have discovered the potential of smart city technology as a high-growth business opportunity. These firms offer a great number and variety of solutions, ranging from energy-efficient and carbon-neutral solutions for city logistics, building management, and public street lighting, to big data analytics tools and dashboards for optimization of public services. Accelerated market growth is expected in the next few years. As an indication, Deloitte (2015) expects the global smart cities market to grow from US$400 billion to US$1.5 trillion by 2020. To explore and exploit new business opportunities in this sector, many of these firms have set up city-centric programmes, of which Cisco's 'Smart+Connected Communities' and IBM's 'Smarter Cities' are prime examples. Moreover, these companies engage in local pilot projects and partnerships with a number of urban stakeholders, including housing corporations, local

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[10] This chapter was published in *Journal of Urban Technology*, 2017, *24*(4), 51-72, with Willem van Winden as co-author (for more details, see co-author statements included elsewhere in this dissertation).

authorities, grid owners, and energy companies, to test or demonstrate innovations in real-life contexts.

The growing interest from city administrations, businesses, research institutes, and all kinds of other urban stakeholders in smart cities has led to a great number of pilot projects in recent years. However, many of them remain small and experimental, and fade out after a (subsidized) demonstration phase; as a consequence, the impact of solutions developed in these pilot projects on urban development often remains limited (Vilajosana et al., 2013). There are obvious cases where scaling does not happen. Some pilots are merely set up to offer inspiration, demonstrating a future possibility or solution without claiming immediate commercial viability. Such projects are typically run in a protected/shielded situation with regards to funding and/or regulation. Other pilot projects end because they fail in terms of technology, feasibility, a lack of demand/interest or otherwise, and scaling in whatever form makes no sense.

Nevertheless, the lack of scaling is widely perceived as a major problem that needs to be addressed by policymakers on all levels. The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) reflects that scaling and replication are considered to be important, and promotes the sharing viable business models, financial tools and procurement instruments in order to make smart city projects economically sustainable instead of dependent on temporary subsidies or grants. Similarly, the requirements for receiving funding from the European Union (EU) for projects is oftentimes conditional on the inclusion of dissemination/replication activities (roadshows, handbooks, toolkits, or online tools enabling other cities to draw lessons and replicate projects).

Despite these policy concerns, the issue of upscaling solutions from pilot projects has been sparsely addressed in the growing literature on smart cities. Many recent papers have focused on defining and conceptualizing smart cities on a higher level of abstraction (Albino et al., 2015; De Jong et al., 2015; Gil-Garcia et al., 2015; Höjer and Wangel, 2015), or analyse mega greenfield smart city projects such New Songdo in South Korea (Shwayri, 2013, Halpern et al., 2013) and Caofeidian International Eco-City in China (Joss and Molella, 2013). Some contributions offer typologies of smart city initiatives, mostly based on the domains to which they apply, including economy, mobility, environment, people, governance, and living (Giffinger et al. 2007). Only a few studies zoom in on the concreter level of smart city initiatives, projects, and business models (Bakıcı et al., 2013; Hielkema and Hongisto, 2013; March and Ribera-Fumaz, 2016; Mulligan and Olsson, 2013), or address the issue of scaling in related fields (May et al., 2015; Van Leeuwen et al., 2015). In this paper, we aim to fill this gap, and make a more thorough analysis of the factors and conditions that affect the scaling of smart city projects. Our focus is primarily on pilot projects in the field of energy and mobility, in which both public and private stakeholders collaborate to develop smart city solutions.

Our objective for this paper is twofold. First, we want to refine and unravel the rather broad concept of scaling. While the importance of upscaling is widely recognized, the concept remains fuzzy, undefined, and undifferentiated. Second, we intend to better understand the conditions and requirements that drive or hinder upscaling processes in various types of smart city projects. Our analysis intends to enhance insights in scaling processes, and may also help to design pilots in such a way that their upscaling potential is maximized.

This paper is structured as follows. The next section clarifies and refines the notion of upscaling based on existing definitions and descriptions, and presents a typology of upscaling in smart city pilot projects. The section after that identifies and discusses a number of factors and conditions that play a role in scaling processes, drawing on insights from an interdisciplinary theoretical framework. That is followed by a section that contains an illustration of upscaling processes, based on an analysis of three smart city pilot projects in Amsterdam. The final section discusses the findings, draws conclusions, and derives some policy recommendations and avenues for future research.

6.2 Dimensions of scaling and smart city project types

There is no single or agreed definition of upscaling. International organizations such as the World Bank and the World Health Organization (WHO) have adopted definitions of upscaling which can be applied to a broad number of domains. The World Bank (2005) notes in relation to upscaling that “implicit in the concept of scaling up is the need to go beyond business as usual, to embrace new technologies, new institutional arrangements, and new approaches” (World Bank 2005, 16). Upscaling in this respect includes spatial dimensions (geographically enlarging projects, practices, or programmes, and reproducing benefits from one local context more broadly); intertemporal dimensions (deepening the impact of projects or programmes by expanding their duration and continuity); and dimensions related to influencing the (inter)national institutional environment to accommodate upscaling processes (World Bank, 2005). Hartmann and Linn (2008, 8) adopt a broad definition for upscaling in line with the World Bank, and define it as “expanding, adapting and sustaining successful policies, programmes or projects in different places and over time to reach a greater number of people”. In the context of health services, the WHO describes upscaling as “deliberate efforts to increase the impact of health service innovations successfully tested in pilot or experimental projects so as to benefit more people and to foster policy and programme development on a lasting basis”, which are “backed by locally generated evidence of programmatic effectiveness and feasibility obtained through pilot demonstration or experimental projects” (WHO 2009, 1). Although this WHO definition is developed specifically in relation to health services, the element of local development and testing of solutions in pilot projects, before scaling them up beyond this local context, is also relevant for other domains.

Other classifications and descriptions of upscaling from the field of development studies are relevant for other domains as well. Uvin (1995) identifies four broad directions for upscaling, which include: Quantitative upscaling, which means reaching more people in the same area, or expanding the geographic area in which a solution is applied; Functional upscaling, which constitutes expanding the scope of activities; Political upscaling, which entails influencing the (local-level) political agenda and institutional frameworks to better facilitate the process of scaling up; And organizational upscaling, which includes enhancing organizational capacity (either by internal capacity-building or via external collaboration with partners) to accommodate the broader diffusion and implementation of solutions (Uvin, 1995). These four directions of scaling are rather similar to the dimensions of upscaling identified by the World Bank (2005), and provide insight into the broad directions for scaling up solutions beyond the (local) context in which they have been developed.

Another distinction between upscaling typologies relevant to a broader set of domains is developed by Cooley and Kohl (2005). They make a distinction between expansion, replication and spontaneous diffusion: Expansion involves bringing a pilot to scale within the organization(s) that developed it; Replication, in their definition, means scaling up by others than the organization that originally developed the initial pilot or model intervention (for example through franchising as one model); And spontaneous diffusion, involving the spread of good ideas or practices largely of their own accord.

Based on these definitions of upscaling of international organizations, and building on the classifications of scaling identified by Cooley and Kohl (2005), we propose three types of scaling for smart city solutions: roll-out, expansion, and replication. We speak of *roll-out w*hen one of the pilot project partners uses the pilot's test results to scale up the developed product, service or solution (market roll-out), or apply the lessons of the experiment within their own organization (organizational roll-out). This type of scaling applies to manufactured smart city products, or service innovations. We define *expansion* as the type of scaling that happens when the pilot project is not closed or dissolved, but is rather expanded with new partners or users to the project, or by enlarging the geographical area in which the project operates. This type of scaling is relevant for smart city projects such as mobility platforms, tourist smart cards, energy exchanges, online neighbourhood communities. The third type of upscaling that we identify is *replication*, the most complex type, which can apply to all types of smart city solutions which are tested and developed in pilot projects. With replication, the solution that has been developed in a pilot project is replicated in another context, which can be in another organization or part of the city, as well as in another city altogether. Hence, replication can be done by the original pilot partnership but also by others, and the replication can be exact or by proxy.

Scaling type	**Description**	**Manifestations**	**Examples**
Roll-out	Bringing a smart city solution to the consumer or business-to-business market, or applying the solution in the entire organization	Market roll-out Organizational roll-out	Smart energy meters introduced in consumer market; system for car sharing implemented in municipal organization
Expansion	Add more partners, users, or functionalities to a smart city solution, or enlarging the geographic area in which the solution is applied	Quantitative expansion Functional expansion Geographic expansion	Add functionalities or partners to a tourist smart card system; enlarge the geographic area of a smart lighting solution
Replication	Replicate (exactly or by proxy) the solution in another context by the original partners involved in the pilot project, or by others	Organizational replication Geographic replication	Replicate a tested vehicle-to-grid system in a new part of the city; replicate a smart traffic light solution in another city

Table 6.1: A typology for upscaling

A smart city project can be subject to several types of scaling; for example, a smart card solution for tourists can be expanded (by adding more partners) or replicated (in another city). Also a distinction must be made between scaling of the project itself (which is the case in expansion and replication) or scaling of particular products/services that were developed in the project (as is the case in roll-out). In the latter case, the project served mainly as test environment, and is dissolved in the scaling stage. Our empirical analysis of smart city pilot projects in Amsterdam will further illustrate these three scaling types and their characteristics. In the next section, we will take the next step and identify, drawing from a variety of literatures, a number of requirements and conditions for upscaling.

6.3 Conditions and factors that affect scaling

Several literatures offer clues on what drives upscaling processes. In this section, we identify the following drivers and enabling conditions: prospects for economies of scale, the management of ambidexterity, knowledge transfer mechanisms and incentives, regulatory and policy frameworks, data exchange and system interoperability, and (lack of) standards to measure return on investment of smart city projects. Each of these factors are described in more detail below, and will be connected to the types of upscaling at the end of this section.

Prospects of economies of scale

Successful pilot projects will be scaled up more easily when there is a prospect of economies of scale (leading to lower unit costs and/or higher profits), and an incentive to capture them. Economies of scale imply that fixed costs (including the costs of research and development (R&D) and pilots) can be spread out over a larger volume (O'Sullivan et al, 2003). This mainly applies to the roll-out type of scaling, in which a single firm or organization is able to capture the benefits of scaling. In this respect, Hartman and Linn (2008, 19) note that where commercial firms have a market incentive for upscaling, public and not-for-profit organizations have a tendency "to move from one new idea to the next, from one project to another", rather than to scale up.

In the last decades, a traditional supply-oriented view on economies of scale has been enriched by a network perspective. In a growing number of information-intensive sectors (and relevant for many smart city solutions), the value of a product or service increases with the number of people who use them; examples are mobile phones and social media applications. These economies are referred to as 'network economies' or 'demand-side economies of scale' (Shapiro and Varian, 1999). To capture such network economies, developers of smart city products or services have an incentive to build a large user base in a short period, taking initial losses for granted. A large user base offers scope for auxiliary services that further enhance the value of the product. For example, when more people drive electrical cars, there is a bigger market for charging stations, or specialized repair services. The recent emergence of digital platforms (such as Uber, Airbnb and Kickstarter) has added a new dimension to network effects. In platforms, network effects are two-sided: the growth of supply and the demand side of the platform (for example, riders and drivers in the case of Uber; suppliers and users of local renewables in the case of a local energy platform) must be well balanced to create value for both sides.

If one side of the platform is underdeveloped, the scaling process stalls. To prevent this, a scaling strategy could be to subsidize growth in the start-up phase (in the case of Uber, the firm gave free rides to do this). In this regard, Parker et al. (2016) discuss the typical "chicken-and-egg" problem: users won't come to a platform when it has no value to offer, and there is no value if there are no users. Many platforms fail to take off because they do not solve this dilemma. This platform perspective on scaling is highly relevant as many smart city solution have platform characteristics: mobility platforms (where traffic information is exchanged), energy platforms (that intermediate between supply and demand of renewable energy), and all sorts of smart city applications in the realm of the sharing economy.

Management of ambidexterity

Scaling requires an adequate management of the transition from the pilot/testing phase of a project to the exploitation phase. From an organizational perspective, the literature on ambidexterity offers important insights. A central tenet here is that explorative activities such as innovation and R&D (or: the pilot stage of a smart city solution) require different competences than activities related to large scale production and exploitation (the scaling phase). Organizations face the challenge to strike a balance between exploration and exploitation (March, 1991, and many others).

A balanced approach of pursuing both exploration and exploitation (i.e. ambidexterity) is essential for performance. Organizations that focus on exploration to the exclusion of exploitation bear the costs of experimentation but gain little of its benefits, whereas an excessive on exploitation will hollow out a firm's competitive performance in the longer run. Scholars have discussed how organizations can achieve and manage balance (Andriopoulos and Lewis, 2009; Lavie et al., 2010; Lavie and Rosenkopf, 2006; Raisch et al., 2009). Most accounts argue for some form of separating exploration from exploitation (Stettner and Lavie, 2014). This separation can be temporal, where a firm manages transitions between exploration and exploitation over time (Brown and Eisenhardt, 1997). Also, it can be organizational (Benner and Tushman, 2003), enabling a firm to maintain distinct activities while engaging in internally consistent tasks within separate organizational units, dedicated to either exploration or exploitation (O'Reilly and Tushman, 2008; Smith and Tushman, 2005). In similar vein, Ries (2011, 261) discusses the challenge of connecting innovation teams in companies with the mainstream company operations. Isolating the innovators from the parent company rarely leads to sustainable innovation and scaling, as operational managers will strongly resist the innovations "sprung upon them". He argues for creating an 'innovation sandbox' in which the innovation team can work independently, but remains in close contact and accountable to the parent organization. Similarly, Samoff and Molapi Sebatane (2001) find that upscaling is hampered when vested interests within an organization accept a small pilot but perceive scaling it as a threat.

In the context of upscaling smart city solutions from pilot projects, the concept of ambidexterity has significance; smart city pilot projects inherently involve exploratory activities, set up to test new technologies or innovative concepts. If we follow the analogy and frame the process of scaling as the transition to the exploitation stage, the literature suggests performance will be enhanced by separating the two stages; scaling up requires different competencies, and this must be accounted for. For each of the different manifestations of upscaling, organizations should therefore take a balanced approach to their exploration and exploitation activities, and arrange a connection between the innovation team and operations/senior management.

Knowledge transfer mechanisms and incentives

Knowledge transfer within and between organizations is often necessary for scaling to happen (Du Plessis, 2007; Foos et al., 2006; Seidler-De Alwis and Hartmann, 2008; Tamer Cavusgil et al., 2003), especially for the replication type of scaling. Replicating a successful smart city solution developed in context a to context b requires that the know-what and know-how (tacit or explicit) is transferred from place to place, but also needs a contextualization of knowledge. Especially the transfer of tacit knowledge, which is "encoded knowledge and resides in the firm's system" that is "difficult to interpret and transfer (i.e. uncodified) from one firm to another" (Tamer Cavusgil et al. 2003, 7), is key in the replication process. Replicating a project in another cultural context requires an adequate accommodation to cultural values and social-interaction patterns, and often implies a re-configuration of the partnership. The simpler the institutional framework and the less complex the relationships between actors, the swifter and more successful replication can be achieved (Binswanger and Aiyar, 2003).

Large companies often are able (and have financial incentives) to organize effective knowledge transfer mechanisms. In the smart city domain, MNEs like IBM or Cisco have developed global smart city programmes that help them capture the benefits from their presence in many locations and their existing relations and contracts with cities across the world. These companies deploy internal knowledge transfer mechanisms, enabling them to apply lessons from pilot projects effectively, and sell smart city solutions in a large number of cities (Paroutis et al., 2014; Söderström et al., 2014). However, many smart city projects are run by municipal authorities and smaller, local players, that do not have an international network of offices, and lack the competences and financial incentives to replicate solutions elsewhere. In such cases, knowledge transfer is more difficult to organize, and good pilot results are often not disseminated. The European Commission (EC) –a big funder of smart city projects– recognizes the relevance of knowledge transfer as a condition for replication, and stipulates that project proposals must have work packages on knowledge sharing and dissemination in order to facilitate replication. In the recent Horizon 2020 'smart cities and communities lighthouse projects' call, leading cities are invited to develop smart city solutions with replication potential for "follower cities", that must be part of the consortium from the outset; Consortia must make explicit how the knowledge transfer is organized between contexts, and dedicate substantial resources to it (EC 2013; 2017).

Regulatory, legal and policy frameworks

Regulatory, legal and policy frameworks play a conditioning role in scaling processes of smart city pilot projects. Scaling up solutions will be easier in cities with high ambitions in the smart city realm (for example reducing CO2 emissions, increasing the use of renewables, reducing energy consumption, and public service digitization). However, in many cases, public funding is a bottleneck. Vilajosana et al. (2013) find that many municipal governments are cash strapped, and have often only piecemeal funding (often external) available for small projects; Scaling is particularly difficult when the pilot relies on expensive technology and other resources (Hartman and Linn, 2008).

Regarding energy-related smart city projects, Vilajosana et al. (2013) note a lack of consistent policy frameworks on key issues, such as feed-in tariffs and carbon pricing; scaling and replication across national borders is hampered by large variations in rules, legislation and incentive schemes. Also, public procurement policies and regulation can affect scaling. One the one hand, a local or regional public administration can act as launching customer when a pilot project results in a good solution, and thus contribute to the scaling of it. On the other hand, public procurement rules can also imply that companies that participated in a successful pilot cannot take for granted that they will win the big order in the scaling stage.

Some pilot projects fail to scale up because they are, for the sake of experimentation, shielded from real-world legislation and market forces. In the literature on transition management and strategic niche management (Coenen et al., 2010; Hoogma et al., 2004; Kemp et al., 1998; Smith et al., 2005; Truffer et al. 2002), pilot projects are framed as playing out in ‘protected niches’, which can be defined as “protected spaces created by specific actors –companies, policymakers or citizen groups– with the strategic aim to test and develop a technology and to prepare it for further diffusion” (Truffer et al. 2002, 113). Niche development occurs through experiments in concrete places (e.g. though pilot projects in cities). At the same time, local experiments tend to add up to a ‘global niche’ through the exchange and sharing of lessons and insights across locales (Geels and Raven, 2006; Raven and Geels, 2010). This leads to the articulation of common/shared problem agendas, expectations, theories, and success narratives, articulated and circulated by intermediary actors such as industrial lobbies, policy networks, user groups, and not-for-profit organizations, thereby influencing new experiments and funding programmes for research and innovation (Carvalho, 2014). In this approach, scaling does not unfold at the project level but rather is a long-term process where pilots may fail (due to overprotection or shielding) but play their part to achieve a system transition.

Data and systems interoperability

Many smart city projects rely on data exchange between organization, and interoperability of information technology (IT) systems. This is especially relevant for multi-stakeholder platform-type projects in which data exchange and sharing is a key element. Here, scaling is hindered when there are no (or not yet) widely accepted technical standards. Walravens and Ballon (2013) note a lack of transversal and interoperable technological platforms to manage the huge amounts of data generated in smart city contexts. In addition to technical compatibility issues, the willingness of partners to engage in interorganizational data sharing matters as well. For data sharing on smart city-related platforms, such as Geographic Information Systems (GIS), Nedović-Budić and Pinto (2000, 461) identify that "the nature of the coordination process is key to establishing an atmosphere of trust and mutual collaboration and for the overall success". Trust inherently matters in interorganizational exchange relations (Zaheer et al., 1998), and is an important condition for partner organizations to share their data.

Standards to measure return on investment

Many smart city technologies are in an immature stage and it is unclear or uncertain what they will deliver in terms of return on investment. They typically hold promises of costs savings and efficiency improvements, but there are high margins of uncertainty, especially in the domain of clean energy solutions where returns depend on fluctuating energy prices, feed-in tariffs, and unpredictable policies, subsidies and regulations. Vilajosana et al (2013) signal a dearth of appropriate and systematic methods to identify return on investment of smart city technologies. For the private sector, all this "translates into a certain immaturity of the market", which in turn is enhanced by the complexity of relationships with the public sector (Vilajosana et al. 2013, 129), resulting in low capital investments.

Summing up

Table 6.2 presents a synthesis of the findings and insights discussed in the last sections. The two heading rows repeat the three types of scaling identified in section 6.2: roll-out, expansion, and replication. Next, the table summarizes the factors and conditions that affect upscaling, as discussed in the last section. Given the large diversity in smart city projects, the scaling dynamics is contingent on the type of smart city solution/innovation that is being tested (a product/service, a process innovation, a platform-type innovation, or a more systemic innovation); Also, as discussed, the weight of the requirements varies between the three types of scaling (roll-out, expansion and replication).

Scaling types **Conditions**	**Roll-out**	**Expansion**	**Replication**
	Bringing a smart city solution to the market (market roll-out), or apply it in the entire organization (organizational roll-out)	Adding partners or users to a smart city solution, enlarging the geographic area, or adding features	Replicate (exactly or by proxy) the solution in another context (organization, geographic area), by the original pilot partnership or by others.
Mainly applies to	Product and service innovations	Projects, platforms, process, and system innovations	Projects, platforms, process, and system innovations
Examples	Smart meters and displays tested in the pilot are now produced at large scale by private company	Mobility app covers wider urban area and also offers parking solutions	Traffic light solution that gives green light to emergency services is replicated in another city
Scaling up a smart city pilot project requires:			
Prospect of economies of scale -Supply-side economies of scale -Network economies	X	X	X
Effective knowledge transfer mechanisms and incentives			X
Effective management of ambidexterity -Separation between exploration and exploitation -Alignment between pilot team and senior management	X	X	X
Enabling regulatory, legal and policy frameworks -Vision and ambitions of public authorities -Procurement policy and regulation -Public funding for scaling -Preventing overprotection of the pilot	X	X	X
Data, standards, and systems interoperability		X	X
Standards to measure returns on investment	X	X	X

Table 6.2: Scaling types and conditions

6.4 Methodology

To illustrate the dynamics of scaling, this section presents an account of three smart city projects developed in Amsterdam. The first case is Climate Street, a pilot project which illustrates the roll-out of product and service innovations, although broader expansion and replication were initially envisioned; The second case is Energy Atlas, in which expansion and replication of an information-based platform on energy data is central to the upscaling process; The third and last case is Cargohopper, a sustainable city logistics solution using electric vehicles, that has been replicated in several cities. For each case, we discuss the process of upscaling in more detail.

For this study, we adopted a qualitative research approach based on a multiple case analysis. Evidence was collected through a documentation study combined with semi-structured face-to-face interviews with project leaders and stakeholders of smart city pilot projects, and representatives from the Amsterdam Smart City platform. All selected projects were in an advanced development stage or finalized at the time of our evaluation, to allow a thorough analysis of upscaling in the project. The three cases presented in this paper (Climate Street, Energy Atlas, Cargohopper) were selected on the basis of theoretical sampling from a set of 12 Amsterdam Smart City pilot projects, which have been evaluated between November 2014 and April 2016. A total of 37 interviews were conducted with participants in these 12 smart city pilot projects, with 12 interviews specifically related to energy efficiency (see appendix A for an overview). Interviewees included representatives of the city administration, multinational enterprises (MNEs), small- and medium-sized enterprises (SMEs), grid management firms, and utilities involved in one of the selected projects. Interviews lasted between one hour and two hours, and were transcribed into detailed interview reports. These results were triangulated with secondary sources such as internal evaluation documents, press releases, and personal communications between project partners (for further details, see van Winden et al., 2016). Each case discusses different types and mixes of upscaling processes in smart city projects, and identify some of the underlying dynamics driving or hindering this process. Although all three projects relied to some extent on subsidies in their pilot stage, they are not excessively ‘shielded’ by legal or regulatory protection, which would have reduced the chance of upscaling from the outset. All three forms of upscaling (roll-out, expansion, replication) are illustrated by one of the cases presented in the next section.

For each case, we briefly describe the history, rationale and development process, and identify the key organizations in the partnership. Inherent to our focus on upscaling of smart city solutions from pilot projects, we identify how the upscaling process has unfolded in each specific project, and what drivers and barriers were faced.

6.5 An illustration of scaling dynamics: three cases from Amsterdam

Climate Street

Climate Street is an illustrative case that demonstrates (i) the co-existence of multiple types of scaling from one pilot project; (ii) the significance of ambidexterity in the roll-out process; (iii) the difficultly of replication in the absence of knowledge transfer incentives; and (iv) the importance of securing public funding after the pilot stage.

Launched in 2009, Climate Street was aimed at turning a busy street in Amsterdam's city centre into a living lab and showcase for smart products and services, to show how to make a high street more sustainable in all respects. Climate Street was envisioned as a beta lab: a platform for all sorts of experiments that would enhance sustainable urban development. The number of activities was very broad from the outset: retailers in this street were invited to apply a broad range of smart city products that would reduce energy use or waste (product innovations), and various experiments were set up in the fields of waste collection, logistics, and innovative street lighting (process innovations). For technology companies and utilities, the project leadership positioned the street as an interesting living lab where they could test new products that could later be commercialized (or 'rolled out' in our terminology). In some cases, the project management team actively approached companies, inviting them to test their products and services there; in other cases, companies approached the project management, to inquire about the possibility to test their products and services in Climate Street. The city was the main funder of the programme, and helped to set conditions for realising urban innovations: permits, solving legal issues, access to civil officers with the right skills and competences.

The partners in the pilot project had different roles and interests. Various city departments involved in the project saw the Climate Street as a unique lab to learn how to work with local retailers, have them adopt cleaner technologies, and thereby contribute to the cities' ambitions regarding emission reduction. The lessons could be disseminated to other retail streets. Moreover, the city administration used the street to experiment with alternative urban services (in the field of garbage collection and street cleaning), expecting that lessons learned could be applied in the municipal organization at large (a case of organizational roll-out). Retailers hoped that applying new technologies would help them achieve saving on their energy bills, and/or increase the sustainability of their businesses. The technology companies and services providers hailed the pilot project to be a unique living lab to test their new products and concepts in a real-life setting, and then roll them out in a later stage (market roll-out). Thus, the partners, implicitly, had different expectations and ambitions regarding the scaling of the Climate Street project. Also, the city administration envisioned the project as a demonstration, to be replicated in other cities.

All envisioned forms of upscaling turned out to be rather problematic. To the knowledge of the project leader, the only roll-out success was realized by Quby, a start-up firm that tested a smart energy display in the Climate Street project. The test was successful, and the solution was bought by Eneco (a major electric utility in the Netherlands) that sold over 100,000 energy displays to date. In this case, exploration (pilot project) and exploitation (a case of market roll-out) were explicitly separated and performed by different organizations. In terms of replication of the concept, the city administration considered the Climate Street project as an example to be followed (replicated) by other streets in Amsterdam, and possibly beyond. To enable other cities to set up a similar project, a consultancy agency was hired to write a document titled 'blueprint for sustainable shopping streets', a handbook and source of inspiration for other high streets based on the experiences in the pilot project. While it is unclear to what extent this blueprint has been used for replication, the project had a broader impact: due to the effective communication of the Amsterdam Smart City platform, Climate Street attracted wide attention from professional media and local governments, nationally and internationally, and many delegations made study visits to learn from experiences in Climate Street. It is beyond the scope of this study to assess whether these visits have played a role in replication, but at least some degree of knowledge transfer took place.

While Climate Street was initially envisioned as a permanent lab for experiments that would contribute to sustainable development in the city, this failed to materialize due to a lack of public funding after the pilot stage and ended in 2012. The project was unable to reach the point of being financially self-sustaining through contributions of private partners. Hence, Climate Street reflects the importance of commitment and ownership amongst project partners as a condition for successful upscaling.

Energy Atlas

Energy Atlas is a platform-type smart city innovation, in which key public and private players in the local energy system decided to share their data and create an online interactive platform (the 'Energy Atlas') that reveals data on real energy, water and sewage use on the level of the building block for the entire city of Amsterdam. The Energy Atlas helps to identify the geographic locations in the city with the highest potential to adopt new energy solutions. The case includes both expansion and replication in the upscaling process, and demonstrates that: (i) the vision and ambitions of public authorities can be an important enabling factor in scaling processes; (ii) knowledge transfer and learning mechanisms are crucial for wider dissemination of smart city solutions; (iii) system interoperability is key to facilitate effective data sharing between different organizations; and (iv) that alignment between the pilot team and senior management of parent organizations is important in the design and scaling stage.

In its initial development stage, the project was supported by European funding from the TRANSFORM project, executed between January 2012 and August 2015, in which six European cities collaborated with the aim to reduce carbon emissions (Van Warmerdam and Brinkman, 2015). The Amsterdam city administration was the driving partner in the project: it led and managed the project from the outset, and organized the process of partner engagement and data integration. Participating utilities and housing corporations in Amsterdam agreed to provide their data for free, on the condition that the platform would be open and would not reveal energy use on the level of individual clients. It was a key challenge for the partners to cluster information on clients in such a way that it would be impossible to trace back individual use. Despite many technical, legal and data issues, senior management of the partner organizations backed the project, as they realized the value of sharing data in the Energy Atlas platform. The project partners, as well as experts in the energy sector that we interviewed, consider the Energy Atlas developed in Amsterdam a great success. It is internationally unrivalled, especially because it gives up-to-date and real (rather than projected or estimated) data on a wide variety of energy consumption and production in the entire city. The Atlas now floats without European subsidies, and the local partner management boards have committed to continue to feed the platform with data, and keep it technically up to date. In scaling up the Energy Atlas developed in Amsterdam, the planned process of expanding of the number of partner organizations willing to share relevant energy data in the platform will enhance the functionality and usability as a decision-making tool even further.

Replication of the Energy Atlas beyond the context of Amsterdam was a central ambition of the project partners from the outset. To this end, knowledge sharing was facilitated by a 'Replication and Exploitation Campaign', aimed at transferring the tools and lessons learned about energy transition to other cities. Three organizations, Accenture, the Austrian Institute of Technology, and Macomi, developed an online 'Decision Support Environment' (DSE) for urban energy planning, which enables partner cities to simulate scenarios, and helps to design and assess interventions in the energy system. In addition, handbooks and masterclasses were developed to transfer the lessons on energy transition that were developed in the project. A key incentive to stimulate this widespread knowledge sharing came from the conditions related to the European funding on which the project relied, as well as the open data vision of the project leader in Amsterdam. In addition to sharing knowledge externally, one of the interviewees identified that consultancy firm Accenture (who played an important role in the development of Energy Atlas) also uses its experiences and lessons learned in Amsterdam to advice other cities on this topic. This illustrates how multinational firms can leverage internal knowledge transfer mechanisms to use experience from pilot projects in one local context, and use these experiences in their activities in other contexts.

Our interviewees indicated that replication in other cities remains difficult. The value of the Energy Atlas critically depends on detailed geo-spatial and energy data inputs that must come from a variety of local partners, including different utilities, housing corporations, and municipal departments. Thus, replication the Atlas elsewhere requires the formation of new local coalitions, involving high communication and transaction costs. Data issues can also be a complicating factor. Given that this information is embedded in the systems of different partners, a limited degree of system interoperability and compatibility between existing data sets can potentially be a hindering factor in this process. The developers of the tool in the pilot project in Amsterdam identified a set of legal, economic and data quality challenges for open energy data, and recognize their "limited success in getting the right data at the right level of granularity", arguing that data owners often face technical difficulties and do not perceive the value behind opening of their data (Accenture 2015, 17). Existing knowledge and experience in working with relevant systems to develop an Energy Atlas, such as Geographic Information Systems (GIS), can contribute to a successful development process. Amsterdam's Energy Atlas could draw on existing databases and maps, while many cities (especially smaller ones) lack the expertise of such systems.

The replication ambition for the Energy Atlas was not confined to the consortium that initially developed it, as many municipalities in the Netherlands expressed their interest to somehow replicate the Energy Atlas as well. Inspired by the Amsterdam example, the association of Dutch municipalities is currently developing a national version of the Energy Atlas. It is supported by the national government, and the Amsterdam team acts as advisor.

Cargohopper

In the Cargohopper project, a private logistics company developed and tested a sustainable solution for inner city deliveries using electric transportation. The solution was first piloted in the city of Utrecht, and was then replicated in Amsterdam in collaboration with the city administration. It demonstrates that (i) firm-level internal knowledge transfer is important for replication; (ii) effective management of ambidexterity is needed to move from exploration to exploitation; (iii) prospects of economies-of-scale can be a prerequisite for a scalable business model; and (iv) local-level regulations –in this case a strict regime to ban diesel trucks from the city centre– can be a driver of sustainable innovation.

The logistics company Transmission was the initiator of the project. This company, with various establishments in the Netherlands, developed the idea for the Cargohopper as a response to the growing number of Dutch cities that had introduced bans of large diesel trucks from inner city zones (labelled as 'environmental zones'), in order to limit pollution and congestion. The Cargohopper solution consists of two interrelated components: an electric freight vehicle and a smart distribution system. The electric freight vehicle has the features of a ‘road train’ with separate carriages, and delivers shipments to businesses in the city’s central area where no diesel trucks are allowed. In a distribution centre (located at a facility just outside the zone), shipments are processed, bundled, and loaded onto the electric freight vehicle. These shipments are bundled by address into separate carriages, allowing efficient delivery to businesses based on the proximity of delivery addresses in the same area. Amsterdam’s city administration allowed Cargohopper to operate within the environmental zone in the city centre for the delivery of goods, and partially subsidized the development of the first electric vehicle. For lead project partner Transmission, the pilot project created an opportunity to replicate the Cargohopper concept in Amsterdam and prepare it for further growth to other cities (i.e. exploitation), after an initial stage of experimentation with the concept in the city of Utrecht (i.e. exploration). At present, multiple Cargohopper vehicles are operational in Amsterdam, as well as in other Dutch cities.

Replicating a smart city solution developed in specific local context requires that both tacit or explicit knowledge is transferred to a new context efficiently. In the case of Cargohopper, where lead project partner Transmission was responsible for the replication process, the transfer of knowledge from the pilot team to senior management and other teams in the organization was an essential part of the replication process. The case also highlights how economic and technical conditions can influence the potential for upscaling to other cities. The prospects of economies-of-scale when replicating the Cargohopper is an important prerequisite; there is a need to have a minimum threshold of clients in a city using the delivery service to develop a viable business model. Achieving scale advantages is especially relevant in the case of commercial transport, given interviewees suggested that a (more sustainable) solution should not impose significantly higher costs for businesses using the service compared to existing modes of (less sustainable) transportation. This potentially makes the service less attractive to smaller cities, in which achieving scale advantages could prove to be difficult. In terms of technical standards, several factors can pose limitations on replicating Cargohopper, including the maximum driving range, driving speed, and cargo load. While these specifications fit with the infrastructure of Amsterdam’s city centre, these specifications may prove to be problematic for major cities which are more spread out over a larger geographic area. If technical standards can be sufficiently adapted to fit with the geo-spatial context to which it is replicated, the solutions becomes more attractive to a broader variety of cities. Interoperability between systems of different transportation firms also complicates the upscaling process: in this case, Transmission can only handle freight which is part of the firm’s own system due to a lack of interoperability with the systems of other transportation firms. Obviously, competition and diverging interests between firms offering these commercial services also impact this process.

Finally, Cargohopper also shows that legal and policy frameworks can be an incentive for sustainable innovation. In this case, such incentives included stricter regulation for vehicles allowed to operate in the environmental zone in the city centre, combined with partial subsidies for the development for the first electric Cargohopper vehicle. The full-electric vehicle design, and underlying distribution system just outside the environmental zone, were developed in response this local-level regulation.

6.6 Discussion and conclusions

Smart city technologies hold the promise of improved urban services and more liveable and sustainable cities. European cities have set up a growing number of smart city pilot projects, in which various stakeholders apply new technologies to address urban challenges or improve service provision. In the last decade or so, European, national, and local public funding for such initiatives has grown, and also the private sector is increasingly interested in investing in smart city projects. Recently, there has been a growing concern among policymakers and funders about the impact of these pilot schemes, mainly because of the low rate of upscaling; many projects fade out after the pilot project ends and/or when the project subsidy dries up and fails to make a substantial impact.

In this paper, we have made an attempt to analyse the process of upscaling in more detail, both theoretically and empirically. We identified three upscaling types: roll-out, expansion, and replication, each with its own dynamics and specificities. Next, we presented a framework (based on a study of various literature) containing conditions and requirements for scaling processes to take off. These include: the prospect of reaching economies-of-scale; the presence of knowledge transfer mechanisms and incentives; management of ambidexterity in exploration-exploitation activities; the presence of enabling regulatory, legal, and policy frameworks; interoperability between systems, data, and standards; and the inclusion of standards to measure returns on investment. Finally, we provided a descriptive analysis of the upscaling process (or the lack of it) in three smart city projects developed in Amsterdam, one of the most active cities in this field.

In the empirical analysis of smart city pilot projects in Amsterdam, we illustrated the impact of the conditions and requirements on upscaling processes in several ways. The first case, Climate Street, demonstrates the importance of organizational ambidexterity in the roll-out process, and shows how the absence of knowledge transfer incentives for partner organizations in a pilot project can hinder replication. The case also reflects how a lack of funding can hinder the upscaling process; the pilot ended prematurely because of a lack of funding and commitment by partner organizations, while it was envisioned to turn the project into a permanent urban lab for experimentation with smart city technologies. The second case, Energy Atlas, reflects how knowledge sharing and learning mechanisms are important for the development and wider dissemination of smart city solutions. It demonstrates, in a multi-stakeholder setting, the importance of having a strong link between a pilot project team and the parent organization, as well as an explicit common interest and commitment to move the project forward. In terms of sharing data, which is a crucial aspect of most smart city platform innovations, the case also showed that system interoperability is a key factor for partners to open up their data sets. The third case, Cargohopper, reveals that internal knowledge transfer mechanisms in the firm are important to replicating a solution from one locale to another, and confirmed that the prospects of economies-of-scale can be a prerequisite for replication; without sufficient scale, the solution developed in the pilot project is not commercially viable. Additionally, the Cargohopper case suggests that effective management of ambidexterity is needed in order to move from exploration to exploitation.

Overall, we conclude, in line with Hartman and Linn (2008), that the design of the pilot project has an impact on its upscaling potential. Hartman and Linn (2008: 16) state in this respect that a pilot project must be set up with a clear vision on how scaling processes will take shape (in any form): pilots should be designed in such a way that they could be scaled up, if successful, and so that key factors which will be necessary for a scaling up decision—with what dimensions, with which approach, along which paths, etc.—are already explored during the pilot phase. Our study also demonstrates that upscaling is a multi-layered process, and different types of scaling might follow from a single pilot project. For both policymakers and practitioners, taking the potential path(s) for upscaling into account in the design stage of the pilot project is, therefore, important for the wider diffusion of smart city solutions.

Understanding the scaling process of smart city solutions requires insights into the subtle interplay between the project level and the individual organizational/firm level. Many smart city projects are collective ventures of different organizations, each with different rationales, ambitions, and perspectives regarding upscaling. Partners may enter a project for a variety of reasons: to test how consumers react to new products; to demonstrate technical feasibility of a solution on a small scale (the technology companies in Climate Street case); to share data in an integrated platform to enable cities to reach sustainability ambitions, improve urban services, and use energy more efficient (as was the case in the Energy Atlas case); or to develop and test a prototype version of a solution in a real-life urban environment, which fits with stricter environmental regulations (which occurred in the Cargohopper case).

Private partners may also join a project to (re)establish close relations to the local government (especially relevant for companies that have the local government as an important client), or from a corporate social responsibility perspective and/or to improve its corporate image. While such partners may have a clear motive for participating in a smart city pilot project, we also found that other projects do not scale because of a lack of incentives; they are often formed by coalitions of small local players who have no incentive to replicate the success elsewhere. The inclusion of mechanisms and incentives in pilot projects to maximize the upscaling potential for solutions, either via a roll-out, expansion, or replication process, should therefore be carefully considered by policymakers.

Our study puts the emerging policy orthodoxy about scaling as the holy grail of project success into perspective. Even in the absence of upscaling, pilots generate lessons and insights that might benefit ensuing projects—if captured, documented, and shared appropriately. On a higher level of abstraction, the transition management literature highlights the value of sequences of experiments, including failed ones, as part of the process of newly emerging narratives and agendas, influencing established regimes. Our interviews with local project leaders and other stakeholders revealed significant project-to-project learning processes, where tacit knowledge from former projects is infused into new ones. Moreover, a project can be successful without upscaling in other respects as well: Energy Atlas is seen by its local stakeholders as a success, the local initiators maintain and fund it without intending to expand or replicate it elsewhere. It evolved from a pilot project to a useful and stable platform. These findings suggest that a single-sided focus on scalability could reduce or impede more fundamental experiments that may not scale immediately but function as small building blocks in a process of systemic and more fundamental changes, and entail important learning processes. Policymakers need to be aware that the changes they are pursuing in society with their funding will take time and require the accumulation of many projects.

Most smart city technology projects are not only technical, but involve social, cultural, political, institutional, and behavioural changes that are very context sensitive. In this respect, there are reasons to be doubtful about the effectiveness of dissemination and replication activities (producing handbooks, toolkits, or online tools) so typical in EU-funded projects, because the required knowledge is tacit; a project’s success is highly contingent on local coalitions and conditions. Finding more effective ways for disseminating tacit knowledge would therefore enhance the upscaling potential of pilot projects. Yet, from the accumulation of local experiments in pilot projects in different cities, and the exchange of lessons and insights across different local contexts, a broader adoption of scalable solutions for sustainable urban development can develop.

Scaling is difficult for small and local players. Technology MNEs such as IBM and Cisco, as well as other international service providers (Accenture in the case of Energy Atlas), are able to apply lessons learned or replicate solutions in cities, namely by combining their local presence in various cities with internal knowledge transfer and ambidexterity. They manage to transfer solutions from one place to another and capitalize on their investments (achieving scale economies). Start-ups and SMEs lack such networks and competencies, and have much more difficulty effectively scaling up smart city solutions. This explains why so many applications and solutions never outgrow the local or even parochial level, unless adopted and scaled up by a larger player. The case of Climate Street is illustrative: the successful roll-out of the energy display only happened after the start-up company was taken over by a larger player that managed to sell the displays on the national market. Further research is needed on the role of multinational firms in smart city pilot projects and the wider diffusion of solutions developed in these projects.

Smart city projects are fascinating new arenas where different urban stakeholders (public, private, and civic) engage in coalitions and innovate together, and more research is needed to study the dynamics in this arena of upscaling where different interests meet and collide. For a start, our research suggests that project participants rarely openly discuss each other's upscaling perspective and ambitions during the pilot project's formation stage, nor do they build in mechanisms that ease the transition to the upscaling phase. When the pilot ends, this puts a strain on the upgrading stage which become a project of its own. This finding resonates with insights from the business literature that long-term competitiveness relates with ambidexterity; a firm's ability to find a good balance between exploration (developing new knowledge and competences associated with R&D and innovation) and exploitation (implementation, scale production, refinement). Hence, specific attention to upscaling potential and achieving longer-term impact beyond the pilot project presents an important opportunity for future research on smart city projects. Pilot projects, after all, are designed for the exploration stage. Also, given the substantial degree of context sensitivity in the upscaling of smart city pilot projects, further empirical research in different geographic contexts beyond Amsterdam would further enhance understanding of upscaling processes in smart city pilot projects.

Appendix A / Table 6.3: Overview of interviews on smart cities and pilot projects

Collaboration in	Organization	Participant role	Date and time
Amsterdam Smart City Network	Amsterdam Smart City	Communication Manager	Semi-structured; 13 April 2015; 60 minutes
Amsterdam Smart City Network	Amsterdam Smart City	Project Manager Internationalization	Semi-structured; 6 May 2015; 50 minutes
Amsterdam Smart City Network	Amsterdam Smart City	Project Manager Energy Innovation	Semi-structured; 11 May 2015; 45 minutes
Amsterdam Smart City Network	Amsterdam Smart City	Business Development Manager	Semi-structured; 29 April 2015; 80 minutes
Amsterdam Smart City Pilot Project	Accenture	Smart City and Sustainability Services Expert	Semi-structured; 16 June 2015; 45 minutes
Amsterdam Smart City Pilot Project	Accenture	Smart City and Energy Market Expert	Semi-structured; 21 May 2015; 50 minutes
Amsterdam Smart City Pilot Project	Alliander	Smart City Expert	Semi-structured; 19 may 2015; 60 minutes
Amsterdam Smart City Pilot Project	Cisco	Smart City and Sustainability Services Expert	Semi-structured; 1 July 2015; 90 minutes
Amsterdam Smart City Pilot Project	City of Amsterdam municipality	Smart City Expert / Programme Manager	Semi-structured; 7 April 2015; 45 minutes
Amsterdam Smart City Pilot Project	KPN	Smart City Expert	Semi-structured; 8 April 2015; 90 minutes
Amsterdam Smart City Pilot Project	Liander	Energy Expert / Programme manager	Semi-structured; 21 May 2015; 50 minutes
Amsterdam Smart City Pilot Project	Waternet	Smart City Expert / Consultant Energy, Resources & Water	Semi-structured; 19 May 2015; 75 minutes

CHAPTER 7: CONCLUSIONS

This dissertation focused on exploring business strategies in response to the diffusion of technologies for sustainable energy production and consumption. This chapter presents the conclusions, contributions, implications, and limitations. Section 7.1 starts with an overview of the key contributions for each study, as well as cross-study linkages which emerge from the dissertation as a whole related to the sub-questions introduced in chapter 1. Several research findings have implications for the broader debate on energy and sustainability, and the role of business as an actor in the transition towards a more sustainable energy future. Section 7.2 discusses how the organizational-level perspectives adopted in each chapter contribute to creating more insight into the role of actors in the energy transition. The final section, 7.3, reflects on the relevance of conducting further phenomenon-driven research on sustainability-related ‘grand challenges’ (Buckley et al., 2017; Doh et al., 2015) in the international business and management literature, and identifies limitations and opportunities for future research.

7.1 Contributions of this dissertation in relation to research questions

Each chapter in the dissertation contributed to the research question presented in chapter 1, and shed light on the strategic responses of business to the diffusion of technologies for sustainable energy production and consumption. The research question was divided into two sub-questions. The first sub-question examined the strategic responses of different types of multinational enterprises (MNEs) to the diffusion of technologies for sustainable energy production and consumption. Chapter 2 identified how firms in the information and communication technology (ICT) industry strategically approach the market for ‘smart city’ technologies, and explored the potential for these firms to build firm-specific advantages (FSAs) from their smart city engagements in multiple urban contexts globally. Chapter 3 researched regionalization strategies of European Union (EU) electric utilities in conventional power generation technologies and renewable energy technologies (RETs), and showed how their strategies are influenced by market liberalization and imperfect harmonization in the (supra-)national institutional environment. Chapter 4 provided insight into the strategies of firms in the oil industry in developing and commercializing a single RET, solar photovoltaic (PV) technology, taking internal resources and capabilities as well as external industry dynamics into account.

The second sub-question investigated how business addresses challenges related to the scalability, affordability, and accessibility of sustainable energy technologies. Chapters 5 and 6 each explored how market-based and business-led approaches can enhance the economic viability and potential for upscaling of sustainable energy solutions, which have historically relied on donor-funded and subsidized activities, in respectively rural and urban settings. In chapter 5, the research focused on business models for off-grid RET-based solutions to establish access to energy in rural areas in developing countries without adequate access to the national electricity grid. Chapter 6 took a management perspective to explore which factors affect the potential for urban energy efficiency solutions to be scaled up beyond pilot projects, and thus create an environmental and social impact beyond local contexts. Table 7.1 provides an overview of the main foci and contributions of the empirical chapters in the dissertation.

Chapter	**2**	**3**	**4**	**5**	**6**
Research Sub-Question	How do MNEs strategically address the diffusion of renewable energy technologies for energy production, and energy efficiency technologies for energy consumption?			How does business address challenges related to the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption?	
Organizations Examined	Multinational Enterprises	Multinational Enterprises	Multinational Enterprises	Entrepreneurial firms	Multinational Enterprises; Entrepreneurial firms
Central themes from the literature	International business; global cities and location strategies; FSAs and liability of foreignness; local contexts	International business; regional institutional coherence; FSAs and liability of foreignness; home-country effects	Strategic management; resource-based perspective; sustainability-oriented innovation	Sustainable development; access to energy financing and delivery models; business model perspective on value creation	Sustainable development; upscaling from pilot projects; management perspective on scaling dimensions
Geographic setting	International; global cities	International; Europe	International; Europe	National; countries in South East Asia	Sub-national; city of Amsterdam
Technology focus	Energy consumption; smart city technologies	Energy production; grid-connected RETs	Energy production; grid-connected RETs	Energy production; decentralized off-grid RETs	Energy consumption; smart city technologies
Main industry or context	ICT	Electricity	Oil	Rural	Urban
Contribution	Exploration of international business strategies and liability of foreignness related to locating firm activities in global cities; case studies on integrating and leveraging FSAs from embeddedness in multiple urban contexts	Exploration of firm internationalization and liability of foreignness related to intra-regional institutional coherence; case studies on the international expansion patterns of EU electric utilities in fossil fuel-based and RET-based power generation portfolio	Conceptual and empirical exploration of investments in the development and commercialization of RETs; case studies on the strategic investments in solar PV technology of incumbent firms	Identification of business model components of market-based models for access to energy in developing countries; empirical illustration with case studies on local companies in multiple developing and emerging countries	Identification of manifestations of upscaling processes, and economic, regulatory, and technological dimensions which affect upscaling processes; empirical illustration with case studies on local smart city pilot projects

Table 7.1: Overview of the chapters in the dissertation

The contributions of each chapter in relation to the sub-questions is discussed in more detail below.

Sub-question A: *How do MNEs strategically address the diffusion of renewable energy technologies for energy production and of energy efficiency technologies for energy consumption?*

Chapter 2 focused on the strategic approaches of MNEs to the international spread of smart city technologies, in response to addressing energy consumption in cities and urban areas. Since city governments of capital cities and large urban areas have started to actively address persistent sustainability issues related to energy and climate change (Bulkeley, 2010; Hodson and Marvin, 2009), international ICT firms have reported on investments in technological innovations which facilitate the creation of smart cities (Macomber, 2013; Paroutis et al., 2014). Embedded in the emergence of smart cities as an increasingly ubiquitous global phenomenon, this chapter examined how these firms have leveraged their international network of subsidiaries to build a strategic presence as smart city technology suppliers in a large number of cities. It showed that locating firm activities in centres of economic agglomeration (Beugelsdijk et al., 2010; Beugelsdijk and Mudambi, 2013), particularly 'global cities' (Goerzen et al., 2013; Sassen, 2000; 2005), reduces the liability of foreignness experienced by firms in host environments (Mehlsen and Wernicke, 2016), and facilitates MNEs in the development and exploitation of firm-specific advantages (FSAs) in and across different locations in the MNE network (Rugman and Verbeke, 2007; 2008c). The presence of the three ICT MNEs in all cities of the Globalization and Word Cities (GaWC) inventory (Beaverstock et al., 1999; 2000) identified as prime cities for the spread of smart city technologies, seems to reflect the fact that these firms are well-positioned to leverage resources and capabilities developed from their smart city engagements on a global scale.

In the international diffusion of smart city technologies, the empirical analysis highlighted a dynamic interplay between leveraging location-bound and non-location-bound FSAs in the strategic approaches of ICT MNEs to the creation of smart cities. On the one hand, firms can leverage non-location-bound FSAs developed from their smart city engagements in multiple heterogeneous urban contexts, which are embedded in their specialized resources and capabilities. These FSAs can be deployed beyond the specific domain in which they have been developed (Rugman and Verbeke, 2007), and can thus provide a potential to create competitive advantages in this market. Firm-specific programmes for smart cities, including IBM Smarter Cities and Cisco Smart+Connected Communities, have facilitated them in building specialized resources and capabilities in the development and marketing of smart city 'solutions', which are transferrable to other subsidiaries in the MNE network. Interviews with the focal MNEs showed that both formal and informal mechanisms for intra-MNE knowledge sharing are key in this respect, as this facilitates the inflow and outflow of knowledge between subsidiaries in different urban contexts in the MNE's network (McCann and Mudambi, 2005; Mudambi, 2002). On the other hand, firms can build on location-bound FSAs within each urban contexts in which they are embedded, which are not transferrable throughout the MNE network. This may include FSAs from ownership over physical resources and assets, from existing relationships with key public and private stakeholders, or from in-depth knowledge of specific urban systems and infrastructures. Such FSAs are location-bound and difficult to transfer beyond the local context in which they are embedded, due to their high degree of context-specificity, given the unique contextual characteristics of each urban environment in terms of economic, social, regulatory, and technological factors. Yet, such location-bound FSAs can enable firms to be responsive to local sustainability requirements, and make them adaptive to the distinct characteristics of each urban contexts in which the firm has activities. Related to sub-question A, this chapter thus highlights that MNEs strategically address the diffusion of technologies for urban energy consumption, by exploiting resources and capabilities which are developed through their smart city engagements in a large number of cities and urban areas globally.

In relation to energy production, chapter 3 studied the geography of MNE internationalization patterns and the influence of the (supra-)national institutional environment on this process, focused specifically on electric utilities in the EU. The European electricity market has been fundamentally reshaped by a series of EU directives adopted since 1996, which has driven a process of market liberalization, aimed at establishing an European internal electricity market (Meeus et al., 2005). This changing context has influenced the profitability, growth, and survival of electric utilities, as well as firm-specific investments in technologies for power generation. Given that the uptake of RETs is an important driver of energy sector transformation (Holdren, 2006; Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000), the investments in renewable energy of EU electric utilities are instrumental in meeting the EU's sustainable energy targets for 2020. The chapter builds on the body of literature on regionalization (cf. Rugman and Verbeke, 2004; 2005), which focuses on how economic and political integration in the triad regions (Li and Guisinger, 1992; Ohmae, 1985) influence the international growth strategies of MNEs. The analysis in chapter 3 identified how increased coherence in the European institutional environment as well as country-specific public policies for RETs have shape firm-specific energy investments and internationalization strategies after the market liberalization was initiated.

Accordingly, chapter 3 shed light on the industry-specific internationalization patterns of these electric utilities, following their transition from state-owned to privatized companies. The findings confirm the influence of the regional (i.e. European) institutional environment on firm strategies, although differences were identified for their installed capacities in RETs compared to fossil fuel-based technologies. In their corporate strategies and installed power generation capacity in fossil fuel-based technologies, all electric utilities follow a region-oriented internationalization pattern in their investment decisions, with strong home-country presence in most cases. This confirms that firms' investments are largely home-region oriented rather than global (Rugman and Verbeke, 2004), and resonates with the underlying assumption that inward and outward investments in the home region are associated with a lower degree of liability of foreignness than inter-regional investments (Rugman and Verbeke, 2004; 2005; 2007; 2008c; Kudina, 2012). Hence, the home-region profiles of firms indicates that they experience less liability of foreignness within the region, influenced by increased regional policy coherence in the European electricity market. Yet, only one of the seven focal firms (E.ON) was present in all EU sub-regions, with most firms focusing their investments outside their home countries on markets within their sub-regions. This reflects the existence of barriers to intra-regional international expansion (Asmussen, 2009), and shows that firms internationalize to countries which are both institutionally and geographically closest to their home market. While future investments may push firms towards presence in multiple or all EU sub-regions, it highlights that (supra-)national institutional integration at the regional level shapes firm-specific investment decisions and internationalization patterns.

Furthermore, the influence of home-country public policy on MNE strategies emerged from the analysis of the seven electric utilities. As energy market liberalization and policy harmonization is incomplete in several EU countries (Joscow, 2008), differences between countries still exist. Home-country effects can shape the geographic profile of sustainable energy investments. Firms show a clear pattern of increasing internationalization outside their home countries, with a home-region orientation for traditional power generation activities. However, their investments in RETs show a more widely dispersed international profile, with a multiple-region presence for some firms. Hence, the analysis of these utilities and their RET-oriented business units and subsidiaries implies that institutional factors play an important role in their investments. Home-market effects strongly influence this process. Favourable RET-oriented policy incentives and regulatory frameworks can support firms to build up unique FSAs in their home market. This can drive their international expansion by leveraging non location-bound FSAs in RETs, creating a greater geographic distribution of their power generation portfolio. In this respect, it highlights the effect of home-country public policy on inward and outward investment decisions of these MNEs. A noteworthy example is the 'green growth plans' in the United States (US), which included incentives for renewable energy investments, and allowed several European electric utilities to leverage their FSAs in RETs and build their wind energy portfolio outside their home region, and in the US. This resulted in bi-regional and host-region orientations for the installed RET capacity of three firms, compared to the regional orientation in their conventional power generation capacity.

Chapter 4 also focused on European MNEs in the energy industry and their investments in RETs, building on a resource-based perspective of the firm (Wernerfelt, 1984; 1995; Peteraf, 1993; Barney, 2001a; 2001b), focused specifically on MNEs with established positions in the oil industry. It explored strategies of incumbent firms in sustainability-oriented technology innovation, and provided a comparative analysis of the strategic approaches of firms in their solar PV investments. Related to the diffusion of technologies for sustainable energy production, the chapter contributed to a better understanding of how internal firm-specific factors can shape investment decisions in technological innovations which are perceived as potentially disruptive to existing resources and capabilities. The analysis examined how oil firms have built resources and capabilities over decades in supplying fossil fuels, creating path dependencies which shape their innovation strategies and firm-specific investments in solar PV. Specifically, the analysis shows that non-complementarity between existing resources and capabilities of oil firms, and the technology-specific characteristics of solar PV, shapes the way in which these firms strategically develop and commercialize this technology.

In technology development, this non-complementarity steered firms towards acquisitions of specialized solar PV firms to obtain technology-specific resources and capabilities, or build inter-organizational collaborations within specialized solar energy firms through joint ventures. Given that oil firms could not build on historical research and development (R&D) investments in solar PV, they were inherently unable to leverage possible complementarities between existing firm-specific resources and capabilities in oil and in solar PV. This lack of intra-firm complementarities was reflected in the strategic decisions of all firms to establish their RET activities outside the organizational structure of their fossil fuel supply chains (Bower and Christensen, 1995). Shell and BP established isolated divisions for their RET activities (respectively Shell Renewables and BP Alternative Energy), while Total opted for shared ownership of multiple subsidiary companies. Hence, this shows how a lack of alignment between existing firm-specific resources and capabilities affected their decision-making to invest in non-complementary and disruptive innovations. The study also illustrates why incumbent firms mostly invest in incremental innovation to optimize performance of existing technologies, rather than focusing substantial efforts on disruptive and breakthrough innovations (Baumol, 2002).

As a consequence of non-complementarity with the existing resources and capabilities of firms, and of the establishment of solar PV activities in rather independent divisions outside their existing supply chains, the analysis showed that commercialization of solar PV technology occurred only in smaller niche markets. The decision to locate the initial market for introducing a disruptive technology outside existing mainstream markets fits with incumbents' strategies for technologies which are perceived as strategically important yet non-complementary to existing activities (Bower and Christensen, 1995). This also highlights a crucial difference between oil firms and electric utilities related to investments in RETs: the interrelatedness between the degree of complementarity between existing resources and capabilities and technology-specific characteristics. Electric utilities are able to integrate RETs, including energy generated by solar PV as well as on- and off-shore wind, into their existing upstream power generation portfolio, and can rely on their existing downstream electricity distribution infrastructure to deliver electricity to end-consumers. Contrary to oil firms, electric utilities therefore have a high degree of complementarity between existing resources and capabilities, which influences their strategic decision-making process for RET investments. These inter-industry differences between complementarity of RETs to the supply chains of oil firms and electric utilities also exemplify how carbon lock-in (Erickson et al., 2015; Unruh, 2000) can influence the diffusion of technologies for sustainable energy production.

Hence, chapter 4 highlighted the influence of internal firm-specific factors on strategic decision-making in RET investments. Given that these incumbent firms in the oil industry lacked resources and capabilities for technology development and commercialization, their initial investments eventually resulted in divestures, rather than in diversification of their power generation portfolio. As chapter 4 highlighted, non-complementarity between internal firm-specific factors and technology-specific characteristics of solar PV led subsidiaries Shell Renewables and BP Alternative Energy to commercialize the technology to niche rather than mainstream markets. Therefore, these technology-specific investments failed to have a substantial impact on a sustainability-oriented diversification of the power generation portfolios of these firms. Related to the contribution of MNEs to the diffusion of technologies for sustainable energy production, the resource-based view of the firm therefore adds an internal perspective on the strategies of MNEs. This complements the contributions of chapter 3 on the influence of the (supra-)national institutional environment in shaping MNE internationalization patterns, and their ability to build FSAs in RETs from home-country public policies. Considering the first sub-question, chapters 2, 3, and 4 therefore illustrated how internal and external factors influence the strategic responses of MNEs to the diffusion of technologies for sustainable energy production and consumption in multiple industries (electricity, oil, and ICT).

Sub-question B: *How does business address challenges related to the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption?*

In exploring business strategies in sustainable energy, two chapters in the dissertation contributed to insight into market-based and business-led approaches to enhance the scalability, affordability, and accessibility of sustainable energy technologies. Chapter 5 explored how local entrepreneurial small- and medium-sized enterprises (SMEs) develop innovative business models for RET-based access to energy solutions in developing countries. Such market-based approaches are pivotal for sustainable development, given that many technologies intended for implementation in developing countries fail to achieve commercial viability, or are only distributed through donor-funded initiatives of non-governmental organizations (Chesbrough et al., 2006). While this market may not be of strategic importance to MNEs or even larger companies operating at a national scale, the (local) private sector is central for long-term market development and for helping address sustainable energy issues.

Taking the perspective of the business model developed by Morris et al. (2005), chapter 5 showed various organizational, financial, regulatory, and technological challenges involved in establishing access to energy in developing countries. It assesses the degree to which entrepreneurial firms are able to build scalable business models to enhance the affordability and accessibility of sustainable energy for customers in these markets. Earlier studies on off-grid delivery and financing models (ARE, 2008; Nygaard, 2009; Umree and Harris, 2006; Zerriffi, 2011) identified a number of different configurations, ranging from fully subsidized models by international non-governmental organizations (e.g. the World Bank and United Nations), to wholly non-subsidized market-based sales models, with mixed methods based on public-private collaborations in between. The analysis of the four companies (Kamworks, Sunlabob, Husk Power Systems, and Grameen Shakti) in this chapter revealed the complexities of building commercially viable business models, especially fully commercial and non-subsidized models. For the majority of firms, this resulted in a mixed model of both self-sustaining commercial activities for business-to-business markets and middle-class consumers, combined with donor-funded activities oriented at consumers with a limited ability to pay. Their offerings included hybrid and fully RET-based energy solutions for different consumer groups (segmented based on spendable income and energy needs), ranging from individual-level to village-level products and services. In addition to selling products and services, their activities include support activities such as installation, maintenance and repair, and on-site training. Knowledge building and private sector development were identified as key components to achieve sustainable long-term market growth and facilitate the creation of a local infrastructure for RET-based off-grid solutions. This stimulates long-term accessibility and affordability of solutions for access to energy in local contexts.

Financing issues were a prevalent barrier in establishing access to energy for customers of virtually all income groups. In order to stimulate the affordability and accessibility of these energy solutions, several firms developed alternative financing schemes to overcome the high capital costs of upfront investments. These financing schemes were primarily oriented at consumers at the bottom/base of the pyramid (BOP), said to consist of 4 billion people globally with an annual per capita income below US$1.500 (Prahalad and Hart, 2002), and have historically relied on donor-funded projects to gain access to energy. Two companies (Kamworks and Sunlabob) developed rental schemes in collaboration with micro-finance institutions and donor organizations. Another company, Grameen Shakti, offered micro-finance ‘soft credit’ schemes in collaboration with the Grameen Bank, and was the only company, of the four studied, which explicitly stated not to receive direct subsidies. This company stated not to focus on making a profit in this market, possibly related to its affiliation with the broader Grameen family of organizations that has the provision of micro-credit as cornerstone of the overall business model. The case studies in chapter 5 illustrate that financial support from donor organizations should primarily fund projects for access to energy carried out by local companies, and include mechanisms which stimulate sustainable and long-term market development. In addition, local companies can collaboratively develop financing schemes with international non-governmental organizations, corporate philanthropy programmes, or venture capital from socially-oriented investors, to enhance the affordability (and thereby accessibility) of these solutions for a larger group of consumers.

Chapter 5 thus showed that local companies and business-led approaches have an important role in longer-term solutions for sustainable development in order to establish affordable and accessible access to energy solutions. (Inter)national regulations and public policy frameworks for access to energy should therefore be inclusive to local companies and market development. Stand-alone donor-funded projects and subsidized programmes can have a distorting effect on local markets conditions, especially when the role of the private sector is insufficiently taken into account. Purely charitable distribution programmes by donor organizations, without the inclusion of market mechanisms, fail to achieve scalable solutions beyond a donor-funded phase, limiting their impact on longer-term environmental sustainability and social development. The adaptability of the focal companies to local conditions, and their in-depth knowledge of market conditions and end consumers stemming from their local embeddedness, is a major strength in comparison to more generic one-size-fits-all solutions. While clear challenges remain in terms of the commercial viability and scalability of existing business models, it allows these local companies to develop context-specific solutions for access to energy though a bottom-up, market-oriented approach.

Hence, the potential for scaling up sustainable energy solutions beyond a donor-funded phase to achieve broader diffusion and create a wider environmental and social impact (Vilajosana et al., 2013), is a key challenge for business. Chapter 6 also focused on similar challenges regarding economic viability, and the complexities associated with scalability, but this time in an urban, developed context. It explored different trajectories for scaling up urban energy solutions developed in multi-stakeholder pilot projects at the local level, and identified which dimensions and conditions affect this process. Similar to chapter 5, it builds on perspectives on upscaling from developing country contexts (Cooley and Kohl, 2005; Hartmann and Linn, 2008; Uvin, 1995; World Bank, 2005), and defines three manifestations of upscaling, each with their own dynamics and context-sensitivity. The first type of upscaling process, 'roll-out', occurs when one of the pilot project partners brings a newly developed technological solution (product/service) to the market, or applies learning outcomes from the pilot project in their own organization. The second form, 'expansion', emerges when a pilot project is not closed or dissolved, but expanded beyond the donor-funded phase, either by adding partners or customers to the project, or by enlarging the geographic area in which it operates. The third form, 'replication', is the most complex, and transpires when a sustainable energy solution developed in the pilot project is replicated (exactly or by proxy) in another geographic or organizational context, by either the original pilot partners or other organizations. Related to existing studies, this classification presented in chapter 6 contributes to understanding how scaling trajectories emerge from local contexts.

From a business perspective, several factors were discussed which affect (i.e. stimulate or hinder) the potential for scaling up solutions beyond a donor-funded pilot project. First, the scaling potential of sustainable energy solutions developed in pilot projects is higher when the prospect of economies-of-scale can bring lower unit costs and/or higher profits (O'Sullivan et al., 2003), and project partners have an incentive to capture them. Public and non-profit organizations lack market-based incentives to scale up solutions, thereby insufficiently taking into account how scaling beyond donor-funding can occur, but rather move 'from one project to another' (Hartmann and Linn, 2008). Hence, similar to findings for market-based developed in access to energy in chapter 5, business (from MNEs to SMEs) have an important role in scaling up solutions beyond local contexts. Second, upscaling requires adequate management of the transition from an exploration-oriented, donor-funded pilot phase, to an exploitation phase that has commercial viability beyond subsidization. The availability of resources and capabilities to engage in both exploration and exploitation activities is therefore relevant to the potential for upscaling. From the perspective of organizational ambidexterity (March, 1991), it is important for firms to achieve a balanced approach between both exploration and exploitation. Given that R&D activities (i.e. exploration in pilot projects) require different resources and capabilities than exploitation of a solution to the market (i.e. upscaling beyond pilot projects), effective management of ambidexterity therefore influences the potential for upscaling.

In addition, a third factor affecting the potential for scaling up technological solutions beyond pilot projects is effective inter- and intra-organizational knowledge transfer (Du Plessis, 2007; Tamer Cavusgil et al., 2003), including the transfer of tacit knowledge (Foos et al., 2006; Seidler-De Alwis and Hartmann, 2008). Firms, especially MNEs, often have effective knowledge transfer mechanisms in place, which allows them to capture the benefits from local presence in multiple cities, and therefore enable them to scale up locally developed solutions to a larger number of locations (Paroutis et al., 2014). This resonates with contributions at the global level presented in chapter 2, which identified how MNEs in this market can build FSAs from their local embeddedness in many cities, and leverage these FSAs through their global network of subsidiaries to build competitive advantages via intra-MNE knowledge transfer. This is reflected in the case of Accenture's involvement in the Energy Atlas pilot project in Amsterdam, and their ability to leverage lessons learned at the local level to consulting activities in other cities. The issues related to scaling as specified in chapter 6, illustrate why MNEs tend to be more successful in scaling up solutions than smaller, local companies. In sum, this is related to the existence of firm-specific resources and capabilities for both exploration and exploitation, opportunities to create economies-of-scale, and mechanisms for intra-organizational knowledge sharing.

Considering the second sub-question, this dissertation showed that market-based approaches to sustainable development can enhance the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption. The scaling trajectories described in chapter 6 related to scaling up urban energy efficiency solutions from smart city pilot projects can also be applied to scaling up of the RET-based access to energy solutions in rural areas discussed in chapter 5. Given that both contexts have historically relied on donor-funded activities of public actors, which have often failed to reach commercial viability (Chesbrough et al., 2006), it can be argued that the private sector is instrumental in scaling up sustainable energy solutions. The empirical case studies in chapter 5 and 6 showed how business-led approaches, both by MNEs and SMEs, have an important role in achieving a wider social and environmental impact beyond local contexts. While the context-specificity of the case studies limits the generalizability of the findings to a wider range of urban and rural contexts (as discussed in more detail below), they indicate that market-based approaches may have the potential to impact stimulate long-term sustainable development.

Overall, the chapters in the dissertation have explored business strategies in response to sustainable energy production and consumption, rooted in multiple theoretical perspectives from the business and management literature. Chapters 3, 4, and 5 focused on business strategies in the diffusion of RETs for energy production, and chapters 2 and 6 examined smart city technologies for more efficient energy consumption, as visualized in table 7.2. The next section elaborates on how the contributions related to both sub-questions are interrelated with transition processes in society, and specify how these perspectives can inform the broader debate on business and sustainable energy.

	Research sub-question	
Technology related to	Business strategies for the diffusion of sustainable energy technologies	Business approaches to enhance the scalability, affordability, and accessibility of sustainable energy solutions
Production	*Chapters 3 and 4*	*Chapter 5*
Consumption	*Chapter 2*	*Chapter 6*

Table 7.2: Overview of the chapters in relation to sustainable energy production and consumption

7.2 Broader implications for the debate on business and sustainability energy

Several contributions discussed in section 7.1 can shed light on the role of firms, particularly MNEs, in the transition towards sustainable energy production and consumption in society, and thus provide an actor-centric perspective on sustainability transitions (Farla et al., 2012; Markard et al., 2012). This complements theoretical conceptualizations of transition processes in socio-technical systems, most notably the Multi-Level Perspective (Geels, 2002; 2004) and Triple Embeddedness Framework (Geels, 2014), as well as industry-specific insights related to the wider diffusion of novel technologies for energy sector transformation (Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000). The management perspective on business strategies in sustainable energy identified that multiple factors, including firm-specific resources and capabilities for both exploration and exploitation activities, opportunities to create economies-of-scale to reduce unit costs, and mechanisms for effective intra-organizational knowledge sharing, contribute to the ability of MNEs to develop and market sustainable energy technologies. In addition, it showed how the development of market-based business models can enhance the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption, and thereby contribute to their diffusion in society. Given that actors are important in understanding the diffusion of technological innovations as part of transition processes (Geels, 2005a), this adds a firm-centric perspective to existing studies on different trajectories and pathways of transformative change in socio-technical systems (Geels, 2005b; Geels and Schot, 2007; Raven, 2007; Smith et al., 2005).

In the same line of thought, central to the Multi-Level Perspective are niche environments, which can act as 'incubation rooms' or 'protected spaces' for technological innovations and prepare them for broader diffusion into the energy system (Geels, 2005a; 2004; Kemp et al., 1998; Smith and Raven, 2012). Pilot projects can provide opportunities for technology experimentation and early adoption in this realm, and facilitate the market formation of radical, potentially disruptive innovations (Carvalho, 2014). Firms can play an important role in the breakthrough of novel technologies for sustainable energy production and consumption beyond niche environments. Large MNEs have competitive advantages over smaller, more locally oriented companies in scaling up novel technologies in this respect, given that MNEs can integrate and leverage FSAs in sustainable energy from multiple contexts through their international network of subsidiaries (Meyer et al., 2011). MNEs with established industry positions have internalized key factors to scale up solutions, including complementary resources for both exploration and exploitation as well as mechanisms for intra-MNE knowledge sharing, and can benefit from the potential to create economies of scale. As chapters 2 and 6 showed, the international presence of ICT firms in all cities in the Globalization and World City (GaWC) inventory allows them to scale up solutions based on smart city technologies in an efficient manner, enabled by the decreased liability of foreignness that firms experience by locating their activities in global cities (Goerzen et al., 2013; Mehlsen and Wernicke, 2016). This reflects that ICT firms (e.g. firms from non-fossil fuel industries) can potentially have a positive impact on transformative change in energy consumption, by exploiting resources and capabilities in developing and marketing ICT-based network and infrastructure solutions (Erlinghagen and Markard 2012; Geels, 2018).

In addition, the strategic management perspective on MNEs in sustainability transitions contributes to understanding how internal factors influence firm-specific investments in radical technological innovations. Geels (2014) identifies that incumbent firms can impact a sustainability-oriented transition process by developing and marketing technological innovations, but can be reluctant to do so because of sunk investments in existing fossil fuel-based technologies (Unruh, 2000), and the risk of potentially disrupting existing capabilities (Tushman and Anderson, 1986). The longitudinal analysis of solar PV investments of oil firms presented in chapter 4 illustrates how strategic decisions of MNEs to develop and commercialize RETs are shaped by internal resources and capabilities. In particular, it shows how (non-)complementarity between a firm's existing resources and capabilities, and the distinctive characteristics of a novel technological, influences the strategic approach of the firm to developing and commercializing it. The oil firms in the sample relied on external acquisitions rather than existing internal R&D capabilities in technology development, and commercialized solar PV to multiple niche markets outside their existing value chains. This reflects the propensity of incumbent firms to focus on incremental, competence-sustaining innovations rather than radical, competence-destroying innovations in technological innovation (Bower and Christensen, 1995; Hill and Rothaermel, 2003; Tripsas, 1997; Tushman and Anderson, 1986). While the diffusion of RETs is only one of multiple factors which influences energy sector transformation (Geels, 2018; Wilson and Tyfield, 2018), it illustrates how incumbent firms can contribute to path-dependency and lock-in experienced by regimes in socio-technical systems (Erickson et al., 2015; Unruh, 2000), and explains why novel technologies for sustainable energy production and consumption can be hindered from widespread diffusion by firms with established positions in the existing energy system (Geels, 2002; 2004; 2005b).

Furthermore, the international business perspective has shown how external factors, specifically the regional (i.e. European) and national (i.e. home country) institutional environment, shape the investments of MNEs in fossil fuel-based technologies and RETs as part of their internationalization strategies. Chapter 3 identified how the changing institutional environment in the European electricity industry is intertwined with the internationalization patterns of electric utilities outside their home market. At the regional level, it showed that cross-border harmonization in the regional institutional environment decreases the liability of foreignness experienced by MNEs, and thereby shapes their intra-regional growth strategies (Rugman and Verbeke, 2004; 2005). Institutional differences between countries continue to exist, given that market liberalization is incomplete in multiple EU countries (Joscow, 2008). The analysis of internationalization patterns of EU electric utilities shows how this provides an opportunity for firms to internationalize to host countries which have seen a faster pace of market liberalization, while also profiting from a protected home market. Similarly, the influence of differences in home-country public policies on firm strategies is also reflected in their RET investments. Favourable public policies on RETs have allowed some EU electric utilities to increase their installed renewable energy capacity in their home market, and enabled them to create FSAs which can be leveraged outside the home market (Rugman and Verbeke, 2007). A noteworthy illustration in this respect is Iberdrola Renovables, which was able to increase their installed wind energy capacity based on public policies in its home market (with a total of 13.690 MW installed renewable energy capacity, compared to 6.102 MW - 1.896 MW for the other firms in the same year). This illustrates how the international growth patterns and firm-specific resources and capabilities in RETs can be shaped by external dynamics in the (supra-)national institutional environment. In this respect, both the strategic management and international business perspective shed light on internal and external factors which influence MNE strategies in sustainable energy, and thereby contribute to understanding how firm strategies can influence transition processes in society (Geels, 2014).

7.3 Limitations and opportunities for future research

Limitations

Several limitations should be mentioned related to the reliability, generalizability, and validity of the research findings, as will be discussed below, divided into three clusters. More generally, the fact that the dissertation consists of separate studies on different themes relevant to business and sustainable energy, with four of them published as articles in refereed journals over a five-year period, has pros and cons. While they have been judged for their suitability, quality and contributions by external experts, the studies were geared to a specific audience and, in two of the four cases, for special issues. This means that the framing is different and that the chapters/articles are embedded in different debates, hampering the coherence of the overall dissertation at points. Especially in the case of Chapter 3, the fact that it was submitted to and published in a special issue of British Journal of Management on (generic) strategies for firm globalization and regionalization has affected its writing and positioning, with (renewable) energy not being central. To partly redress this drawback from the perspective of the dissertation, Chapter 2 starts with the energy transition and the emergence of smart city solutions as technological innovations, and embeds this in the generic debate on globalization/regionalization/localization.

Perhaps more importantly, the article-based set-up covering a longer period overall also means that some of it is time-based, regarding the empirics, a common feature, but particularly concerning the theoretical debates and literature used. This is notable, for example, in the case of Chapter 5, which covers business models, an area where many advances have been made, both in terms of the generic literature and specific for sustainability (e.g. see Bittencourt Marconatto et al., 2016; Bohnsack et al., 2014; Gabriel and Kirkwood, 2016; Matos and Silvestre, 2013; Palomares-Aguirre et al., 2017). Additionally, the technological advancement in multiple sources of renewable energy, especially solar PV (REN21, 2017), has potentially affected the technology-specific investments of firms in RETs for power generation in recent years. For chapter 4, which specifically addressed solar PV, as well as the other chapters which focused on RETs for power generation (chapters 3 and 5, see table 7.2 for an overview), this could have influenced technology-specific investments of firms in RETs in recent years, after the publication of the articles.

Concerning the three sets of more specific limitations, first, the focus on qualitative research through a multiple case study analysis in each chapter affects the generalizability of findings, albeit to different degrees and in different ways. Chapters 2, 3, and 4 explored whether and how business contributes to the diffusion of technologies for more sustainable energy production and consumption. The focal firms in the empirical section represent a sample of leading firms in each industry, respectively ICT (chapter 2), electric utilities (chapter 3), and oil (chapter 4). Given the established positions of these firms in their respective industries, findings for their strategies and investments in sustainable energy technologies can be considered to be rather generalizable to other comparable MNEs in the specific industry context. In chapter 3, limitations to generalizability arise from the focus on one specific region (EU) and type of firm (electric utilities). Developments in the (supra-)national institutional environment, most notably market liberalization and deregulation, shape the strategies of the focal firms in the empirical section, making findings both industry-specific as well as region-specific. Hence, they can be considered to be generalizable to other firms within the same context, but not necessarily to other industries or triad regions. A similar observation can be made for chapter 4. The focus on exploring how oil firms develop and commercialize solar PV technology make the empirical research findings both industry-specific and technology-specific. While limiting the generalizability of findings to firms in other industries and RETs with other characteristics, it does provide an illustrative case that adds to existing literature on how firm resources and capabilities shape their strategic investments in technology innovations which are radical and non-complementary in nature. Hence, all chapters make contributions to existing literature, and provide illustrative cases within specific industry contexts.

Similar observations apply to chapters 5 and 6. Both chapters focus on whether and how business addresses challenges related to the scalability, affordability, and accessibility of sustainable energy solutions. Given the lack of existing academic studies on this issue in the business and management literature to date, case studies on specific urban and rural contexts were conducted in the empirical sections of both studies. While a core strength of the multiple case design is the opportunity to study a phenomenon in more detail in its real-life context (Yin, 2003), the dynamic interaction between unit of analysis and the external environment in which it emerges limits the generalizability of findings. The context-specific dimensions of the external environment in which the research is conducted influence and shape the strategies of the focal organizations in the analysis. Yet, both chapters present exemplary case studies to illustrate a phenomenon within a specific context: how smaller, locally embedded SMEs aim to develop commercially viable business models for sustainable energy technologies in developing countries in chapter 5, and how the process of scaling solutions to urban energy efficiency beyond pilot projects unfolds in a specific city in chapter 6. Given that both studies provide insight into a phenomenon, and unravel factors which influence the scalability, affordability, and accessibility of sustainable energy solutions within each specific context, the empirical work makes relevant contributions to existing research to date.

Second, data problems concerning the lack of geographic reporting on key company figures including revenues, assets, and number of employees limits the opportunities for making a more comprehensive analysis of the geographic profile of firm activities and their degree of globalization-regionalization-localization. In chapter 2, gathering data on the sub-national level presence of firms with an eye to establishing the size and scope of their activities in specific cities based on exact figures was impossible due to a lack of company reporting at that level of specificity. While the GaWC inventory was introduced to determine whether the focal firms had local presence in specific cities through either their corporate headquarters or subsidiaries, the scope and size of firm activities in each city could not be determined because of a lack of data. While this allowed an assessment of the sub-national presence at the local level for each focal firm, more detailed geographic reporting would have enabled a more fine-grained analysis. Similarly, it was rather challenging to collect firm-level regional data on the activities of electric utilities in chapter 3. While annual reports provided an overview of home versus non-home country data for key company figures, and installed power generation capacity for each firm, enabling a longitudinal analysis of internationalization over time, collecting country-specific data for activities outside the home market proved to be rather challenging. Although this did not hinder an analysis of the regionalization strategies of the focal firms, and even allowed for the identification of sub-regions, the lack of geographic reporting of company figures limited a more detailed analysis of firm internationalization patterns.

A third limitation is related to the validity of findings which are based on data from firm self-representations. For chapters 2, 3, and 4, data was collected for the focal MNEs from firm documentation, including annual reports, corporate social responsibility (CSR) reports, and issue-specific publications related to activities in sustainable energy, including smart city technologies for urban energy efficiency (chapter 2) and RETs for power generation (chapters 3 and 4). Similarly, for chapters 5 and 6 documents were also collected from sources reflecting data based on self-representations. These include web-based sources on the activities and RET-based offerings of SMEs for decentralized energy (chapter 5), and on the solutions for urban energy efficiency developed in smart city pilot projects (chapter 6). Hence, for all chapters, the inclusion of data based on firm self-representations poses a potential threat for the validity of research findings, without a triangulation of this data by incorporating other sources. To enhance validity, steps for additional data collection were taken for each study through combining the documentation with semi-structured interviews (chapters 2, 5, and 6), (which enable at least a check with firm representatives and sometimes external experts), and with newspaper articles from reputable sources through a systematic search process in the LexisNexis database (chapters 3 and 4).

Future research

From the research findings presented in each chapter, a number of areas for future research can be identified. Related to the geography of internationalization strategies and the debate on globalization-regionalization-localization, it would be fruitful to conduct more research focused on the sub-national level as it has received limited attention to date. Specifically, examining which mechanisms enable MNEs to build FSAs from their presence in global cities would be interesting. The ability of ICT firms to establish leading positions in the market for smart city technologies by leveraging and integrating FSAs developed form a multitude of smart city engagements in heterogeneous urban contexts, provided insight into one specific industry in this respect. Exploring how local contexts shape the strategies and internationalization patterns of MNEs in other industries could enable a more fine-grained analysis of how firms build competitive advantages from combining global presence with local embeddedness.

While the influence of the region on firm internationalization patterns has been well-established across a broad range of industries, the interaction between MNE internationalization strategies and (supra-)national institutional context should also receive further attention. Within the EU electricity market, chapter 3 showed how home-country public policy and favourable regulation for RETs shaped both inward and outward investment decisions of electric utilities. Hence, home market effects stemming from imperfect harmonization of national institutional environments allowed utilities to non-location-bound FSAs in RETs. This influenced the international patterns of investments of electric utilities, and allowed RET-oriented subsidiaries (most notably Iberdrola Renovables) to build a competitive advantage in sustainable energy. While recent studies have focused on the influence of public policies on renewable energy investments (Polzin et al., 2015), and provided insight into support policies for RETs in different countries (Dusonchet and Telaretti, 2015; Kaplan, 2015; Nordensvärd and Urban, 2015), it would be interesting to explore how country-specific public policies affect MNEs' firm-specific investments in RETs. The influence of public policies on the uptake of renewable energy as a source of power generation by EU electric utilities (chapter 3) illustrates how the RET investments of MNEs can contribute to achieving the EU's 20/20/20 targets for sustainable energy.

Furthermore, the role of incumbent firms in sustainability-oriented technology innovation should receive further attention. The conceptual model developed in chapter 4 explored how internal resources and capabilities as well as external industry-level dynamics influence and shape firm strategies in developing and commercializing RETs. Related to the non-complementarity between the value chains of oil firms and the characteristics of solar PV, all firms primarily relied on external acquisition for technology development rather than on internal resources and capabilities, and commercialized the technology to niche markets rather than mainstream markets. However, other

RETs with the potential for better alignment with existing resources and capabilities could potentially see other outcomes in terms of technology development and commercialization. In this respect, the value chains of electric utilities from power generation to electricity distribution has a much higher degree of complementarity, possibly affecting the nature of their RET investments. Therefore, it would be relevant to further explore incumbent firms and their technology-specific investments related to these internal factors.

Additionally, the role of MNEs in the creation of industries for renewable energy provides an interesting opportunity to further examine linkages between the firm strategies and transition processes. A recent study by Bohnsack et al. (2016) in this realm showed how firms influenced the creation of the solar energy industry between 1982 and 2012. Their analysis showed that "companies and governments were both found to be dominant actors in driving the institutional evolution process that laid the foundation for the creation of the global solar industry", whereby companies "were responsible for the technological breakthroughs that changed the institutional foundation of the industry by making mainstream production possible and allowing for an efficiency-based business model to become dominant" (Bohnsack et al., 2016, 31). In exploring how actors influence transition processes in society (Farla et al., 2012; Markard et al., 2012), this provides an illustration of how actor-related patterns can influence the creation of new industries which facilitate more sustainable modes of energy production and consumption (Geels, 2005b). Multiple chapters in the dissertation, most notably chapter 2 (i.e. ICT firms and energy efficiency technologies) and chapter 4 (i.e. oil firms and solar PV technology), shed light on how MNEs influence the development trajectory of industries which facilitate more sustainable modes of energy production and consumption. For future research at the intersection of business and management studies and transition processes in society, the influence of MNEs could be explored for other sectors that face persistent sustainability challenges in a similar way.

Related to the question of how business and market-based models can address challenges related to the scalability, affordability, and accessibility of sustainable energy solutions, chapters 5 and 6 provide opportunities for further research. Both chapters identified that interrelatedness between conditions in the environment of actors influenced their ability to develop sustainable energy solutions. The case studies on business models for decentralized RET-based power generation in emerging markets (chapter 5), and upscaling trajectories for energy efficiency solutions developed in urban pilot projects (chapter 6), are all characterized by a high degree of context-sensitivity. It would be highly interesting to conduct similar research in other geographic regions, and perform a cross-case analysis which explicitly takes contextual characteristics (both physical and institutional) into account. Related to chapter 5, this implies extending research beyond Asian countries to other regions which face similar issues concerning access to energy in developing and emerging countries, including sub-Saharan Africa and Latin America. For chapter 6, this could be done by performing a comparative analysis of urban pilot projects developed in other capital cities beyond Amsterdam, which have similar city-level environmental sustainability ambitions.

Notwithstanding the limitations regarding generalizability mentioned above, chapter 5 suggests that the role of business in sustainable development should also examine the role of bottom-up approaches initiated by smaller, locally embedded companies in more detail. The analysis of SMEs in chapter 5 showed that local conditions in the external environment have a major influence on the degree to which a commercially viable business model can be developed. Literature on the activities of MNEs in sustainable development has been well-established in multiple ways, for example through their CSR activities and through public-private partnerships by collaborating with governments and international organizations. However, the role of financing and delivery models of SMEs and local entrepreneurs which take a more bottom up rather than top-down approach to market development, has largely been overlooked to date. Perspectives from the business and management literature, such as the business model perspective adopted in chapter 5, can help to shed light on market-based responses to sustainable development issues. Future research should therefore take the peculiarities of developing market contexts into account, and specifically explore the emergence of bottom-up approaches.

Recent publications have already started to explore business models for renewable energy in developing countries (Gabriel and Kirkwood, 2016), and within BOP contexts more generally (Bittencourt Marconatto et al., 2016; Palomares-Aguirre et al., 2017). This includes rethinking the way in which donor funding for sustainable development affects market conditions for the private sector, and the scaling potential of locally developed energy solutions. In the case of RET-based rural off-grid electrification, local entrepreneurs stated that donor-funded projects by international organizations can potentially have a distorting effect on local market development. This limits the opportunity for SMEs and local entrepreneurs to develop market-based solutions for access to energy. The focal firms researched in chapter 5 showed that most of them still relied on mixed forms of donor-funded and commercial activities, or provided rental schemes in collaboration with public or non-profit organizations to make access to energy affordable and accessible to local customers. For long-term market development, this may require different forms of collaboration by public, private and non-profit actors in terms of donor funding, or other types of partnership arrangements. Similarly, this was also reflected in the analysis of urban energy efficiency pilot projects in chapter 6, which showed that donor-funded projects insufficiently incorporated mechanisms through which locally developed solutions could be scaled up beyond pilot projects. Hence, more research is needed on the conditions which affect the ability of local actors to scale up energy solutions, in order to inform policymakers on how to incorporate market-based mechanisms into donor-funded projects, and thereby facilitate local actors in reaping the benefits from scaling up energy solutions.

To conclude, both academics and practitioners perceive the diffusion of sustainable energy technologies for energy production and consumption as a key challenge for the decades to come. The magnitude of investments needed to address this challenge requires that actors from all societal spheres contribute to this transformative change process, ranging from intergovernmental organizations, national governments, and city administrations on the public side, to small and large firms on the private side. For energy production, this primarily entails moving beyond fossil fuel dependence towards a more diversified and RET-based power generation portfolio. In chapters 3, 4, and 5, the analysis showed how firms invest in centralized (grid-connected) and decentralized (off-grid) RET-based power generation contribute to sustainable development and lowering GHG emissions. For energy consumption, this principally means improving the resource efficiency of existing technologies and systems, particularly in energy-intensive contexts. Chapters 2 and 6 identified how firms develop and market smart city technologies, which enable energy-intensive systems and processes in cities and urban areas to become more efficient, thereby diminishing their carbon footprint. Overall, the research findings presented in this dissertation shed light on business strategies in sustainable energy in heterogeneous contexts, and provide a basis for further research at the intersection of business and sustainability-related societal challenges.

REFERENCES

2thinknow (2014). *Innovation Cities Index 2014 - Europe*. <http://www.innovation-cities.com/innovation-cities-europe-index-2014/8897> Accessed June 10th, 2016.

Accenture (2011). *Building and managing an Intelligent City.* <http://www.fm-house.com/wp-content/uploads/2015/01/Building-Managing-Intelligent-City.pdf> Accessed January 25th, 2017.

Accenture (2012). *Intelligent urban infrastructure.* <https://www.accenture.com/~/media/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Industries_4/Accenture-Intelligent-Urban-Infrastructure.pdf> Accessed January 25th, 2017.

Accenture (2013). *Accenture sustainability services.* <https://www.accenture.com/nl-en/~/media/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Strategy_4/Accenture-Sustainability-Service-Brochure.pdf> Accessed January 25th, 2017.

Accenture (2015). *Open Energy Data: A Prerequisite for Cities to Become Low-Carbon*. <http://urbantransform.eu/wp-content/uploads/sites/2/2013/02/Transform-open-data-booklet.pdf> Accessed October 10th, 2016.

Accenture (2017). *Capabilities for tomorrow's digital city hall*. <https://www.accenture.com/t20170920T185448Z__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_26/Accenture-City-Operating-Model-US.pdf> Accessed December 30th, 2017.

Aharoni, Y. (2006). Book review: Alan M. Rugman, The regional multinationals MNE and global strategic management. *International Business Review, 15*(4): 439-446.

Ahuja, G., and Lampert, C. (2001). Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough inventions*. Strategic Management Journal, 22*: 521-543.

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., and Airaksinen, M. (2017**).** What are the differences between sustainable and smart cities? *Cities*, *60*(A): 234-245.

Alawadhi, S., Aldama-Nalda, A., Chourabi, H., Gil-García, J., Leung, S., Mellouli, S., Nam, T., Pardo, A., Scholl, H., and Walker, S. (2012). Building understanding of smart city initiatives. *Electronic government*: 40-53.

Albino, V., Berardi, U., and Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1): 3-21.

Allwinkle, S., and Cruickshank, P. (2011). Creating smart-er cities: An overview. *Journal of urban technology*, *18*(2), 1-16.

Alusi, A., Eccles, R. G., Edmondson, A. C., and Zuzul, T. (2011). Sustainable cities: oxymoron or the shape of the future?. *Harvard Business School Organizational Behavior Unit Working Paper*: 1-26.

Amable, B. (2003). *The Diversity of Modern Capitalism.* Oxford: Oxford University Press.

Amitrano, C, Alfano, A., and Bifulco, F. (2014). New Smart Cities: a focus on some ongoing projects. *Proceedings of the 3rd International Virtual Conference of Informatics and Management Sciences:* 383-388.

Anderson, P., and Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative science quarterly*: 604-633.

Andriopoulos, C., and Lewis, M. W. (2009). Exploitation-exploration tensions and organizational ambidexterity: Managing paradoxes of innovation. *Organization Science*, *20*(4): 696-717.

Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities*, *47*, 95-106.

Arcadis (2015). *Sustainable Cities Index 2015.* <https://www.arcadis.com/media/E/F/B/%7BEFB74BBB-D788-42EF-A761-4807D69B6F70%7D9185R_Arcadis_whitepaper_2015.pdf> Accessed June 10th, 2016.

ARE (2008). *Best Practices of ARE: What Renewable Energy Can Achieve in Developing Countries.* <https://www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Misc/ARE_Best_Practice_2011.pdf> Accessed October 28th, 2012.

Asmussen, C. G. (2009). Local, regional, or global? Quantifying MNE geographic scope. *Journal of International Business Studies*, *40*(7): 1192-1205.

Backer, L., and Clark, T. S. (2008). Eco-Effective Greening Decisions and Rationalizations: The Case of Shell Renewables. *Organization and Environment, 21*(3): 227-244.

Baden-Fuller, C., and Morgan, M. S. (2010). Business models as models. *Long Range Planning*, *43:* 156-171.

Bakıcı, T., Almirall, E., and Wareham, J. (2013). A smart city initiative: the case of Barcelona. *Journal of the Knowledge Economy*, *4*(2): 135-148.

Banalieva, E. R., and M. D. Santoro (2009). Local, regional, or global? Geographic orientation and relative financial performance of emerging market multinational enterprises. *European Management Journal, 27*: 344-355.

Banerjee, A. V., and Duflo, E. (2010). Giving credit where it is due. *Journal of Economic Perspectives*, *24*(3): 61–80.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of management*, *17*(1): 99-120.

Barney, J. B. (2001a). Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of management*, *27*(6): 643-650.

Barney, J. B. (2001b). Is the resource-based “view” a useful perspective for strategic management research? Yes. *Academy of management review*, *26*(1): 41-56.

Bartlett, C., and Ghoshal, S. (1989). Managing Across Borders: The Transnational Solution. Boston, MA: Harvard Business School Press.

Baumol, W. (2002). Entrepreneurship, innovation, and growth: the David-Goliath symbiosis. *Journal of Entrepreneurial Finance and Business Ventures, 1*: 1-18.

Benner, M. J., and Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of management review*, *28*(2): 238-256.

Beaverstock, J. V., Smith, R. G., and Taylor, P. J. (1999). A roster of world cities. *Cities, 16*(6): 445-458.

Beaverstock, J. V., Smith, R. G., and Taylor, P. J. (2000). World-City Network: A New Metageography?. *Annals of the association of American geographers, 90*(1): 123-134.

Betsill, M., and Bulkeley, H. (2006). Cities and the multilevel governance of global climate change. *Global Governance: A Review of Multilateralism and International Organizations*, *12*(2): 141-159.

Beugelsdijk, S. (2011). Liability of foreignness and location specific advantages; time, space, and relative advantage. *Advances in International Management, 24:* 181-210

Beugelsdijk, S., McCann, P., and Mudambi, R. (2010). Place, space and organisation: Economic geography and the multinational enterprise. *Journal of Economic Geography*, 10(4): 485–493.

Beugelsdijk, S., and Mudambi, R. (2013). MNEs as border-crossing multi-location enterprises: The role of discontinuities in geographic space. *Journal of International Business Studies*, *44*(5): 413-426.

Binswanger, H. and Aiyar, S. (2003). *Scaling Up Community Driven Development, Theoretical Underpinnings and Program Design Implications.* <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=636401> Accessed April 1st, 2016.

Biswas, W., Bryce, P., and Diesendorf, M. (2001). Photovoltaic technologies for poverty alleviation in rural Bangladesh. *Environmental Science and Policy, 4*: 333-344.

Bittencourt Marconatto, D., Barin-Cruz, L., Pozzebon, M., and Poitras, J-E. (2016). Developing sustainable business models within BOP contexts: mobilizing native capability to cope with government programs. *Journal of Cleaner Production, 129*: 735-748.

Bohne, E. (2011). Conflicts between national regulatory cultures and EU energy regulations. *Utilities Policy, 19*(4): 255-269.

Bohnsack, R., Pinkse, J., and Kolk, A. (2014). Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles. *Research Policy*, *43*(2): 284-300.

Bohnsack, R., Pinkse, J., and Waelpoel, A. (2016). The institutional evolution process of the global solar industry: The role of public and private actors in creating institutional shifts. *Environmental Innovation and Societal Transitions*, *20*: 16-32.

Boons, F., and Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*: 9-19.

Boons, F., Montalvo, C., Quist, J., and Wagner, M. (2013). Sustainable innovation, business models and economic performance: an overview. *Journal of Cleaner Production*, *45*: 1-8.

Boulton, L. (1997). Solar expansion planned by Shell. Financial Times, 7 October.

Bower, J., and Christensen, C. (1995). Disruptive technologies: catching the wave. *Harvard Business Review, 1*: 43-53.

BP. (2008). *Sustainability Review: 100 Years of Operating at the Frontiers.* London: BP Publications.

Bridge, G., Bouzarovski, S., Bradshaw, M., and Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, *53:* 331-340.

Broto, V., and Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92-102.

Brown, S. L., and Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative science quarterly*: 1-34.

Brown, R. R., Farrelly, M. A., and Loorbach, D. A. (2013). Actors working the institutions in sustainability transitions: The case of Melbourne's stormwater management. *Global Environmental Change*, *23*(4): 701-718.

Buchan, D., and Mallet, V., 2001. The captain of a very French multinational. Financial Times, 5 June.

Buckley, P. J., Doh, J. P., and Benischke, M. H. (2017). Towards a renaissance in international business research? Big questions, grand challenges, and the future of IB scholarship. Journal of International Business Studies: 1-20.

Bulkeley, H. (2010). Cities and the governing of climate change. *Annual Review of Environment and Resources*, *35*: 229-253.

Bulkeley, H., and Betsill, M. (2005). Rethinking sustainable cities: multilevel governance and the 'urban' politics of climate change. *Environmental politics*, *14*(1): 42-63.

Bulkeley, H., Broto, V., Hodson, M., and Marvin, S. (Eds.). (2010). *Cities and low carbon transitions*. London: Routledge.

Bulkeley, H., and Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3): 361-375.

Byrne, J., Shen, B., and Wallace, W. (1998). The economics of sustainable energy for rural development: A study of renewable energy in rural China. *Energy Policy, 26*(1): 45-54.

Caragliu, A., Del Bo, C., and Nijkamp, P. (2011). Smart cities in Europe. *Journal of urban technology*, *18*(2): 65-82.

Carvalho, L. (2014). Smart cities from scratch? A socio-technical perspective. *Cambridge Journal of Regions, Economy and Society*, *8*(1): 43-60.

Carvalho, L., Berg, L. van den, Borg, J. van der, Tuijl, E. van, Germini, M. and Lazzerini, I. (2013), Review, Background and Frame of Analysis & First Case Study: Stockholm. *Enel Foundation Working Paper Series*, 1/2013. Enel Foundation, Rome.

Chakrabarti, A., and Chakrabarti, A. (2002). Rural electrification programme with solar energy in remote region – case study in an island. *Energy Policy, 30*: 33-42.

Chesbrough, H. (2003). The era of open innovation. *MIT Sloan Management Review, 1*: 35 – 41.

Chesbrough, H., Ahern, S., Finn, M., and Guerraz, S. (2006). Business models for technology in the developing world: The role of non-governmental organizations. *California Management Review, 48*(3): 48-61.

Christensen, T. B., Wells, P., and Cipcigan, L. (2012). Can innovative business models overcome resistance to electric vehicles? Better Place and battery electric cars in Denmark. *Energy Policy*, *48*: 498-505.

Christmann, P. (2004). Multinational companies and the natural environment: Determinants of global environmental policy. *Academy of Management Journal*, *47*(5): 747-760.

Christmann, P., and Taylor, G. (2001). Globalization and the environment: Determinants of firm self-regulation in China. *Journal of international business studies*, *32*(3): 439-458.

Choma, R. (2009). *Overseas firms collecting most green energy money*. <http://investigativereportingworkshop.org/investigations/wind-energy-funds-going-overseas/story/overseas-firms-collecting-most-green-energy-money/> Accessed October 10th, 2010.

Chu, M. (2007). Commercial returns at the Base of the Pyramid. *Innovations*, *2*(1-2): 115-146.

Cisco (2010). *Connecting cities - achieving sustainability through innovation.* <http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/Connecting_Cities_Sustainability_Through_Innovation_IBSG_1021FINAL.pdf> Accessed December 1st, 2016.

Cisco (2011). *Smart+Connected City services.* <http://www.cisco.com/c/dam/en_us/about/ac79/docs/ps/Busan-Green-u-City_IBSG.pdf> Accessed December 1st, 2016.

Cisco (2012). *Smart city framework: a systematic process for enabling Smart+Connected Communities.* <http://www.cisco.com/c/dam/en_us/about/ac79/docs/ps/motm/Smart-City-Framework.pdf> Accessed December 10th, 2016.

Cisco (2013a). *Smart cities and the Internet of Everything.* <http://www.cisco.com/c/dam/en_us/solutions/industries/docs/scc/ioe_citizen_svcs_white_paper_idc_2013.pdf> Accessed December 10th, 2016.

Cisco (2013b). *The Internet of Everything for cities.* <http://www.cisco.com/c/dam/en_us/solutions/industries/docs/gov/everything-for-cities.pdf> Accessed December 10th, 2016.

Cisco (2014). *Cisco Smart+Connected Communities: envisioning the future of cities now.* <http://www.cisco.com/c/dam/en_us/solutions/industries/docs/smart-cities-expo-barcelona.pdf> Accessed December 10th, 2016.

Coenen, L., Benneworth, P., and Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. Research policy, 41(6): 968-979.

Coenen, L., Raven, R., and Verbong, G. (2010). Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. *Technology in Society*, *32*(4): 295-302.

Coenen, L.. and Truffer, B. (2012). Places and spaces of sustainability transitions: geographical contributions to an emerging research and policy field. European Planning Studies, 20(3): 367-374.

Collinson, S., and Rugman, A. M. (2008). The regional nature of Japanese multinational business. *Journal of international business studies*, *39*(2): 215-230.

Cooley, L. and Kohl, R. (2005). *Scaling Up-From Vision to Large-scale Change: A Management Framework for Practitioners,* Washington DC: Management Systems International.

Dahan, N. M., Doh, J. P., Oetzel, J., and Yaziji, M. (2010). Corporate-NGO collaboration: Co-creating new business models for developing markets. *Long Range Planning*, *43*: 326-342.

Danneels, E. (2004). Disruptive technology reconsidered: A critique and research agenda. *Journal of product innovation management*, *21*(4): 246-258.

Davis, J. (2006). Why don't oil companies commit to "renewables"? A corporate constraints perspective. In J. Davis (Ed.): The Changing World of Oil: An Analysis of Corporate Change and Adaptation: 169-189. Aldershot: Ashgate Publishing.

Davis, M. (1998). Rural household energy consumption: The effects of access to electricity – evidence from South Africa. *Energy Policy, 26*(3): 207-217.

De Jong, M., Joss, S., Schraven, D., Zhan, C., and Weijnen, M. (2015). Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner production*, *109*: 25-38.

Deloitte, *Monitor Deloitte. Smart Cities… Not Just the Sum of its Parts* (New York: Deloitte, 2015) <https://www2.deloitte.com/content/dam/Deloitte/xe/Documents/strategy/me_deloitte-monitor_smart-cities.pdf> Accessed October 10th, 2016.

Denzin, N.K. (1978). The logic of naturalistic inquiry. In Denzin, N.K. (ed.), *Sociological methods: A source* book. 2nd ed. New York: McGraw-Hill.

Derudder, B., Taylor, P., Witlox, F., and Catalano, G. (2003). Hierarchical tendencies and regional patterns in the world city network: a global urban analysis of 234 cities. *Regional Studies*, 37(9): 875–886.

Derudder, B., and Witlox, F. (2004). Assessing central places in a global age: on the networked localization strategies of advanced producer services. *Journal of Retailing and Consumer Services*, *11*(3): 171-180.

Devinney, T. M., Midgley, D. F., and Venaik, S. (2000). The optimal performance of the global firm: Formalizing and extending the integration-responsiveness framework. *Organization Science*, *11*(6): 674-695.

Dincer, I. (2000). Renewable energy and sustainable development: a crucial review. *Renewable and Sustainable Energy Reviews*, *4*(2): 157-175.

Doh, J. (2015). From the Editor: Why we need phenomenon-based research in international business. *Journal of World Business, 50*(4): 609-611.

Doh, J., McGuire, S., and Ozaki, T. (2015). The Journal of World Business Special Issue: Global governance and international nonmarket strategies: Introduction to the special issue. *Journal of World Business, 50*: 256–261.

Domanico, F. (2007). Concentration in the European electricity industry: The internal market as solution?. *Energy Policy*, *35*(10): 5064-5076.

Dowell, G., Hart, S., and Yeung, B. (2000). Do corporate global environmental standards create or destroy market value?. *Management science*, *46*(8): 1059-1074.

Du Plessis, M. (2007). The role of knowledge management in innovation. *Journal of knowledge management*, *11*(4): 20-29.

Dunning, J. H., Fujita, M., and Yakova, N. (2007). Some macro-data on the regionalisation/globalisation debate: a comment on the Rugman/Verbeke analysis. *Journal of International Business Studies*, *38*(1): 177-199.

Dusonchet, L., and Telaretti, E. (2015). Comparative economic analysis of support policies for solar PV in the most representative EU countries. *Renewable and Sustainable Energy Reviews*, *42*: 986-998.

Economist Intelligence Unit and Siemens (2009). *The European Green City Index.* <http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_en.pdf> Accessed June 20th, 2016.

Economist Intelligence Unit and Siemens (2011). *US and Canada Green City Index.* <http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_northamerica_en.pdf> Accessed June 20th, 2016.

Economist Intelligence Unit and Siemens (2012). *The Green City Index.* <https://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/gci_report_summary.pdf> Accessed June 20th, 2016.

Eikeland, P. O., Hasselknippe, H., and Sæverud, I. A. (2004*). Energy sector integration in Europe - The role of leading upstream oil and gas companies.* FNI report 20/2004. Lysaker, Norway: The Fridtjof Nansen Institute.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, *14*(4): 532-550.

Eisenhardt, K. M., and Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal*, *50*(1): 25-32.

ENTSOE (2010). *Ten-year network development plan 2010-2020.* Brussels: European Network of Transmission System Operators for Electricity.

Erickson, P., Kartha, S., Lazarus, M., and Tempest, K. (2015). Assessing carbon lock-in. *Environmental Research Letters*, *10*(8): 084023.

Erlinghagen, S., and Markard, J. (2012). Smart grids and the transformation of the electricity sector: ICT firms as potential catalysts for sectoral change. *Energy Policy*, *51*: 895-906.

European Commission. (2010*). Energy 2020: A Strategy for Competitive, Sustainable and Secure Energy*. <https://ec.europa.eu/energy/sites/ener/files/documents/2011_energy2020_en_0.pdf> Accessed April 8th, 2014.

European Commission (2013). *Smart Cities Stakeholder Platform - Using EU funding mechanism for Smart Cities.* <https://eu-smartcities.eu/sites/all/files/Guideline-Using%20EU%20fundings%20mechanism%20for%20smart%20cities.pdf> Accessed March 1st, 2017.

European Commission (2014). *Mapping Smart Cities in the EU.* <http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf> Accessed October 10th, 2016.

European Commission (2017). *Smart Cities and Communities Lighthouse Projects.* <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/scc-1-2016-2017.html> Accessed March 1st, 2017.

Eyring, M. J., Johnson, M. W., and Nair, H. (2011). New business models in emerging markets. *Harvard Business Review*, *89*(1-2): 89-95.

E&Y (2012). *Renewable energy country attractiveness indices.* London: Ernst and Young.

Farla, J., Markard, J., Raven, R., and Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological forecasting and social change*, *79*(6): 991-998.

Filippaios, F., and Rama, R. (2008). Globalisation or regionalisation? The strategies of the world's largest food and beverage MNEs. *European Management Journal*, *26*(1): 59-72.

Foos, T., Schum, G., and Rothenberg, S. (2006). Tacit knowledge transfer and the knowledge disconnect. *Journal of knowledge management*, *10*(1): 6-18.

Fortanier, F., and Kolk. A. (2007). On the economic dimensions of CSR: Exploring Fortune Global 250 reports. *Business and Society*, *46*(4): 457-478.

Gabriel, C. A., and Kirkwood, J. (2016). Business models for model businesses: Lessons from renewable energy entrepreneurs in developing countries. *Energy Policy*, *95*: 336-349.

Gan, L., Eskeland, G. S., and Kolshus, H. H. (2007). Green electricity market development: Lessons from Europe and the US. *Energy Policy*, *35*(1): 144-155.

Gardner, J.C., and McGowan, B. (2010). A note on the regional triad model and the soft drink industry. *Multinational Business Review, 18*(1): 89-94.

Garrette, B., and Karnani, A. (2010). Challenges in marketing socially useful goods to the Poor. *California Management Review*, *52*(4): 29-47.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, *31*(8): 1257-1274.

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): 897-920.

Geels, F. W. (2005a). Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective. *Technological forecasting and social change*, *72*(6): 681-696.

Geels, F. W. (2005b). The dynamics of transitions in socio-technical systems: a multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930). *Technology Analysis and Strategic Management, 17*(4): 445-476.

Geels, F. W. (2005c). Co-evolution of technology and society: The transition in water supply and personal hygiene in the Netherlands (1850–1930)—a case study in multi-level perspective. *Technology in Society, 27*(3): 363-397.

Geels, F. W. (2006). Major system change through stepwise reconfiguration: a multi-level analysis of the transformation of American factory production (1850–1930). *Technology in Society*, *28*(4): 445-476.

Geels, F. W. (2007). Transformations of Large Technical Systems A Multilevel Analysis of the Dutch Highway System (1950-2000). *Science, Technology and Human Values, 32*(2): 123-149.

Geels, F. W. (2011a). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental innovation and societal transitions*, *1*(1), 24-40.

Geels, F. W. (2011b). The role of cities in technological transitions. In H. Bulkeley et al. (Eds.), Cities and low carbon transitions (13–28). London: Routledge.

Geels, F. W. (2014). Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework. *Research Policy*, *43*(2): 261-277.

Geels, F. W. (2018). Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the Multi-Level Perspective. *Energy Research & Social Science, 37*: 224-231.

Geels, F. W., and Deuten, J. J. (2006). 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): 265-275.

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

Geels, F. W., and Raven, R. (2007). Socio-cognitive evolution and co-evolution in competing technical trajectories: biogas development in Denmark (1970–2002). *The International Journal of Sustainable Development and World Ecology, 14(*1): 63-77.

Geels, F. W., and Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, *36*(3): 399-417.

Ghemawat, P. (2001). Distance still matters. *Harvard business review*, *79*(8): 137-147.

Ghemawat, P. (2003). Semiglobalization and international business strategy. *Journal of International Business Studies, 34*(2): 138-152.

Ghemawat, P. (2005). Regional strategies for global leadership. *Harvard Business Review, 83*(12): 98-108.

Gil-Garcia, J. R., Pardo, T. A., and Nam, T. (2015). What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. *Information Polity*, *20*(1): 61-87.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., and Meijers, E. (2007). *Smart cities-Ranking of European medium-sized cities*. Vienna University of Technology.

Goerzen, A., Asmussen, C. G., and Nielsen, B. B. (2013). Global cities and multinational enterprise location strategy. *Journal of International Business Studies, 44*(5): 427-450.

Goetzberger, A., Luther, J., and Willeke, G. (2002). Solar cells: past, present, future. *Solar Energy and Solar Cells, 74:* 1-11.

Grant, R. M. (2003). Strategic planning in a turbulent environment: Evidence from the oil majors. *Strategic Management Journal, 24*(6): 491-517.

Grant, R. M. (2005). Oil company strategies from 1970 to the present. In Eni (Ed.), Encyclopaedia of Hydrocarbons, IV: 301-321. Rome: The Instituto Della Enciclopedia Italiana Treccani.

Grant, R. M., and Cibin, R. (1996). Strategy, structure and market turbulence: The international oil majors, 1970-1991. *Scandinavian Journal of Management, 12*(2): 165-188.

Grimaldi, D., and Fernandez, V. (2015)**.** The alignment of University curricula with the building of a Smart City: A case study from Barcelona. *Technological Forecasting and Social Change*, in Press.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., and Briggs, J. M. (2008). Global change and the ecology of cities. *Science*, *319*(5864): 756-760.

Grin, J., Rotmans, J., and Schot, J. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*. London: Routledge.

Gross, R., Leach, M., and Bauen, A. (2003). Progress in renewable energy. *Environmental international, 29*: 105-122.

Grosse, R. (2005). Are the largest financial institutions really 'global'?. *Management International Review*: 129-144.

Halpern, O., LeCavalier, J., Calvillo, N., and Pietsch, W. (2013). Test-bed urbanism. *Public Culture*, *25*(2 70): 272-306.

Hansen, T., and Coenen, L. (2015). The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions, 17:* 92-109.

Hartmann, A., and Linn, J. (2008). *Scaling up - A Framework and Lessons for Development Effectiveness from Literature and Practice*. <https://www.brookings.edu/wp-content/uploads/2016/06/10_scaling_up_aid_linn.pdf> Accessed April 1st, 2016.

Hejazi, W. (2007). Reconsidering the concentration of US MNE activity: Is it global, regional or national?. *Management International Review, 47*(1): 5-27.

Herring, H. (2006). Energy efficiency—a critical view. *Energy*, *31*(1): 10-20.

Herring, H., and Sorrell, S. (2009). *Energy efficiency and sustainable consumption.* London: Palgrave Macmillan.

Hielkema, H., and Hongisto, P. (2013). Developing the Helsinki smart city: The role of competitions for open data applications. *Journal of the Knowledge Economy*, *4*(2): 190-204.

Hill, C. W., and Rothaermel, F. T. (2003). The performance of incumbent firms in the face of radical technological innovation. *Academy of Management Review*, *28*(2): 257-274.

Hodson, M., and Marvin, S. (2009). Cities mediating technological transitions: understanding visions, intermediation and consequences. *Technology Analysis and Strategic Management*, *21*(4): 515-534.

Hodson, M., and Marvin, S. (2010). Can cities shape socio-technical transitions and how would we know if they were?. *Research policy*, *39*(4): 477-485.

Höjer, M., and Wangel, J. (2015). Smart sustainable cities: definition and challenges. In *ICT innovations for sustainability* (333-349). Springer, Cham.

Holdren, J. P. (2006). The energy innovation imperative: Addressing oil dependence, climate change, and other 21st century energy challenges. *Innovations: Technology, Governance, Globalization*, *1*: 3-23.

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?. *City*, *12*(3): 303-320.

Hoogma, R., Kemp, R., Schot, J., and Truffer, B. (2004). Experimenting for sustainable transport: the approach of strategic niche management. *Technology Analysis & Strategic Management*, *16*(4): 561-566.

Huber, P. (2003). On the Determinants of Cross-border Cooperation of Austrian Firms with Central and Eastern European Partners. *Regional Studies, 37*(9): 947-955.

IBM (2009). *A vision for smarter cities.* <http://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf> Accessed January 15th, 2017.

IBM (2011a). *IBM Smarter City Solutions – leadership and innovation for building smarter cities.* <ftp://ftp.software.ibm.com/la/documents/imc/la/cl/news/events/infrastructuresummit/smarter_city_solutions.pdf> Accessed January 15th, 2017.

IBM (2011b). *Actionable business architecture for smarter cities.* <https://www.ibm.com/smarterplanet/global/files/in__none__smarter_cities__actionable_business_architecture_smarter_cities__2.54mb.pdf> Accessed January 30th, 2017.

IBM (2011c). *Smarter Cities Series: a foundation for understanding IBM Smarter Cities.* <http://www.redbooks.ibm.com/redpapers/pdfs/redp4733.pdf> Accessed January 30th, 2017.

IBM (2012). *IBM intelligent operations center for smarter cities.* <ftp://public.dhe.ibm.com/software/solutions/soa/pdfs/IBM_Intelligent_Ops_Center_Solution_Brief.pdf> Accessed January 30th, 2017.

IBM (2014). *IBM Smarter Cities – creating opportunities through leadership and innovation.* <http://www.ibm.com/smarterplanet/global/files/in__none__smarter_citeies__SmarterCities_SmarterCitiesSolutionBrochure__689KB.pdf> Accessed January 30th, 2017.

IBM (2015). *IBM Annual Report 2015.* <https://www.ibm.com/annualreport/2015/bin/assets/IBM-Annual-Report-2015.pdf> Accessed February 7th, 2018.

IBM (2017). *IBM invites cities worldwide to compete for grants to help address their toughest challenges.* <http://www-03.ibm.com/press/us/en/pressrelease/51551.wss> Accessed December 30th, 2017.

International Energy Agency (2010). *World Energy Outlook 2010*. <http://www.worldenergyoutlook.org/media/weo2010.pdf> Accessed September 1st, 2011.

International Telecommunication Union (2015). *Smart sustainable cities: an analysis of definitions.* <http://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx> Accessed September 1st, 2016.

Ireland, J. (2008). Lessons for successful BOP marketing from Caracas´ slums. *Journal of Consumer Marketing*, *25*(7): 430-438.

Jacobides, M.G., Knudsen, T., and Augier, M. (2006). Benefiting from innovation: value creation, value appropriation and the role of industry architectures. *Research Policy*, *35*: 1200–1221.

Jacobson, A. (2007). Connective power: Solar electrification and social change in Kenya. *World Development, 35*(1): 144-162.

Jacobsson, S., and Johnson, A. (2000). The diffusion of renewable energy technology: an analytical framework and key issues for research. *Energy policy*, *28*(9): 625-640.

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

Jacobsson, S., and Lauber, V. (2006). The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. *Energy policy*, *34*(3): 256-276.

Jäger-Waldau, A. (2002). *PV Status Report 2002*. Ispra (VA), Italia: European Commission, DG Joint Research Centre, Institute for Energy, Renewable Energy Unit.

Jäger-Waldau, A. (2003). *PV Status Report 2003*. Ispra (VA), Italia: European Commission, DG Joint Research Centre, Institute for Energy, Renewable Energy Unit.

Jäger-Waldau, A. (2004). *PV Status Report 2004*. Ispra (VA), Italia: European Commission, DG Joint Research Centre, Institute for Energy, Renewable Energy Unit.

Jäger-Waldau, A. (2006). *PV Status Report 2006*. Ispra (VA), Italia: European Commission, DG Joint Research Centre, Institute for Energy, Renewable Energy Unit.

Jäger-Waldau, A. (2009). *PV Status Report 2009*. Ispra (VA), Italia: European Commission, DG Joint Research Centre, Institute for Energy, Renewable Energy Unit.

Johnson, J. H. (1995). An empirical analysis of the integration-responsiveness framework: US construction equipment industry firms in global competition. *Journal of International Business Studies*, *26*(3): 621-635.

Jones, C. (2010). The European Union's policy on the development of renewable energy. In: Moselle, B., Padilla. J., and Schmalensee, R. (eds). Harnessing Renewable Energy in Electric Power Systems, 233-252. London: Earthscan.

Joscow, P. (2008). Lessons learned from electricity market liberalization. *The Energy Journal, Special issue*: 9-42.

Joss, S., and Molella, A. P. (2013). The eco-city as urban technology: Perspectives on Caofeidian international eco-city (China). *Journal of Urban Technology*, *20*(1): 115-137.

Kaplan, Y. A. (2015). Overview of wind energy in the world and assessment of current wind energy policies in Turkey. *Renewable and Sustainable Energy Reviews*, *43:* 562-568.

Karlan, D., and Morduch, J. (2010). Access to finance, in Rodrik, D. and Rosenzweig, M. (Eds.), Handbook of Development Economics, Elsevier, North-Holland, 5: 4703-4784.

Kemp, R., Schot, J., and 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.

Klepper, S. (1997). Industry life cycles. *Industrial and Corporate Change, 6*: 145-182.

Kley, F., Lerch, C., and Dallinger, D. (2011). New business models for electric cars—A holistic approach. *Energy Policy*, *39*(6): 3392-3403.

Kolk, A. (2005). Environmental reporting by multinationals from the Triad: convergence or divergence?. *Management International Review, 45*(1): 145-166.

Kolk, A. (2010). Social and sustainability dimensions of regionalization and (semi)globalization. *Multinational Business Review, 18*(1): 51-72.

Kolk, A. (2016). The social responsibility of international business: From ethics and the environment to CSR and sustainable development. *Journal of World Business, 51*(1), 23-34.

Kolk, A., Kourula, A. and Pisani, N. (2017). Multinational Enterprises and the Sustainable Development Goals: What do we know and how to proceed? *Transnational Corporations*, *24*(3), 9-32.

Kolk, A., and Levy, D. L. (2001). Winds of change: Corporate strategy, climate change and oil multinationals. *European Management Journal, 19*(5): 501-509.

Kolk, A., and Levy, D. L. (2004). Multinationals and global climate change: issue for the automotive and oil industries. In S. M. Lundan (Ed.), Multinationals, Environment and Global Competition, 9: 171-193. Amsterdam: Elsevier.

Kolk, A., and Margineantu, A. (2009). Globalisation/regionalisation of accounting firms and their sustainability services. *International Marketing Review*, *26*(4/5): 396-410.

Kolk, A., and Pinkse, J. (2008). A perspective on multinational enterprises and climate change: Learning from "an inconvenient truth"?. *Journal of International Business Studies*, *39*(8): 1359-1378.

Kolk, A., and Pinkse, J. (2010a). *Policy Modes for Climate Change: The Role of Tripartite Partnerships*. Partnerships Resource Centre, Working Paper 003, May.

Kolk, A., and Pinkse, J. (2010b), *The Climate Change – Development Nexus and Tripartite Partnerships*. Partnerships Resource Centre, Working Paper 006, December.

Kolk, A., Rivera-Santos, M., and Rufín, C. (2010). What do we really know about the Base of the Pyramid? A review and research agenda. *Paper presented at the Academy of Management Annual Conference, Montreal (August 6-10).*

Kolk, A., Van Tulder, R., and Kostwinder, E. (2008). Partnerships for development. *European Management Journal*, *26*(4): 262-273.

Kolk, A., Van Tulder, R., and Westdijk, B. (2006). Poverty alleviation as business strategy? Evaluating commitments of frontrunner multinational corporations. *World Development*, *34*(5): 789-801.

Komninos, N. (2011). Intelligent cities: Variable geometries of spatial intelligence. *Intelligent Buildings International*, *3*(3): 172-188.

Komninos, N. (2014). *The age of intelligent cities: Smart environments and innovation-for-all strategies* (Vol. 78). London: Routledge.

Kramers, A., Höjer, M., Lövehagen, N., and Wangel, J. (2014). Smart sustainable cities–Exploring ICT solutions for reduced energy use in cities. *Environmental modelling and software*, *56*: 52-62.

Kudina, A. (2012). Regional strategies, liability of foreignness, and firm performance. *Multinational Business Review*, *20*(4): 331-351.

Lavie, D., and Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, *49*(4): 797-818.

Lavie, D., Stettner, U., and Tushman, M. L. (2010). Exploration and exploitation within and across organizations. *Academy of Management annals*, *4*(1): 109-155.

Lee, J.H., Hancock, M.G., and Hu, M. C. (2014)**.** Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change*, 89(1): 80-99.

Levy, D. L. (2009). Back to petroleum? Climate Inc., 13 August.

Levy, D. L., and Kolk, A. (2002). Strategic responses to global climate change: conflicting pressures on multinationals in the oil industry. *Business and Politics, 4*(3): 275-300.

Leydesdorff, L., and Deakin, M. (2011). The triple-helix model of smart cities: a neo-evolutionary perspective. *Journal of Urban Technology*, *18*(2): 53-63.

Li, J., and Guisinger, S. (1992). The globalization of service multinationals in the “triad” regions: Japan, Western Europe and North America. *Journal of International Business Studies*, *23*(4): 675-696.

Li, L. (2005). Is regional strategy more effective than global strategy in the US service industries?. *Management International Review, 45*(1): 37-57.

Li, L., and Li, D. (2007). Testing the global and regional strategic of multinational enterprises. In: Rugman, A. M. (Ed.). Regional Aspects of Multinationality and Performance, 263-296. Oxford: Elsevier.

Ling, S., Twiddell, J., and Boardman, B. (2002). Household photovoltaic market in Eining, Qinghai province, China: The role of local PV business. *Solar Energy, 4*: 227-240.

Lombardi, P., Giordano, S., Farouh, H., and Yousef, W. (2012). Modelling the smart city performance. *Innovation: The European Journal of Social Science Research*, *25*(2): 137-149.

Lüdeke-Freund, F. (2009). Business model concepts in corporate sustainability contexts: From rhetoric to a generic template for 'business models for sustainability'. *Leuphana Universität Lüneburg: Centre for Sustainability Management (CSM).*

Macomber, J. D. (2013). Building sustainable cities. *Harvard business review*, *91*(7): 40-50.

Maguire, S., and Hardy, C. (2009). Discourse and deinstitutionalization: The decline of DDT. *Academy of Management Journal, 52*(1): 148–178.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization science*, *2*(1): 71-87.

March, H., and Ribera-Fumaz, R. (2016). Smart contradictions: The politics of making Barcelona a Self-sufficient city. *European Urban and Regional Studies*, *23*(4): 816-830.

Martinot, E. (2001). Renewable energy investments by the World Bank. *Energy Policy, 29*: 689-699.

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

Matos, S., and Silvestre, B. S. (2013). Managing stakeholder relations when developing sustainable business models: the case of the Brazilian energy sector. *Journal of Cleaner Production*, *45*: 61-73.

May, K., Sigrist, L., Vingerhoets, P., Morch, A., Verboven, P., and Rouco, L. (2015). Improving scalability and replicability of smart grid projects. *Paper presented at CIRED 23rd International Conference on Electricity Distribution, Lyon (15-18 June 2015).*

McCann, P., and Mudambi, R. (2004). The location behavior of the multinational enterprise: Some analytical issues. *Growth and Change*, *35*(4): 491-524.

McCann, P., and Mudambi, R. (2005). Analytical differences in the economics of geography: the case of the multinational firm. *Environment and Planning A*, *37*(10): 1857-1876.

Meeus, L., Purchala, K., and Belmans, R. (2005). Development of the internal electricity market in Europe. *The Electricity Journal*, 18(6): 25-35.

Mehlsen, K., and Wernicke, G. (2016). Global cities and liability of foreignness. *European Journal of International Management*, *10*(1): 78-94.

Meyer, K. E. (2004). Perspectives on multinational enterprises in emerging economies. *Journal of International Business Studies*, *35*: 259-276.

Meyer, K. E., Mudambi, R., and Narula, R. (2011). Multinational enterprises and local contexts: the opportunities and challenges of multiple embeddedness. *Journal of Management Studies*, *48*(2): 235-252.

Miles, M.B and A.M. Huberman. (1994). Qualitative data analysis: An expanded sourcebook. 2nd ed. London: SAGE.

Milgrom, P., and Roberts, J. (1990). The Economics of Modern Manufacturing: Technology, Strategy, and Organization. *The American Economic Review, 80*(3): 511-528.

Miller, D. and Hope, C. (2000). Learning to lend off-grid solar power: Policy lessons from World Bank loans to India, Indonesia, and Sri Lanka. *Energy Policy, 28*: 87-105.

Mohiuddin, S. (2006). Expanding the role of microfinance in promoting renewable energy access in developing countries. *The Georgetown Public Policy Review, 11*(1): 119-124.

Morris, M., Schindehutte, M. and Allen, J. (2005). The entrepreneur's business model: Toward a unified perspective. *Journal of Business Research*, *58*: 726-735.

Mudambi, R. (2002). Knowledge management in multinational firms. *journal of international management*, *8*(1): 1-9.

Mudambi, R., and Swift, T. (2011). Leveraging knowledge and competencies across space: The next frontier in international business. *Journal of International Management*, *17*(3): 186-189.

Mulligan, C. E., and Olsson, M. (2013). Architectural implications of smart city business models: An evolutionary perspective. *IEEE Communications Magazine*, *51*(6): 80-85.

Navigant (2013). *Navigant Research Leaderboard report: smart city suppliers.* <http://www.navigantresearch.com/wp-content/uploads/2013/07/LB-SCITS-13-Brochure.pdf> Accessed September 1st, 2016.

Navigant (2014). *Navigant Research Leaderboard report: smart city suppliers.* <http://www.ibm.com/smarterplanet/global/files/us__en_us__smarter_cities__navigant_research_report.pdf> Accessed September 1st, 2016.

Nedović-Budić, Z., and Pinto, J. K. (2000). Information sharing in an interorganizational GIS environment. *Environment and planning B: Planning and Design*, *27*(3): 455-474.

Nevens, F., Frantzeskaki, N., Gorissen, L., and Loorbach, D. (2013). Urban Transition Labs: co-creating transformative action for sustainable cities. *Journal of Cleaner Production*, *50*: 111-122.

Nevens, F., and Roorda, C. (2014). A climate of change: A transition approach for climate neutrality in the city of Ghent (Belgium). *Sustainable Cities and Society*, *10*: 112-121.

Nguyen, K. (2007). Alternatives to grid extension for rural electrification: Decentralized renewable energy technologies in Vietnam. *Energy Policy, 35*: 2579-2589.

Nordensvärd, J., and Urban, F. (2015). The stuttering energy transition in Germany: Wind energy policy and feed-in tariff lock-in. *Energy Policy*, *82*: 156-165.

Nygaard, I. (2009). The compatibility of rural electrification and promotion of low-carbon technologies in developing countries – The case of solar PV for Sub-Saharan Africa. *European Review of Energy Markets, 3*(2): 1-34.

O'Brien, G., O'Keefe, P., and Rose, J. (2007). Energy, poverty and governance. *International Journal of Environmental Studies, 64*(5): 605-616.

Oh, C.H. (2009). The international scale and scope of European multinationals. *European Management Journal, 27*: 336-343.

Oh, C.H., and Rugman, A.M. (2006). Regional sales of multinationals in the world cosmetics industry. *European Management Journal, 24*(2/3): 163-173.

Ohmae, K. (1985). Triad Power: The Coming Shape of Global Competition. New York: The Free Press.

Ojo, A., Curry, E., and Zeleti, F. A. (2015). A tale of open data innovations in five smart cities. In *System Sciences (HICSS), 2015 48th Hawaii International Conference*: 2326-2335.

O'Reilly, C. A., and Tushman, M. L. (2008). Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in organizational behavior*, *28*: 185-206.

Osegowitsch, T., and Sammartino, A. (2008). Reassessing (home-)regionalisation. *Journal of International Business Studies, 39*: 184-196.

O'Sullivan, A. and Sheffrin, S. (2003). *Economics: Principles in Action*. Upper Saddle River NJ, Prentice Hall.

Palomares-Aguirre, I., Barnett, M., Layrisse, F. and Husted, B. (2017). Built to Scale? How Sustainable Business Models Can Better Serve the Base of the Pyramid. Journal of Cleaner Production, <https://doi.org/10.1016/j.jclepro.2017.11.084> Accessed January 2nd, 2018.

Parker, G. G., Van Alstyne, M. W., and Choudary, S. P. (2016). *Platform Revolution: How Networked Markets Are Transforming the Economyand How to Make Them Work for You*. New York: W. W. Norton and Company.

Paroutis, S., Bennett, M., and Heracleous, L. (2014). A strategic view on smart city technology: The case of IBM Smarter Cities during a recession. *Technological Forecasting and Social Change*, *89*: 262-272.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource‐based view. *Strategic management journal*, *14*(3): 179-191.

Persson, M. (2006). The impact of operational structure, lateral integrative mechanisms and control mechanisms on intra-MNE knowledge transfer. *International Business Review*, *15*(5): 547-569.

Pinkse, J., and Kolk, A. (2009). *International Business and Global Climate Change.* London: Routledge.

Pinkse, J., and Kolk, A. (2010). Challenges and trade‐offs in corporate innovation for climate change. *Business Strategy and the Environment*, *19*(4): 261-272.

Pinkse, J., and Kolk, A. (2012). Multinational enterprises and climate change: Exploring institutional failures and embeddedness. *Journal of International Business Studies*, *43*(3): 332-341.

Pisani, N., Kourula, A., Kolk, A. and Meijer, R. (2017). How global is international CSR research? Insights and recommendations from a systematic review. *Journal of World Business*, *52*(5), 591-614.

Pitta, D. A., Guesalaga, R., and Marshall, P. (2008). The quest for the fortune at the Bottom of the Pyramid: Potential and challenges. *Journal of Consumer Marketing*, *25*(7): 393-401.

Polzin, F., Migendt, M., Täube, F. A., and von Flotow, P. (2015). Public policy influence on renewable energy investments—A panel data study across OECD countries. *Energy Policy*, *80*: 98-111.

Prahalad, C.K. and Y.L. Doz (1987). The Multinational Mission. Balancing Local Demands and Global Vision. New York: The Free Press.

Prahalad, C. K., and Doz, Y. L. (1999). *The multinational mission: Balancing local demands and global vision*. New York, NY: Simon and Schuster.

Prahalad, C. K., and Hart, S. (1999). Strategies for the Bottom of the Pyramid: Creating sustainable development. Ann Arbor and Chapel Hill.

Prahalad, C. K., and Hart, S. L. (2002). The fortune at the Bottom of the Pyramid. *Strategy+Business, 20*: 1-13.

Proff, H. (2002). Business unit strategies between regionalisation and globalisation. *International Business Review, 11*(2): 231-250.

Raisch, S., and Birkinshaw, J. (2008). Organizational ambidexterity: Antecedents, outcomes, and moderators. *Journal of management*, *34*(3): 375-409.

Raisch, S., Birkinshaw, J., Probst, G., and Tushman, M. L. (2009). Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. *Organization science*, *20*(4): 685-695.

Rao, P. S., Miller, J. B., Wang, Y. D., and Byrne, J. B. (2009). Energy-microfinance intervention for below poverty line households in India. *Energy Policy*, *37*(5): 1694-1712.

Raven, R. (2007). Niche accumulation and hybridization strategies in transition processes towards a sustainable energy system: an assessment of differences and pitfalls. *Energy Policy, 35*: 2390-2400.

Raven, R., and Geels, F. W. (2010). Socio-cognitive evolution in niche development: Comparative analysis of biogas development in Denmark and the Netherlands (1973–2004). *Technovation*, *30*(2): 87-99.

Raven, R., Van den Bosch, S., and Weterings, R. (2010). Transitions and strategic niche management: towards a competence kit for practitioners. *International Journal of Technology Management*, *51*(1): 57-74.

Reiche, D., and Bechberger, M. (2004). Policy differences in the promotion of renewable energies in the EU member states. *Energy Policy, 32*(7): 843-849.

REN21 (2008). *Renewables Global Status Report 2007.* <http://www.ren21.net/Portals/0/documents/activities/gsr/RE2007_Global_Status_Report.pdf> Accessed June 8th, 2011.

REN21 (2009). *Renewables Global Status Report 2009 Update.* <http://www.ren21.net/Portals/0/documents/activities/gsr/RE_GSR_2009_Update.pdf> Accessed June 8th, 2011.

REN21 (2010). *Renewables Global Status Report 2010*. <http://www.ren21.net/Portals/0/documents/activities/gsr/REN21_GSR_2010_full_revised%20Sept2010.pdf> Accessed June 8th, 2013.

REN21 (2017). *Renewables Global Status Report 2017*. <http://www.ren21.net/wp-content/uploads/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf> Accessed January 8th, 2018.

Rhodes, M., Van Apeldoorn, B. (1997). Capitalism vs. capitalism in Western Europe. In: M. Rhodes, P. Heywood and V. Wright (eds), Developments in West European Politics, 171-189. London: St. Martin's Press.

Richter, M. (2013). Business model innovation for sustainable energy: German utilities and renewable energy. *Energy Policy*, *62*: 1226-1237.

Ries, E. (2011). *The Lean Startup*. New York: Crown Business.

Roome, N., and Louche, C. (2016). Journeying Toward Business Models for Sustainability A Conceptual Model Found Inside the Black Box of Organisational Transformation. *Organization and Environment*, *29*(1): 11-35.

Roth, K., and Morrison, A. J. (1990). An empirical analysis of the integration-responsiveness framework in global industries. *Journal of International Business Studies*, *21*(4): 541-564.

Rothwell, R. (1994). Towards the Fifth-generation innovation process. *International Marketing Review, 11*(1): 7-31.

Rotmans, J., Kemp, R., and Van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *foresight*, *3*(1): 15-31.

Rugman, A.M. (2001). The myth of global strategy. *Insights, 1*(1), *AIB Newsletter 7*(2): 11-14.

Rugman, A.M. (Ed.) (2007). *Regional Aspects of Multinationality and Performance*. Oxford: Elsevier.

Rugman, A. M., and Collinson, S. (2004). The regional nature of the world's automotive sector. *European Management Journal*, *22*(5): 471-482.

Rugman, A., and Girod, S. (2003). Retail multinationals and globalization:: the evidence is regional. *European management journal*, *21*(1): 24-37.

Rugman, A., and Hodgetts, R. (2001). The end of global strategy. *European Management Journal*, *19*(4): 333-343.

Rugman, A. M., and Oh, C. H. (2013). Why the home region matters: location and regional multinationals. *British Journal of Management*, *24*(4): 463-479.

Rugman, A. M., and Verbeke, A. (1992). A note on the transnational solution and the transaction cost theory of multinational strategic management. *Journal of international business studies*, *23*(4): 761-771.

Rugman, A. M., and Verbeke, A. (1998). Corporate strategies and environmental regulations: An organizing framework. *Strategic management journal*: 363-375.

Rugman, A. M., and Verbeke, A. (2001). Subsidiary-specific advantages in multinational enterprises. *Strategic Management Journal*, *22*(3): 237-250.

Rugman, A. M., and Verbeke, A. (2003). Extending the theory of the multinational enterprise: Internalization and strategic management perspectives. *Journal of International Business Studies*, *34*(2): 125-137.

Rugman, A.M., and Verbeke, A. (2004). A perspective on regional and global strategies of multinational enterprises. *Journal of International Business Studies, 35*(1): 3-18.

Rugman, A.M., and Verbeke, A. (2005). Towards a theory of regional multinationals: A transaction cost economics approach. *Management International Review, 45*(1): 5-17.

Rugman, A. M., and Verbeke, A. (2007). Liabilities of regional foreignness and the use of firm-level versus country-level data: A response to Dunning et al.(2007). *Journal of International Business Studies*, *38*(1): 200-205.

Rugman, A. M., and Verbeke, A. (2008a). A regional solution to the strategy and structure of multinationals. *European Management Journal*, *26*(5): 305-313.

Rugman, A. M., and Verbeke, A. (2008b). A new perspective on the regional and global strategies of multinational services firms. *Management International Review*, *48*(4): 397-411.

Rugman, A. M., and Verbeke, A. (2008c). The theory and practice of regional strategy: a response to Osegowitsch and Sammartino. *Journal of International Business Studies*, *39*(2): 326-332.

Sæverud, I. A., and Skjærseth, J. B. (2007). Oil companies and climate change: Inconsistencies between strategy formulation and implementation?. *Global Environmental Politics, 7*(3): 42-62.

Sagar, A. (2005). Alleviating energy poverty for the world's poor. *Energy Policy, 33*: 1367-1372.

Saidur, R., Islam, M., Rahim, N., and Solangi, K. (2010). A review of global wind energy policy. *Renewable and Sustainable Energy Reviews, 14:* 1744-1762.

Samoff, J., and Molapi Sebatane, E. (2001). Scaling up by Focusing Down: Creating Space to Expand Education Reform. *Paper presented at Biennal Meeting of the Association for the Development of Education in Africa*, *Arusha (October 2001).*

Sandén, B. A., and Azar, C. (2005). Near-term technology policies for long-term climate targets - economy wide versus technology specific approaches. *Energy Policy, 33*: 1557-1576.

Sassen, S. (2000). The global city: strategic site/new frontier. *American studies*, *41*(2/3): 79-95.

Sassen, S. (2005). Global City: Introducing a Concept, *The Brown Journal of World Affairs*: *11*(2): 27-43.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., and Oliveira, A. (2011). Smart cities and the future internet: Towards cooperation frameworks for open innovation. *The future internet*: 431-446.

Schaltegger, S., Lüdeke-Freund, F., and Hansen, E. G. (2012). Business cases for sustainability: the role of business model innovation for corporate sustainability. *International Journal of Innovation and Sustainable Development*, *6*(2): 95-119.

Schaltegger, S., Ludeke-Freund, F. And Hansen, E. (2016). Business Models for Sustainability: Origins, present research, and future avenues. *Organization and Environment, 29(1)*: 3-10.

Schmidt, V.A. (2000). Still three models of capitalism? The dynamics of economic adjustment in Britain, Germany, and France. In: Czada, R. and Lütz, S. (eds), Die Politische Konstruktion von Märkten, 38-72. Wiesbaden: Westdeutscher Verlag.

Schmidt, V.A. (2002). The Futures of European Capitalism. Oxford: Oxford University Press.

Schot, J., and Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis and Strategic Management*, *20*(5): 537-554.

Schülke, C. (2010). The EU's Major Electricity and Gas Utilities since Market Liberalization. France: Institut Français des Relations Internationales.

Seidler-de Alwis, R., and Hartmann, E. (2008). The use of tacit knowledge within innovative companies: knowledge management in innovative enterprises. *Journal of knowledge Management*, *12*(1): 133-147.

Seno-Alday, S. (2009). Market characteristics and regionalisation patterns. *European Management Journal, 27*: 366-376.

Sethi, D. (2009). Are multinational enterprises from the emerging economies global or regional?. *European Management Journal, 27*: 356-365.

Shafer, S. M., Smith, H. J., and Linder, J. C. (2005). The power of business models. *Business Horizons*, *48*: 199-207.

Shapiro, C., and Varian, H. R. (1999). The art of standards wars. *California management review*, *41*(2): 8-32.

Sharma, D. (2007). Transforming rural lives through decentralized green power. *Futures, 39*: 583-569.

Shell. (2008). *Sustainability Report – Responsible Energy.* The Hague: Shell publications.

Shum, K. L., and Watanabe, C. (2007). Photovoltaic deployment strategy in Japan and the USA - an institutional appraisal. *Energy Policy, 35*: 1186-1195.

Shwayri, S. T. (2013). A model Korean ubiquitous eco-city? The politics of making Songdo. *Journal of Urban Technology*, *20*(1): 39-55.

Simanis, E., and Hart, S. (2008). The Base of the Pyramid protocol: Toward next generation BoP strategy, Second edition. Cornell University: Center for Global Sustainable Enterprise.

Simmons, G., Giraldo, J. E. D., Truong, Y., and Palmer, M. (2018). Uncovering the link between governance as an innovation process and socio-economic regime transition in cities. *Research Policy*, *47*(1): 241-251.

Smith, A. (2007). Translating sustainabilities between green niches and socio-technical regimes. *Technology analysis and strategic management*, *19*(4): 427-450.

Smith, A., and Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research policy*, *41*(6): 1025-1036.

Smith, A., Stirling, A., and Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research policy*, *34*(10): 1491-1510.

Smith, W. K., and Tushman, M. L. (2005). Managing strategic contradictions: A top management model for managing innovation streams. *Organization science*, *16*(5): 522-536.

Smith, A., Voß, J. P., and Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research policy*, *39*(4): 435-448.

Söderström, O., Paasche, T., and Klauser, F. (2014). Smart cities as corporate storytelling. *City*, *18*(3): 307-320.

Spalding-Fecher, R. (2005). Health benefits of electrification in developing countries: A quantitative assessment in South Africa. *Energy for Sustainable Development, 9*(1): 53-62.

Spalding-Fecher, R., Winkler, H., and Mwakasonda, S. (2005). Energy and the World Summit on Sustainable Development: What next?. *Energy Policy, 33*: 99-112.

Stratigea, A., Papadopoulou, C.-A., and Panagiotopoulou, M. (2015). Tools and technologies for planning the development of smart cities. *Journal of Urban Technology*, 22(2): 43-62.

Stettner, U., and Lavie, D. (2014). Ambidexterity under scrutiny: Exploration and exploitation via internal organization, alliances, and acquisitions. *Strategic management journal*, *35*(13): 1903-1929.

Stevens, M.J., and Bird, A. (2004). On the myth of believing that globalization is a myth: Or the effects of misdirected responses on obsolescing an emergent substantive discourse. *Journal of International Management, 10*(4): 501-510.

Taggart, J. H. (1997). An evaluation of the integration-responsiveness framework: MNC manufacturing subsidiaries in the UK. *Management International Review*: 295-318.

Tamer Cavusgil, S., Calantone, R. J., and Zhao, Y. (2003). Tacit knowledge transfer and firm innovation capability. *Journal of business and industrial marketing*, *18*(1): 6-21.

Taylor, P., Derudder, B., Faulconbridge, J., Hoyler, M., and Ni, P. (2014). Advanced producer service firms as strategic networks, global cities as strategic places. *Economic Geography*, *90*(3): 267-291.

Thomas III, L.G., and Waring, G. (1999). Competing capitalisms: Capital investment in American, German, and Japanese firms. *Strategic Management Journal, 20*: 729-748.

Total. (2007). *Environment and Society – Our Corporate Responsibilities. Paris*: Total publications.

Townsend, A. (2014). *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: W. W. Norton and Company.

Tripsas, M. (1997). Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry. *Strategic Management Journal, 18*(1): 119-142.

Truffer, B., and Coenen, L. (2012). Environmental innovation and sustainability transitions in regional studies. *Regional Studies*, *46*(1): 1-21.

Truffer, B., Metzner, A., and Hoogma, R. (2002). The coupling of viewing and doing: strategic niche management and the electrification of individual transport. *Greener Management International*: 111-125.

Tsur, Y., and Zemel. A. (2000). Long-term perspective on the development of solar energy. *Solar Energy, 68*: 379-392.

Turnheim, B. and Geels, F. (2012). Regime destabilisation as the flipside of energy transitions: Lessons from the history of the British coal industry (1913–1997), Energy Policy, 50: 35-49.

Turnheim, B., and Geels, F. W. (2013). The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). *Research Policy*, *42*(10): 1749-1767.

Tushman, M. L., and Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative science quarterly*: 439-465.

Umree, T., and Harries, D. (2006). Renewable energy based rural electrification programs in developing countries: Lessons and perspectives. *Sustainable Energy and Environment Conference Proceedings.*

Umree, T., Harries, D., and Schlapfer, A. (2008). A survey of the views of program implementers on success factors of solar PV programs in Asia and the Pacific. *Ecocity World Summit 2008 Proceedings.*

Umree, T., Harries, D., and Schlapfer, A. (2009). Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific. *Renewable Energy, 34*: 354-357.

United Nations (2012). *Sustainable Energy for All. A Framework for Action.* <http://www.un.org/wcm/webdav/site/sustainableenergyforall/shared/Documents/SE%20for%20All%20-%20Framework%20for%20Action%20FINAL.pdf> Accessed September 8th, 2013.

United Nations (2016). *The world's cities in 2016.* <http://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2016_data_booklet.pdf> Accessed September 12th, 2016.

UNEP (2011). *Towards a green economy: pathways to sustainable development and poverty eradication.* <https://web.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/image/green_economyreport_final_dec2011.pdf> Accessed on December 10th, 2017.

UNEP (2017). *Global trends in renewable energy investments 2017*. <http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf> Accessed on December 10th, 2017.

Unruh, G. C. 2000. Understanding carbon lock-in. *Energy Policy, 28*: 817-830.

Unruh, G. C. (2002). Escaping carbon lock-in. *Energy policy, 30*(4): 317-325.

Utterback, J. M., and Abernathy, W. J. (1975). A dynamic model of process and product innovation. *Omega*, *3*(6): 639-656.

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

Vaaler, P.M., and Schrage, B.N. (2009). Residual state ownership, policy stability and financial performance following strategic decisions by privatized telecoms. *Journal of International Business Studies, 40*(4): 621-641.

Van den Bergh, J.C.J.M., Truffer, B., Kallis, G., 2011. Environmental innovation and societal transitions: introduction and overview. Environmental Innovation and Societal Transitions 1 (1), 1–23.

Van de Wateringen, S. L. (2005). *The greening of black gold - Towards international environmental alignment in the petroleum industry*. Veenendaal: Universal Press.

Van Leeuwen, R. P., Fink, J., de Wit, J. B., and Smit, G. J. (2015). Upscaling a district heating system based on biogas cogeneration and heat pumps. *Energy, sustainability and society*, *5*(1): 1-16.

Van Warmerdam, R., and Brinkman, J. (2015). *Amsterdam Becoming a Smart City*. <http://urbantransform.eu/wp-content/uploads/sites/2/2015/07/Amsterdam-Becoming-A-Smart-City.pdf> Accessed April 10th, 2016.

Van Winden, W., Oskam, I., Van Den Buuse, D., Schrama, W., and Van Dijck, E. (2016). *Organising Smart City Projects: Lessons From Amsterdam.* Amsterdam: Amsterdam University of Applied Sciences.

Verbeke, A., and Asmussen, C. G. (2016). Global, local, or regional? The locus of MNE strategies. *Journal of Management Studies*, *53*(6): 1051-1075.

Verbong, G., and Geels, F. (2007). The ongoing energy transition: lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy policy*, *35*(2): 1025-1037.

Vilajosana, I., Llosa, J., Martinez, B., Domingo-Prieto, M., Angles, A., and Vilajosana, X. (2013). Bootstrapping smart cities through a self-sustainable model based on big data flows. *IEEE Communications Magazine*, *51*(6): 128-134.

Viswanathan, M., Seth, A., Gau, R., and Chaturvedi, A. (2009). Ingraining product-relevant social good into business processes in subsistence marketplaces: The sustainable market orientation. *Journal of Macromarketing*, *29*(4): 406-425.

Viswanathan, M., and Sridharans, S. (2009). From subsistence marketplaces to sustainable marketplaces: A bottom-up perspective on the role of business poverty alleviation. *Ivey Business Journal*, *73*(2). <http://www.iveybusinessjournal.com/article.asp?intArticle_ID=816> Accessed September 6, 2010.

Wadin J., Ahlgren, K. and Bengtsson, L. (2017). Joint business model innovation for sustainable transformation of industries – a large multinational utility in alliance with a small solar energy company. *Journal of Cleaner Production, 160*: 139-150.

Walravens, N., and Ballon, P. (2013). Platform Business Models for Smart Cities: From Control and Value to Governance and Public Value. *IEEE Communications Magazine, 51*(6): 72-79.

Wamukonya, N., and Davis, M. (2001). Socio-economic impacts of rural electrification in Namibia: Comparisons between grid, solar and un-electrified households. *Energy for Sustainable Development, 5*(3): 5-13.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic management journal*, *5*(2): 171-180.

Wernerfelt, B. (1995). The resource-based view of the firm: Ten years after. *Strategic management journal*, *16*(3): 171-174.

Westney, D.E. (2006). The regional multinationals: MNEs and 'global' strategic management. *Journal of International Business Studies, 37*: 445-449.

Wilson, C. (2018). Disruptive low-carbon innovations. *Energy Research & Social Science, 37*: 216-223.

Wilson, C., and Tyfield, D. (2018). Critical perspectives on disruptive innovation and energy transformation. *Energy Research & Social Science, 37*: 211-215.

World Bank (2005). *Reducing Poverty on a Global Scale.* <http://documents.worldbank.org/curated/en/157381468242667024/pdf/336860Reducing1R0OFFICIAL0USE0ONLY1.pdf> Accessed on December 10th, 2016.

World Bank (2008a). *Designing Sustainable Off-Grid Rural Electrification Projects: Principles and Practices*. <http://siteresources.worldbank.org/EXTENERGY2/Resources/OffgridGuidelines.pdf> Accessed on June 10th, 2012.

World Bank (2008b). *The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits*. <http://siteresources.worldbank.org/EXTRURELECT/Resources/full_doc.pdf> Accessed on June 10th, 2012.

World Economic Forum (2016). *Renewable infrastructure investment handbook: a guide for institutional investors.* <http://www3.weforum.org/docs/WEF_Renewable_Infrastructure_Investment_Handbook.pdf> Accessed on December 10th, 2017.

World Energy Assessment (2000). *Energy and the Challenge of Sustainability*. <http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/sustainable-energy/world-energy-assessment-energy-and-the-challenge-of-sustainability/World%20Energy%20Assessment-2000.pdf> Accessed on June 10th, 2012.

World Health Organization (2009). *Practical Guidance for Scaling Up Health Service Innovations.* <*http://apps.who.int/iris/bitstream/10665/44180/1/9789241598521_eng.pdf*> Accessed on April 10th, 2016.

Wüstenhagen, R., and Menichetti, E. (2012). Strategic choices for renewable energy investment: Conceptual framework and opportunities for further research. *Energy Policy*, *40*: 1-10.

Yin, R. (1994). *Case Study Research - Design and Methods. Thousand* Oaks: Sage Publications.

Yin, R. (2003). *Case Study Research - Design and Methods, 3rd ed.* London: SAGE Publications.

Yunus, M., Moingeon, B., and Lehmann-Ortega, L. (2010). Building social business models: Lessons from the Grameen experience. *Long Range Planning*, *43*: 308-325.

Zaheer, S. (1995). Overcoming the liability of foreignness. *Academy of Management journal*, *38*(2): 341-36.

Zaheer, A., McEvily, B., and Perrone, V. (1998). Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization science*, *9*(2): 141-159.

Zerriffi, H. (2011). *Rural Electrification: Strategies for Distributed Generation*. London: Springer.

Zott, C., Amit, R., and Massa, L. (2011). The business model: recent developments and future research. *Journal of management*, *37*(4): 1019-1042.

ENGLISH SUMMARY

Moving towards a more sustainable energy future is widely regarded as one the key challenges for the decades to come, related to the negative economic, political, environmental, and social externalities associated with fossil fuel dependence. The international diffusion of technologies which enable more sustainable modes of energy production and consumption across the world is a central factor in this respect. For energy production, this implies that major investments in renewable energy technologies (RETs) are needed to replace fossil fuel-based technologies as a source for power generation; for energy consumption, this entails the widespread deployment of technologies which enable energy-intensive economic activities to become more energy efficient. This dissertation examines the strategies of firms in developing and marketing technologies for sustainable energy production and consumption in heterogeneous empirical contexts, with specific attention for the role of multinational enterprises (MNEs) as they are crucial and powerful players in addressing global sustainability issues.

The dissertation consists of six chapters which explore business strategies in sustainable energy, informed by business and management theories. It seeks to contribute insights into the strategic responses of business to the diffusion of technologies for sustainable energy production and consumption, guided by two interrelated research questions. The first research question, *how do MNEs strategically address the diffusion of renewable energy technologies for energy production and of energy efficiency technologies for energy consumption?,* is examined in chapters 2, 3, and 4. Each of these chapters provides an organizational-level, industry-specific analysis, focused on MNEs with established positions in their respective industries. Chapter 2 explores how firms in the information and communication technology (ICT) industry strategically approach the market for smart city technologies, and assesses their role in addressing energy consumption in cities and urban areas on a global scale. Chapter 3 focuses on electric utilities with established positions in the European electricity market, and examines how technology-specific investments in power generation technologies are shaped by transformative changes in the institutional environment. Chapter 4 examines the strategic investments of European firms in the oil industry in developing and commercializing RETs to diversify their power generation portfolio, taking both internal resources and capabilities and external industry dynamics into account.

The second research question, *how does business address challenges related to the scalability, affordability, and accessibility of solutions for sustainable energy production and consumption?,* is addressed in chapters 5 and 6. Chapter 5 focuses on access to energy in developing countries, and explores business models of entrepreneurial firms to introduce RET-based solutions in rural areas without access to the national electricity grid. Chapter 6 identifies which dimensions and conditions

affect the potential for urban energy efficiency solutions to be scaled up beyond pilot projects, and examines how business-led approaches can create a broader environmental and social impact beyond the local level. Finally, chapter 7 reflects on the wider contributions of each chapter to the debate on business strategies and the transition towards more sustainable modes of energy production and consumption, and discusses limitations and areas for further research. Each chapter is discussed in some more detail below.

Chapter 2 examines how firms in the ICT industry strategically respond to the emergence and spread of smart city technologies to address energy efficiency in cities and urban areas. It adopts and international business perspective, and focuses on the ability of MNEs to balance environmental pressures for global integration and the effective coordination of activities distributed across the firm's international network, with responsiveness to the demands and conditions of the heterogeneous host environments in which the firm is embedded. In particular, the chapter studies whether and how MNEs may be able to exploit resources and capabilities developed in multiple urban contexts to develop firm-specific advantages (FSAs). The empirical section explores to which degree international smart city technology suppliers seem to have developed FSAs from their smart city engagements on a global scale, and sheds light on the role of three key ICT firms in addressing urban sustainability issues though the spread of smart city technology-based solutions. It draws on semi-structured interviews with multiple firms, public authorities, and experts in the field of smart cities, combined with an in-depth documentation study on the activities of ICT firms in relation to urban management. This is a key issue in relation to sustainable energy, given that cities account for approximately 60% to 80% of energy consumption and carbon emissions (UNEP, 2011), and that the number of people living in cities and urban areas is expected to grow from 3.6 billion at present towards approximately 6.3 billion in 2050 (UN, 2009). Chapter 2 therefore contributes to further insights into the role of firms in addressing energy consumption in cities and urban areas.

The next three chapters focus on RETs and energy production, given that the diversification of power generation sources away from fossil fuel-based technologies is a central challenge in the energy transition. A wide variety of RETs has become available to diversify energy supply by replacing fossil fuel-based power generation, including solar PV technology, onshore and offshore wind power, biomass, and geothermal energy. While investments in RETs for power generation outpaced fossil fuel-based technologies in 2016 (UNEP, 2017), the installed capacity of all modern RETs combined (excluding traditional biomass) only account for 10.2% of final energy consumption (REN21, 2017). Chapters 3, 4, and 5 explore two distinct contexts for energy production, embedded in the wider context of the energy transition. First, the strategic approaches of MNEs in the energy industry to investing in RETs for grid-connected power generation (i.e. centralized energy production) are addressed. Their large financial investments give them major decision-making power over the diversification their power generation portfolios, and thus the broader diffusion of renewable energy in the existing energy system. Two studies in the dissertation assess the strategic approach of MNEs to investing in RETs for power generation, and contribute to further insight into the role of energy firms with established positions in the energy transition. Second, the off-grid application of RETs for power generation (i.e. decentralized energy production) in areas with inadequate access to the energy grid are examined. While grid-connected electricity is oftentimes available in urban areas, a combination of financial, technological, and organizational challenges can hinder the extension of the electricity grid to all rural parts of developing and emerging countries (ARE, 2008). One study explores the role of market-based and business-led responses to establishing RET-based solutions for access to energy in this context, related to the wider diffusion of renewable energy for power generation.

Chapter 3 explores the internationalization patterns of MNEs in the European electricity industry, a context which has been fundamentally reshaped over the last two decades, driven by market liberalization and increased institutional coherence. This has had major strategic implications for (formerly state-owned) electric utilities in terms of their internationalization expansion outside their home markets, and has created policy-related investment opportunities in RETs to diversify their power generation portfolios. This chapter sheds light on the (changing) role of the home country/region in internationalization processes, based on the regionalization perspective of firm internationalization (Rugman and Verbeke, 2004; 2005). The empirical section explores the internationalization patterns of seven key firms from five European home countries, and draws on data collected from annual and corporate social responsibility (CSR) reports for multiple time intervals, combined with newspaper articles from reputable sources. By distinguishing between installed fossil fuel-based and RET-based power generation capacity, this chapter provides a comparative analysis of firm-specific internationalization patterns related to developments in the European institutional environment. It gives insight into the ability of firms to create unique firm-specific advantages (FSAs) from RET-oriented policy incentives and regulatory frameworks in their home markets, and reflects how these factors shapes the internationalization patterns of MNEs.

Chapter 4 also focuses on investments of MNEs in RETs for energy production, and specifically addresses the strategic approaches of firms to the development and commercialization of one specific RET, solar PV technology. By taking into account both internal factors related to firm-specific resources and capabilities, and external factors resulting from industry dynamics, this chapter presents a research model to analyse the investments of MNEs in renewable energy. The model distinguishes between three factors which impact firm-specific strategic decision-making processes: (i) the firm's perceived degree of complementarity between a novel technology and existing resources and capabilities, built up over decades in a particular industry; (ii) the firm's approach to technology development, based on either internal development or external acquisition; and (iii) the firm's strategy for technology commercialization, oriented towards either mainstream or niche markets. Empirically, this chapter examines three key MNEs with established positions in the oil industry in Europe and their investments in solar PV technology, based on archival data collected from annual and CSR reports, as well as newspaper articles. This leads to a longitudinal account of firm-specific investments and divestures in solar PV technology spanning over two decades, which unravels the strategic decision-making processes of MNEs in developing and commercializing this specific RET. This contributes to our understanding of how both internal and external factors shape MNE investments in renewable energy, as part of the broader transition towards sustainable energy.

Chapter 5 continues the investigation of renewable energy production, but with a very different context and set of firms. It explores whether and how the decentralized off-grid application of RETs can be an economically viable option to establish access to energy in developing countries beyond the reach of the national energy grid. It is projected that approximately 1.2 billion people will remain without electricity in 2030 (IEA, 2010), with 80% of these people living in rural areas (ARE, 2008). A diverse range of RET-based solutions has become available in this respect, including systems based on solar, wind, hydro and hybrid technologies. Drawing on a business model perspective, this chapter studies how market-based approaches are emerging as an alternative to donor-funded projects in this realm, focusing specifically on how entrepreneurial firms aim to create economic, social, and environmental value in this market. It provides a review of scholarly work on private sector involvement in sustainable development, and identifies which financing schemes and delivery models have been applied in development studies to establish access to energy. It provides a categorization of delivery and financing models along two dimensions (subsidized-unsubsidized; public-private), which reflect the nature of existing approaches to establish access to energy. The empirical section explores the activities of four entrepreneurial firms in Asia, which aim to develop market-based business models for access to energy in their respective home countries by using decentralized RET-based solutions for off-grid electrification. The study draws on semi-structured interviews to identify the core components of business models for sustainable energy in this context, and reflects on the complexities involved in building commercial business models in this market.

Chapter 6 focuses on energy consumption in cities and urban areas, similar to chapter 2, and explores the dynamics underlying upscaling trajectories of ICT-based solutions for sustainable urban development that have been developed in donor-funded smart city pilot projects. While such locally developed pilot projects for urban sustainability have proliferated in European cities in recent years (EU, 2014), many projects have failed to generate scalable solutions. Based on insights from development studies, this study presents three scaling trajectories: roll-out, expansion, and replication. The first, *roll-out,* occurs when one of the pilot project partners uses the pilot's test results to scale up the developed product, service or solution (market roll-out), or applies the lessons of the experiment within their own organization (organizational roll-out). The second, *expansion*, happens when the pilot project is not closed or dissolved, but rather expanded with new partners and users (quantitative expansion) or functionalities (functional expansion) to the project, or by enlarging the geographical area in which the project operates (geographic expansion). The third, *replication*, follows when a solution that has been developed in a pilot project is replicated in another context, which can be in another organization (organizational replication), in another part of the city (geographic replication), or in another city altogether. In addition, this chapter provides an overview of economic, regulatory, and technological factors which can potentially drive or hinder upscaling processes. The empirical section explores upscaling trajectories in three smart city pilot projects in the field of energy efficiency and sustainable mobility, which have been developed as part of the Amsterdam Smart City network. Drawing on semi-structures interviews with public and private organizations involved in each pilot project, combined with a review of internal project documentation, this chapter identifies how upscaling trajectories are influenced and shaped by each of these factors. The chapter contributes to understanding the dynamics involved in upscaling trajectories, and the role of the private sector in this process. It establishes insight into the conditions underlying the potential to scale up locally developed energy efficiency solutions, to achieve a wider impact on sustainable urban development. It also links these findings to the strategic approaches of ICT MNEs in this context, as discussed in chapter 2, to identify what the role of these international smart city technology suppliers is in these pilot projects.

Chapter 7, finally, reflects on the contributions of each empirical study related to firm strategies and the diffusion of technologies for sustainable energy production and consumption in society, as well as the broader implications for the energy transition. The strategic management and international business literature adopted in chapters 2, 3, and 4 (i.e. related to the first research question), provide a novel perspective on how internal and external factors impact firm strategies in sustainable energy, and explain how these factors influence technology-specific investments of MNEs. The business model and management perspectives adopted in chapters 5 and 6 (i.e. related the second research question), shed light on the business-led and market-based approaches of firms in developing and scaling up sustainable energy solutions, in contexts which have historically relied on donor-funded projects and subsidized activities. The contributions of each chapter are discussed in relation to a wider set of persistent global sustainability challenges, such as global climate change, and the role of firms as central actors in response to these challenges. The chapter concludes by proposing directions for future research based on the findings and limitations of this dissertation.

NEDERLANDSE SAMENVATTING

De energietransitie wordt wereldwijd gezien als één van de meest urgente uitdagingen op het gebied van duurzame ontwikkeling voor de komende decennia, gekoppeld aan de negatieve economische, politieke, ecologische, en sociale externaliteiten die samenhangen met afhankelijkheid van fossiele brandstoffen. Het grootschalig inzetten van technologieën die het duurzamer produceren en consumeren van energie mogelijk maken is hierin een centrale factor. Voor energieproductie betekent dit dat er substantiële investeringen in duurzame energietechnologieën nodig zijn om fossiele brandstoffen als bron voor energievoorziening te vervangen. Voor energieconsumptie impliceert dit dat het inzetten van technologieën die energie-intensieve economische activiteiten meer energie-efficiënt maken van groot belang is.

Deze dissertatie onderzoekt de strategieën van bedrijven in het ontwikkelen en op de markt brengen van technologieën voor duurzame energieproductie en -consumptie. Hierbij is specifiek aandacht voor de rol van grote ondernemingen, gezien hun positie als cruciale spelers in het realiseren van de energietransitie op internationale schaal. De dissertatie bestaat uit vijf empirische studies, alsmede een inleidend en concluderend hoofdstuk. De strategieën van bedrijven in duurzame energie worden beschouwd vanuit verschillende theoretische invalshoeken uit de bedrijfskundige literatuur. Het proefschrift draagt hiermee bij aan meer inzicht in de strategische benadering van bedrijven met betrekking tot de verspreiding van technologieën voor duurzame energieproductie en -consumptie.

In de dissertatie staan twee onderzoeksvragen centraal. De eerste onderzoeksvraag - *hoe benaderen internationale ondernemingen op strategische wijze de verspreiding van technologieën voor duurzame energieproductie en -consumptie?* - wordt behandeld in de hoofdstukken 2, 3, en 4. Elk hoofdstuk geeft een analyse van de strategie en investeringen van internationale ondernemingen in relatie tot duurzame energie, waarbij de nadruk ligt op bedrijven met een leidende positie in de industrie waarin ze actief zijn. In hoofdstuk 2 wordt onderzocht hoe ICT-bedrijven de markt voor zogenaamde ‘smart city’ technologieën strategisch benaderen, en wordt geanalyseerd hoe deze bedrijven een rol spelen in het efficiënter maken van energieconsumptie in steden wereldwijd. Hoofdstuk 3 is gericht op bedrijven met gevestigde posities in de Europese elektriciteitsmarkt, waarbij wordt bekeken hoe investeringen in duurzame-energietechnologieën worden beïnvloed door de institutionele omgeving in de landen waarin deze bedrijven actief zijn. In hoofdstuk 4 wordt vervolgens ingegaan op de strategische investeringen van bedrijven in de olie-industrie gericht op de ontwikkeling en vermarkting van duurzame-energietechnologieën, in de bredere context van de diversificatie van hun bestaande portfolio’s.

De tweede onderzoeksvraag - *hoe benaderen bedrijven uitdagingen gerelateerd aan de opschaalbaarheid, betaalbaarheid, en toegankelijkheid van oplossingen voor duurzame energieproductie en -consumptie?* - wordt behandeld in de hoofdstukken 5 en 6. In hoofdstuk 5 wordt onderzoek gedaan naar de energievoorziening in ontwikkelingslanden, en wordt geanalyseerd op welke wijze lokale bedrijven bijdragen aan het introduceren van duurzame-energieoplossingen in rurale gebieden die geen toegang hebben tot het nationale elektriciteitsnetwerk. In hoofdstuk 6 wordt ingegaan op de factoren en condities die invloed hebben op het opschalen van duurzame oplossingen voor energie-efficiëntie in steden, waarbij er specifiek aandacht is voor de vraag hoe bedrijven hieraan kunnen bijdragen. In hoofdstuk 7 worden de belangrijkste bijdragen van ieder hoofdstuk besproken in relatie tot de rol van bedrijven in de transitie naar duurzame energieproductie en -consumptie, alsmede potentiële gebieden voor verder onderzoek.

STATEMENTS OF CO-AUTHORSHIP

Statement of co-authorship regarding chapter 3, by Prof. dr. Ans Kolk

This *British Journal of Management* (BJM) article (co-authored by Daniel van den Buuse & Johan Lindeque; authors listed in alphabetical order) built on earlier work that I had done on globalization & regionalization in relation to CSR and sustainability (in 2009, *International Marketing Review* (IMR), and 2010, *Multinational Business Review* (MBR)). The idea for this specific piece came up when Daniel worked for me as a junior researcher, given our joint interest in energy firms, broadly defined. The theoretical part directly stemmed from my earlier MBR 2010 article, but its adaptation for this specific paper and empirical setting was done in close collaboration with Daniel. Daniel also took the lead in collecting all the data included in the article (inspired by the empirical parts of my 2009 IMR article), and in the write-up of the other parts. Here he was supported by Johan Lindeque, whom I had asked to join the author team when the call for papers for this special issue came up. In the various revise-and-resubmit rounds the three of us collaborated closely, a process in which I had a guiding and fine-tuning role, with Daniel and Johan taking care of the actual revision (with the same division of tasks as for the initial submission, as indicated). I regard this BJM article as truly joint work, but also one in which Daniel showed to master the various dimensions required, with a clear lead in and responsibility for the empirical work.

Statement of co-authorship regarding chapter 4, by Prof. dr. Jonatan Pinkse

This article published in *Energy Policy*, which we co-authored, built on earlier work of Daniel for his MSc thesis. The main idea for the article was developed jointly. Daniel then conducted all the research for the extended version of the manuscript. He collected, read and summarized the relevant literature; he collected and analysed the data; and he did the full write-up of the study. As the full manuscript was far too long for journal publication, I distilled a more concise version from the long manuscript which now only focused on the oil industry. This version was then presented by me at a workshop on investments in renewable energy in St. Gallen. We adapted the paper based on the feedback we received during the workshop and submitted it to Energy Policy. Since Daniel was travelling when we received the opportunity to revise the paper, I was responsible for making the revisions. Overall, this article is joint work where Daniel did all the groundwork while I was responsible for the final framing and fine-tuning.

Statement of co-authorship regarding chapter 5, by Prof. dr. Ans Kolk

This article, which we co-authored (authors listed in alphabetical order), stems from research done by Daniel van den Buuse when he worked for me as a junior researcher on a project commissioned to me by the Partnerships Resource Centre, resulting in a position paper on accessing sustainable energy through multi-stakeholder partnerships. The inventory of global and regional-level partnerships compiled from secondary documentation was supplemented with primary research (interviews) on local initiatives in four countries in South East Asia, initiated and carried out by Daniel who also arranged contacts and visits, and took responsibility for writing the position paper. In the process Daniel worked under my guidance, with support from Jonatan Pinkse (he and I had been publishing on climate change, also in relation to multi-stakeholder partnerships, before and he still worked at UvA at the time). The four local initiatives in South East Asia turned out to be small companies with a variety of innovative business models rather than partnerships as such. In the year after the position paper was finished, I took the initiative to write up a paper for a special issue based on the primary research done by Daniel, given that it directly related to business and development, one of my areas of expertise. The two of us collaborated to bring it further, resulting in joint work on a different theme than the position paper but with Daniel’s basic material as prime foundation.

Statement of co-authorship regarding chapter 6, by dr. Willem van Winden

This chapter is based on an article published in *Journal of Urban Technology* in 2017. It stems from research project done by Daniel van den Buuse under my supervision, on the evaluation a number of smart city pilot projects in Amsterdam in the field of energy. On each smart city pilot project we collected secondary and primary data. Daniel organized and held interviews with project leaders and other stakeholders in order to understand different managerial aspects of each project, with a focus on the questions how and under what conditions smart city projects are scaled up. He wrote the case studies (supervised by me) and also contributed to the overall cross case analysis. We reworked the findings together in an academic paper. On top of the case studies, Daniel substantially contributed to the literature review of the paper, the theoretical framework, and the conclusions. Thus, I clearly regard this paper as joint work.

ACKNOWLEDGEMENTS

The process of writing the PhD dissertation has been a very challenging and exciting experience, which has created a great opportunity to study a topic which has fascinated me for many years now: the nature of business strategies in response to global sustainability issues, and the wider impact that these responses have for society as a whole. While responding to these issues require major investments, such as investing in renewables as part of the energy transition on a substantial scale, I feel very optimistic that the next decade will see an increasingly strong momentum for sustainability-oriented investments by firms across different types of industries. The PhD has continuously provided a highly interesting context to develop in-depth knowledge in this realm, informed by interdisciplinary perspectives from academic literature as well as empirical research on business strategies in different types of settings. Looking back on this process, I would like to thank several people who have had an important role during my time as a PhD candidate in this section.

First, I would like to express my deep gratitude to Ans Kolk, who has supervised me throughout this process, for all her guidance, encouragement, expertise, and contributions over the course of my PhD. Your constant support has motivated and stimulated me enormously over the years, and your feedback and advice has been invaluable in writing this dissertation. I really appreciate that you have always taken the time to discuss and assess my work, and made this a priority during the whole process of writing the PhD dissertation, even when the circumstances where sometimes challenging. You arranged that I could join the University of Amsterdam as a junior researcher, and facilitated me in starting at the Amsterdam University of Applied Sciences as a lecturer, while maintaining a position as external PhD candidate at the same time at the University of Amsterdam. You have had a major impact on my professional and academic development over the years, and I feel very grateful that I have been able to start and complete my PhD track under your supervision.

A very special thanks also goes to my co-supervisor, Willem van Winden, for all his great contributions during this process. I am very thankful for your involvement in writing the dissertation, and for all the support that you have given me ever since I joined the Amsterdam University of Applied Sciences. You have been very important in facilitating my PhD from the start, and I feel we have always collaborated in a very positive and constructive way, both in relation to the PhD as well as on other projects as part of the Urban Economic Innovation group. I have really enjoyed the times we worked together over the last few years, including all the times we conducted interviews in the field of smart cities, and I am very grateful for all your input, guidance, and feedback in writing the PhD.

I would like to thank all members of the doctorate committee, for agreeing to being part of the doctorate committee, and for taking the time to read and examine my dissertation. I also want to thank the many great current and former colleagues that I have worked with over the years at the Business Economics section at the Amsterdam University of Applied Sciences, the Centre for Applied Research on Economics and Management, and the International Strategy & Marketing section at the Amsterdam Business School. Thank you for your continued interest in my research projects and for providing your support throughout this process. It has been great to work together in many different ways, from teaching different types of courses and supervising thesis projects, to conducting research projects and having dinner and drinks on a great number of different occasions. I especially want to thank all fellow PhD candidates that I spend time with in Amsterdam during this period, as well as the great colleagues that are part of the Urban Economic Innovation group, for all their direct and indirect support for my PhD.

There are several people I want to thank in particular for their contribution to my PhD, including the great co-authors that I have been privileged enough to work with over the years. Jonatan Pinkse, for introducing me to the field of business strategy and sustainability during my MSc program at the University of Amsterdam, and laying the foundation for my PhD through our collaboration on my first project. I have great memories of our trip (which was my first conference visit ever) to the Asian Institute of Technology in Bangkok, and I want to thank you for all your enthusiasm for my PhD project during the early stages. Johan Lindeque, for our collaboration in the field of international business and sustainable energy, and for sharing all his expert knowledge in this field. Gerard Dukker, who has been my manager at the Business and Economics faculty for over four years now, and has provided fantastic support for both my teaching and research during this period. Irith Kist, who was very enthusiastic about my PhD project when I first applied for the lecturer position at the Amsterdam University of Applied Sciences, and hired me on the spot. Victor Cabral and Michel Knoppel, for being paranymphs during the PhD defence ceremony. And everyone that has provided administrative support for the PhD, including Bas Bouten, Lucy Kerstens, and Eline van der Steen.

The first time I seriously considered to pursue a PhD was during a management and leadership course at the University of California Los Angeles, almost exactly a decade ago now, which was taught by John Ullmen. His way of engaging with students during each lecture, and enthusiastic way of teaching us on developing leadership skills, were the first moments that I got exciting about the opportunity to potentially do a PhD. While I had not even started a MSc program at that time, in hindsight I can say that this experience (combined with other inspiring courses during the MSc program) has eventually led to the completion of the PhD in 2018. I want to thank him, as well as other professors/lecturers at the University of Amsterdam, that contributed to my academic development in the years leading up to the PhD. I also want to thank everybody who took the time to give an interview to share their expertise on a wide range of issues, mostly related to smart cities and urban management (for chapters 2 and 6) and off-grid renewable energy solutions (for chapter 5). Your perspectives on the role of business in sustainable energy have been very insightful and relevant to the dissertation. This includes all interviewees from the Amsterdam Smart City network and its partner organizations, as well as interviewees from the firms, international organizations, and the Amsterdam municipality that contributed to the dissertation. This also includes the local entrepreneurs and energy experts in South-East Asia that have been kind enough to share their insights and experiences.

Additionally, I would like to thank the organizers of conferences, seminars, and meetings which have had an impact throughout the process of writing this PhD dissertation, especially the ones focused specifically at PhD researchers. In particular, this includes the ‘Ivey PhD Sustainability Academy’ at the University of Western Ontario, the ‘Sustainability Transitions PhD Seminar’ at the Arctic University of Norway, and the ‘Medici PhD Summer School in Management Studies’ at the NYU Florence campus. The contributions of the speakers, faculty, and fellow PhD candidates from all over the world has really helped in developing new research ideas and directions, and has provided a lot of insights in how sustainability is emerging as a field of study across academic disciplines. It has also provided an international network of colleagues that are working on similar topics, given that I am still in touch with several of them.

While the PhD has not always been an straightforward process, I feel that I have managed to keep a really great balance between work and personal life for the vast majority of it, apart from a few months of working non-stop in the finalization stage earlier this year. I owe that to an amazing group of friends and family, to whom I am very grateful for all the good times we have shared over the years, from holidays and weekend trips to dinners and drinks on numerous occasions. Although I am not getting more personal here, as I feel there are far more appropriate settings to share my gratitude with you all, I really want to thank you all for the direct as well as indirect support during my PhD (you know who you are). Still, there are four people that I want to give a very special thanks to: my parents, Co and Ilse, my brother, Beau, and my girlfriend, Dorian, who have always been my greatest source of support in life... Thank you for everything!