

## **Business strategies in sustainable energy - summary**

Moving towards a more sustainable energy future is widely regarded as one of 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 an 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 through 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-structured 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.