The wicked problem of a low carbon energy transition

Structure, agency and framing in the multi-actor process of solar PV deployment in Finland

Teresa Haukkala
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Climate change is a wicked problem, inextricably bound up with environmental and sustainability issues. Policies responding to wicked problems are neither good nor bad, and there seem to be no solutions. Due to the urgency to mitigate climate change, there is a need for a more sustainable energy transition, which has likewise proved to be a wicked problem. Renewable energy that produces fewer or no greenhouse gas emissions meets with resistance, and a higher deployment of solar PV in Finland has not been easy to implement. This thesis addresses the equally wicked problem of a low carbon energy transition in Finland by examining the multi-actor process of solar PV deployment in Finland from the perspective of the classic social science triangle of structure, agency and framing.

This interdisciplinary study draws on several research traditions. It adopts an analytic eclecticism approach that aims to integrate concepts and theories into a middle-range theory. The thesis also extends the timeline of energy transitions to include past energy transitions, and outlines possible alternatives for a future energy system.

The research questions in the thesis are organized according to structure, agency and framing: How do the old structures act as barriers? What are the structural barriers that hinder a higher deployment of solar energy in Finland, and an energy transition in general? How can they be overcome? How have the advocacy coalitions been formed? How have the actor positions and interactions between the advocacy coalitions changed? How well have they achieved their targets? How have the framings changed?

The thesis is based on four separate research papers. Three of the papers have been published in international peer-reviewed journals and one is an unpublished manuscript.

The findings show that barriers related to policy, business and consumers exist with regard to solar PV deployment. The most significant of these involve the lack of political will and a support policy, vested interests towards the current energy regime, the low competitiveness of solar PV, and general attitudes. These can be overcome with new policies, regulation and behaviour. When it comes to barriers concerning structure, namely vested interests, path dependence and lock-in, the state should take a more active role in policies that are conducive to structural change. The thesis also finds that there is a new energy political situation in Finland characterized by proponents of a green-transition on the one hand, and the old traditional coalition of energy producers and large industrial incumbents on the other. The advocacy position of different groups during the solar energy field framing process has also been influenced by how strongly they argued for or against the deployment of solar energy. The framings changed over time from accentuating a future energy system, moving to economic promise, and towards a struggling, competing position.

**Keywords** energy transition, socio-technical change, solar energy, structure, agency, framing
Tiivistelmä
Ilmastonmuutos on viheliäinen ongelmainteresta olemassa maailman ympäristöongelma ja kestävän kehityksen
ongelma. Viheliäisiin ongelmien vastauksia tarjoavat politiikat eivät ole hyviä eivätkä pahoja, eikä
niihin vaikuta olevan ratkaisuja. Ilmastonmuutoksen hillinnän kiireellisyyden takia on tarve siirtyä
kestävämpään energiatuotannoon, mikä on myös osoittautunut iltapotilaisuuden viheliäiseksi
ongelmaaksi. Uusiutuvaa energiaa, joka tuottaa vähemmän tai ei lainkaan kasvihuonekaasupäästöjä
kohtaa vastarintaa, eikä esimerkiksi aurinkosähkön tuotantoa ole ollut helppo lisätä. Tämä viitii
käsitteleee viheliäistä viheliäiseen energiatuotannoon, jossa tyrkytään energian tuotannosta
käyttöön Monitoimijaprosessissa Suomessa. Viihdet ja kehystäminen aurinko-

Tekijä
Teresa Haukkala

Väitöskirjan nimi
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Avainsanat energiatransition, sotiokekkien muutos, aurinkoenergia, rakennus, toimimusi, kehystäminen

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Meanwhile, during our longer stays in London and Scotland, I became more aware of the world changing around me as climate change rose on the agenda, thanks to Al Gore’s *An Inconvenient Truth*, although I had always been interested in environmental issues and concerned about the ‘greenhouse effect’ even as a teen in the 1980s. I then found myself on another course called Master of Environmental Management & Responsible Business (MEMA) at Helsinki University of Technology. It is at this juncture that I would like to thank Susanna Monni, the then director at Finnish Business & Society, for providing me with a research topic for my final dissertation during the MEMA course that led me to specialize in climate change, and Professor Hanna-Leena Pesonen from the University of Jyväskylä, who encouraged me to pursue my PhD studies and advised me to contact Aalto University School of Business. Professor Minna Halme kindly recommended that I should contact Raimo Lovio, which was when this journey began in earnest.

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witty and funny characters. This thesis is dedicated to my family. I love you.

Tampere, 28 March 2019

Teresa Haukkala
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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACF</td>
<td>The advocacy coalition framework</td>
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<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<tr>
<td>GI</td>
<td>Grassroots innovation</td>
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<tr>
<td>ECTS</td>
<td>European Credit Transfer and Accumulation System</td>
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<td>FCEA</td>
<td>The Finnish Clean Energy Association</td>
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<tr>
<td>ICT</td>
<td>Information and communication technology</td>
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<tr>
<td>IEA</td>
<td>International Energy Agency</td>
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<tr>
<td>IR</td>
<td>International relations</td>
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<td>IPCC</td>
<td>Intergovernmental Panel of Climate Change</td>
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<td>MEMA</td>
<td>Master of Environmental Management and Responsible Business</td>
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<td>MEP</td>
<td>Member of Parliament</td>
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<tr>
<td>MLP</td>
<td>Multi-level perspective</td>
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<tr>
<td>NEP</td>
<td>New Energy Policy project</td>
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<tr>
<td>NGO</td>
<td>Non-governmental organization</td>
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<tr>
<td>PV</td>
<td>Solar photovoltaic</td>
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<tr>
<td>R&amp;D</td>
<td>Research and development</td>
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<tr>
<td>SAF</td>
<td>Strategic action field theory</td>
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<tr>
<td>SNM</td>
<td>Strategic niche management</td>
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<tr>
<td>TIS</td>
<td>The technological innovation systems</td>
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<tr>
<td>TM</td>
<td>Transition management</td>
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<tr>
<td>UNRIC</td>
<td>United Nations Regional Information Centre for Western Europe</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wide Fund for Nature</td>
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List of Publications

This doctoral dissertation consists of a summary and of the following publications which are referred to in the text by their letters.


**Article D.** Tea Lempiälä, Eeva-Lotta Apajalahti, Teresa Haukkala and Raimo Lovio. (Unpublished manuscript). Interactive development of field frames and actor positions during the emergence of a novel technological field: The case of solar energy.
Author’s Contribution

**Article A:** Does the sun shine in the High North? Vested interests as a barrier to solar energy deployment in Finland  
**Status:** Published in *Energy Research & Social Science* (2015, 6: 50–58)  
Single-authored by Teresa Haukkala

**Article B:** The role of solar photovoltaics and energy storage solutions in a 100% renewable energy system for Finland in 2050  
**Status:** Published in *Sustainability* (2017, 9: 1358)  
**Authors:** Michael Child, Teresa Haukkala and Christian Breyer  
*Michael Child* conceived and designed the simulations for the Finnish energy system with the help of Christian Breyer. Michael Child performed the numerical analysis of hourly energy system data.  
*Teresa Haukkala*, the second author, proposed the initial barriers to high levels of renewable energy in the Finnish energy system and provided much of the theoretical background for this paper.  
*Christian Breyer*, the third author, contributed to the quality of the research and research narrative. He also provided his insights into the discussion of results in light of data.  
All three authors were involved in the further analysis of barriers and provided insights into their possible solutions. Teresa Haukkala and Michael Child wrote the paper under the supervision of Christian Breyer.

**Article C:** A struggle for change—The formation of a green-transition advocacy coalition in Finland  
**Status:** Published in *Environmental Innovation and Societal Transitions* (2018, 27: 146–156).  
**Authors:** Single-authored by Teresa Haukkala
Article D: Interactive development of field frames and actor positions during the emergence of a novel technological field: The case of solar energy

Status: Unpublished paper, newer version submitted to Research Policy. Accepted for publication with minor revisions.

Authors: Tea Lempiälä, Eeva-Lotta Apajalahti, Teresa Haukkala and Raimo Lovio

Tea Lempiälä, was the lead author of this paper. She was responsible for developing the research idea and finding the focus of the theoretical framework and literature review. She also designed the research, the procedure of the analysis, and authored the discussion of results in light of data.

Eeva-Lotta Apajalahti, the second author, revised the theoretical framing and contributed to the positioning of the results within the existing research. She provided her insights into the quality of the research, research narrative and discussion of the results.

Teresa Haukkala, the third author, contributed to the quality of the presentation of findings, research narrative and discussion of the results. She also brought her expertise in the literature into the author team and contributed by copy-editing the text.

Raimo Lovio, the fourth author, contributed to the quality of the research and research narrative. He also provided his insights into the discussion of results in light of data.

All four authors were responsible for gathering empirical material.
PART I
1. Introduction

The key characteristics of environmental problems are their complexity, their long timeframes, and the fact that their consequences and causes are unequally distributed. They also entail huge uncertainties, and involve stakeholders with different belief systems and conflicting goals (Mickwitz, 2003). Wicked problems are problems that are difficult or almost impossible to resolve because they cannot easily be described. Policies that respond to wicked social problems are neither true nor false, good nor bad, and there would appear to be no solutions (Rittel and Webber, 1973).

Climate change is undoubtedly both an environmental and a wicked problem, but also a sustainability problem. The physical processes behind climate change are complex and uncertain in and of themselves, but when economic, social and political aspects are included, the complexity and uncertainties mount (Mickwitz, 2006, 15). As a rule, one wicked problem leads to another, and climate change is no exception. There is an urgent need to mitigate climate change, and pathways limiting global warming to 1.5°C would require rapid and far-reaching transitions in energy (Intergovernmental Panel of Climate Change IPCC, 2018). Current energy systems are unsustainable in terms of social, economic and environmental criteria. However, a more sustainable energy transition has proved to be a wicked problem, too: renewable energy that produces less or no greenhouse gas emissions meets with resistance, and a higher deployment of solar photovoltaic (PV) technology in Finland, for instance, has not been easy to implement. This thesis aims to investigate why this is such a wicked problem and whether or not it can be resolved.

1.1 Motivation for the research

Energy transitions have always taken decades to realize (e.g. Fouquet, 2010; Fouquet and Pearson, 2012; Sovacool, 2016), and a transition from fossil fuels to renewables will be no exception. In the 2010s, the transition to renewables started in a manner that was nothing short of an energy revolution. Solar PV in particular has increased much faster than anticipated. The next dominant energy source remains a question mark, however. For instance, the International Energy Agency IEA (2017) estimates that solar PV will have the largest annual capacity additions for renewables by 2022, and even earlier, the IEA had estimated that solar would become the largest source of electricity by 2050 (IEA, 2014). Despite these prognoses, solar power generates just two per cent of the
world’s electricity at present (The Economist, 2018). In contrast, nuclear power was once envisioned as the energy of the future and still has many proponents.

It seems obvious that the current energy system needs to be phased out due to climate change and energy security concerns, but the question of the dominant energy source still remains: Will renewables fulfil their promise? Alternative visions of what a future energy system might look like have been developed, with some envisioning a mix of renewable energy and nuclear as the next substitution, or even an energy system based on 100% renewables, as Germany has decided to opt for.

Government policy plays a significant role in the transitions: in some countries, policy has enabled a symbiosis between energy and industry to emerge, while in other countries it has prevented it (Moe, 2010). In the last two decades, many governments have subsidized wind and solar energy and promoted them in the electricity system in order to diversify their countries’ energy sources, create new jobs, and reduce emissions. Until recently, this has not had much of an effect on the overall system, however (Victor and Yanosek, 2017). Yet today, the cost of renewables is plummeting, their share of the power supply is rising, and investments in renewable energy have “risen like a rocket” (Paukku, 2017; Victor and Yanosek, 2017). The pressure to mitigate climate change is further strengthening their role.

These changes in the energy field have already transformed electricity markets, and the ways in which companies generate and deliver electric power. A new, more decentralized electricity industry is emerging, and traditional utilities have struggled to adapt. For established utilities, the larger share commanded by renewable energy production has posed a threat for some time now. They fear that the growth in solar and wind power is destabilizing the grid, leading to blackouts or brownouts, and a shift to renewables entails replacing established utilities with something less reliable and much more expensive (The Economist, 2013). Financial and emotional commitments – vested interests – nonetheless determine which country benefits more from new energy sources such as renewables (Moe, 2010).

Solar energy in Finland was in a very marginal position in 2011 when I started my doctoral studies. I have since followed its emergence (both solar PV and solar thermal) in Finland and witnessed its transformation from something that was seen as a rather utopian idea into a relevant source of energy that could be discussed seriously. Solar energy cannot be seen as the single, overarching solution in the Finnish energy system, but rather as a complementary source of energy in the northern latitudes; nevertheless, the fact that solar power is the fastest growing source of new energy worldwide (Vaughan, 2017) makes it an interesting case that cannot be disregarded in the Finnish energy debate.
Figure 1 also shows how, after a slow start, annual investments in solar PV have grown exponentially and more than doubled from 2015 onwards.

This thesis focuses on solar PV, and although the study takes place in the Finnish context, it may nevertheless be applicable to other countries in high latitudes that face similar kinds of challenges on account of solar irradiation, but also due to old rigid societal structures that undergird the current energy system. The study also contributes to the literature on the emergence of other types of novel technology.

1.2 Research focus and research questions

This thesis examines the ongoing low carbon energy transition in Finland. The study focuses on the multi-actor process in the Finnish low carbon energy transition by investigating different actors in the field of energy policy, their views on both the barriers to a higher deployment of solar energy and the low carbon energy transition in general, solutions to overcoming them, and achieving such an energy transition. Closer attention will be paid to the development of solar power in Finland, which has risen from an underprivileged position to a relevant player in the field. This provides a case study that sheds light on structural change through the emerging field of a new form of energy.
However, this structural change has also given rise to tensions and resistance from vested interest groups. The thesis therefore examines the field of energy policy, which includes divergent coalitions: the old coalition composed of the branch organization for the industrial and labour market policy of the energy sector together with incumbents, and the new challenging actors, such as the green-energy transition advocacy coalition, with the administration and the government positioned somewhere between the two, and influenced by the stakeholders. The study also investigates how these coalitions include actors that shift their positions and their framings during the studied time period.

This interdisciplinary study draws on several research traditions, including management studies, social science, political science, and futures studies. In particular, I apply evolutionary economics, structuration theory, transition studies, the theory of strategic action fields (SAF), the advocacy coalition framework (ACF) and socio-cultural framing, with the aim of explaining the ongoing low carbon energy transition and the case study of solar PV deployment in Finland. I adopt an *analytic eclecticism* approach that “seeks to extricate, translate, and selectively integrate analytic elements – concepts, logics, mechanisms, and interpretations – of theories or narratives that have been developed within separate paradigms but that address related aspects of substantive problems that have both scholarly and practical significance” (Sil and Katzenstein, 2010, 10). The thesis follows the classic social theory triangle of *structure, agency and meaning* (= framing in this thesis, which I take to mean how an issue is portrayed in different ways, in that an issue based on the same facts can change depending on the perspective or filter through which it is being viewed) (e.g. Giddens, 1984; Sovacool and Hess, 2017) in order to further develop a social structurationist model based on Giddens’ (1984) structuration theory. Special emphasis on the whole is put on the perspective of *change*.

To this end, the research questions that will be addressed are:

**STRUCTURE:** How do the old structures act as barriers? What are the structural barriers that hinder a higher deployment of solar energy in Finland and energy transition in general? How can they be overcome?

**AGENCY:** How have the advocacy coalitions been formed? How have the actor positions and interaction of the advocacy coalitions changed? How well have they achieved their targets?

**FRAMING:** How have the framings changed?

In addition, the thesis draws a timeline from past energy transitions to the present with the aim of detecting similarities and differences, and above all of placing the ongoing energy transition on a continuum to show how the landscape is changing, external shocks appear, and structural change occurs over time.
1.3 Structure of the thesis

The study consists of two parts: Part I comprises the introduction and Part II consists of the four articles that form the empirical material for the thesis. The two parts are organized as follows. Part I begins by introducing the topic. The theoretical foundations of the study are discussed in chapter 2, while chapter 3 presents the key empirical findings in the extant literature. Chapter 4 focuses on explaining the research design and key methodological choices. Chapter 5 presents the four articles that form the empirical basis of the research findings and the conclusions. Chapter 6 draws the contributions together, discusses the implications, and suggests topics for further research. Part II consists of the three published articles and one unpublished paper that are included in the thesis.
2. Theoretical frameworks: From the past to the future and beyond research traditions

The study of energy issues has been regarded as difficult because it is a “no-man’s land lying between the various social sciences” (Strange 1994, 191). Aalto et al. (2013) have also noted that: “No discipline has managed to fully cover the complex space of energy”. Throughout my PhD process, I have struggled to find a specific research tradition that would accommodate this work. It was not until the very end of the PhD process that I realized that this was not imperative. I have always looked at the world from a holistic perspective and combined approaches from many disciplines and this is what this study of energy transitions also required in order to comprehend the big picture. Sil and Katzenstein (2010, 2) use the term analytic eclecticism to describe this alternative way of thinking about relationships, concepts, theories, and real-world problems.

In this chapter, I first present the concept of analytic eclecticism, and then move on to presenting the theories and approaches from different disciplines, using three tenses (past, present and future) to organize the frameworks. At the same time, I will be developing my theoretical argument according to the following steps: i) Figure 2 presents the idea of analytic eclecticism, ii) Figure 3 shows a simplified version of the social structurationist model and explains the process of policy formation, iii) Figure 4 presents the relationship between the Multi-level perspective (MLP) and Kondratiev waves, iv) Figure 5 combines analytic eclecticism with the structuration approach and applies energy transition as an example, v) Figure 6 depicts the relationship between the MLP model and Kondratiev waves, illustrating the ongoing energy transition in Finland, and lastly, vi) Figure 7 presents the conceptual framework developed in this thesis, which explains my perspective as a whole.

2.1 Analytic eclecticism

The three markers of analytic eclecticism are: 1) an open-ended problem formulation encompassing the complexity and multi-dimensionality of phenomena, not intended to advance or fill gaps in paradigm-bound research, 2) a middle-range causal account incorporating complex interactions among multiple mechanisms and logics drawn from more than one paradigm, 3) the
construction of theories or narratives, findings and arguments that pragmatically engage both academic debates and the practical dilemmas of policymakers/practitioners (Sil and Katzenstein, 2010, 19–22). Analytic eclecticism duly seeks to link “a pragmatist orientation towards the production of useful knowledge to problem-driven research aimed at a better understanding of real-world phenomena and to mid-range causal accounts that draw upon mechanisms and processes normally analyzed in isolation within separate paradigms” (ibid., 23).

Analytic eclecticism is not a theoretical synthesis as such but “a flexible approach that needs to be tailored to a given problem and to existing debates over aspects of this problem” (ibid., 17). The eclecticism in this thesis entails a more holistic search for interactions among theoretical principles found across disciplines, and aims to produce a middle-range theory that does not offer a general model or universal theory, but rather sheds light on specific sets of empirical phenomena (ibid., 19–22) – in this case the wicked problem of energy transition in Finland.

The starting point for the work is the interplay between agency, structure and material, and ideational aspects. As Figure 2 explains, “assumptions concerning the ontological primacy of agency/structure or material/ideational domains of social reality cannot be converted into a priori causal primacy of either agents or structures, and of either material or ideational factors” (ibid., 21). All of the aspects in the Figure are intertwined with each other. Eclectic research considers the different ways in which individual and collective actors form and pursue their material and ideational preferences within given environments, and draws attention to how external environments influence actors’ understandings of their interests, capabilities, opportunities, and constraints (ibid.).

The most significant problem in analytic eclecticism is the possible incommensurability in drawing on different paradigms or research traditions (ibid., 14). However, the concepts and terms in the theories that I am applying in this thesis are defined and used in a rather similar way, which mitigates the problem of incommensurability.
Analytic eclecticism has been discussed and adopted mainly in the field of international relations (IR) studies that also aim to enhance understanding of the world, for instance in a study on nuclear nonproliferation to understand the interplay between sanctions and nonproliferation (Drezner, 2012), in analyzing EU foreign policy action (Pohl and van Willigen, 2015), but also in environmental issues, for instance in Meissner’s (2015) study on the governance of urban wastewater treatment infrastructure in South Africa.

In order to achieve a better understanding of the world, Lake (2011; 2013), for instance, has contributed to the discussion on analytic eclecticism and points to the need to be able to communicate across theoretical traditions and work on questions with theories from other disciplines “without fear of being criticized for inconsistency” (Lake, 2011, 472). However, even if arguing from a particular paradigm or worldview might provide powerful insights, it could also become an obstacle to understanding (Lake, 2011; Meissner, 2015; Sil and Katzenstein, 2010). Analytic eclecticism does not have a predetermined set of factors and variables that it seeks to investigate, but openly asks what kind of problems exist in the world and then seeks to understand and explain them (Meissner, 2015). The approach has also come in for criticism, for example by Parsons (2015), who states that the ‘eclectic turn’ in the literature largely overlooks competition between approaches, and emphasizes instead that they answer different parts of the questions. According to Parsons (ibid., 2), “empirical work necessarily begins with the assertion of contrasting accounts about the world”, and “all of the meaning of scholarly claims derives from positioning vis-à-vis
other accounts. Thus all scholars should be concerned with contrasting their accounts directly to others”.

Notwithstanding the critics, as well as the risk of becoming too extensive and complex, the eclectic approach nevertheless provides fruitful avenues for transition research and futures studies, which, in the same vein as international relations studies, aim to enhance understanding of the world. In light of this, I have chosen to adopt this approach in my analysis of energy transitions in order to gain broader insights by combining complementary perspectives.

2.2 Past tense framework: Historical context

Like any writer, “the futurist tells stories” (Michael, 1987). Even though this thesis is not entirely centred on futures studies, it has a strong focus on the future, and in order to understand the future, we have to look at the past. Hence, this thesis has to include a story about the past, as well as the present. Before delving into the ongoing energy transition, this chapter first takes a look back in time. As George Santayana (1905, 284) once said, “those who cannot remember the past are condemned to repeat it”, a saying that has spawned a number of variants, such as “those who cannot learn from history are doomed to repeat it” and “those who fail to learn from the mistakes of their predecessors are destined to repeat them”.

To avoid making the same mistakes, it is important to consider history and examine what past energy transitions have been like, in order to see if there are similarities or differences compared to the energy transition we are facing today. This will enhance understanding of the current transition and shed light on why it is a wicked problem. In this context, transitions are examined within a unifying historical framework based on the perspectives of Kondratiev waves and neo-Schumpeterian theory (e.g. Freeman and Perez, 1988), the ideas of which have been extended in the transition literature that will be introduced and applied later in this study.

2.2.1 Kondratiev waves globally and in Finland

Past energy transitions have been widely studied in contemporary industrialized economies. For instance, Fouquet and Pearson (2012) suggest that an energy transition was likely to unfold when new energy sources and technologies that were initially developed in niche markets and the services associated with them became sufficiently cheap to compete with the incumbents and diffused more widely. Both learning and major economies of scale were vital for the new energy source and technology to become competitive (Grübler et al., 1999). Although new energy sources were initially more expensive than the incumbent
sensors, some consumers were willing to pay for them because of the enticing characteristics they offered: ease of use, flexibility and cleanliness, or exclusivity, novelty and status (Fouquet and Pearson, 2012).

Traditionally, the process from technological innovation via niche market to dominance involving the entire economy has taken at least 40 years, or even centuries (e.g. Fouquet, 2010; Fouquet and Pearson, 2012). Shifts in major energy sources have coincided with industrial waves since the mid-18th century – long-run fluctuations in economic growth called ‘Kondratiev waves’ (Köhler, 2012). They are also a concept discussed in futures studies (Wilienius, 2017, 33).

Nikolai Kondratiev identified three kinds of cycles: long ones of a 50-year duration, middle ones of 7–10 years, and short ones of 3–4 years. His analysis of long-run fluctuations in economic growth covered the period from 1770 to the 1920s and the duration of his long cycles ranged from 40 to 60 years (Kondratiev, 1998). Kondratiev argued that modern economies fluctuate in cycles that always start with technological innovations that penetrate economic and social systems (Wilienius, 2017, 34). Kondratiev waves can duly be understood as regime shifts in the world economy (Wilienius and Kurki, 2012, 12).

Five Kondratiev waves have been identified, although there is no official consensus on the timing, as there are differences between individual industrial countries and different authors use different chronologies (ibid., 21). According to Wilienius and Kurki (ibid.), the first Kondratiev wave (1780–1830) was dominated by the invention of the steam engine, while Freeman and Louçã (2001) define the first wave as the water-powered mechanization of industry. The second wave (1830–1880) was dominated by the proliferation of railways and steel, and the steam-powered mechanization of industry and transport; the third wave (1880–1930) entailed electrification of industry, transport and the home; the fourth wave (1930–1970) comprised motorization (the car industry); and the fifth wave (1970–2010) consisted of the computerization of the economy (Freeman and Louçã, 2001; Wilienius and Kurki, 2012).

Traditionally, Kondratiev waves have been accompanied by the discovery and exploitation of a new source of cheap and abundant energy. Even though the waves are not primarily associated with energy but with technological development, a symbiosis between energy and industry has arisen. Successful uptake depended on the co-evolution of technologies, industries and institutions that enabled new energy sources to emerge from niches and to become core elements in the system (e.g. Foxon, 2011). This allowed technological clusters to dominate and create lock-ins (Grübler et al., 1999; Unruh, 2000) that led to the losing incumbents ‘fighting back’ and creating ‘sailing ship’ or ‘last-gasp’ effects (which means that the introduction of a new technology to a market accelerates the innovation of an incumbent technology) by which the incumbents may
try to defend themselves by improving the existing technology (Geels, 2005; Snow, D.C., 2010).

During the first Kondratiev wave, waterwheels and wind power were in use, while wood was the dominant energy source in the mid-1850s. In Britain, the transition to coal had largely taken place as early as 1800, but in the rest of Europe coal started substituting wood, water and wind in the 1850s. The transition to an energy system based on coal was a huge economic boost, facilitated with the help of steam engines and railroad infrastructure. The end of the 19th century was the era of electrification and finally, in the mid-1900s, oil substituted coal as the primary energy source, ushering in cars and mass production to transform people’s lives. In the 1980s, energy conservation and efficiency created a different type of energy substitution, and more recently nuclear power and natural gas have been emerging as the predominant energy sources (Moe, 2010; Sadorsky, 2011). The salient energy sources in each of the Kondratiev waves, together with the key technological drivers, are summarized in Table 1.

<table>
<thead>
<tr>
<th>Kondratiev wave</th>
<th>Time period</th>
<th>Key driver</th>
<th>Dominant energy source</th>
</tr>
</thead>
<tbody>
<tr>
<td>First wave</td>
<td>1780–1830</td>
<td>Steam engine, water-powered mechanization of industry</td>
<td>Wood</td>
</tr>
<tr>
<td>Second wave</td>
<td>1830–1880</td>
<td>Railways and steel</td>
<td>Coal</td>
</tr>
<tr>
<td>Third wave</td>
<td>1880–1930</td>
<td>Electricity and chemicals</td>
<td>Coal</td>
</tr>
<tr>
<td>Fourth wave</td>
<td>1930–1970</td>
<td>Motorization (car industry) and petrochemicals</td>
<td>Oil</td>
</tr>
<tr>
<td>Fifth wave</td>
<td>1970–2010</td>
<td>Computerization/digital technology</td>
<td>Oil, energy conservation and efficiency</td>
</tr>
<tr>
<td>Sixth wave</td>
<td>2010–</td>
<td>Information and communication technology (ICT), smart technology, robotization and artificial intelligence (AI)</td>
<td>Expected dominant energy source: Renewables and/or nuclear power and gas</td>
</tr>
</tbody>
</table>

There are, however, exceptions to the global development, the theme of this thesis being a case in point. The Finnish industrial process has taken a somewhat different path. During the first and second wave, and the early days of its independence after 1917, Finland used a lot of timber as firewood but towards the end of the third wave, the use of wood for heating decreased rapidly, due to improved space heating efficiency, and a decrease in slash-and-burn cultivation and in the production of tar and pitch. After the Second World War, the forest
industry started to use wood again increasingly (Kunnas and Myllyntaus, 2009; Statistics Finland, 2007).

The industrial revolution generally entailed a switch from renewables to fossil fuels. However, Finland was ‘the odd one out’ in Europe as its industrialization process was based on renewable energy sources. Another exception was Norway, where the predominant energy source was hydropower. Finland relied on a combination of fuel wood, wood refuse, and hydropower. The country’s vast wood resources thus allowed the transition to fossil fuels to take place relatively late, in the 1960s (Kunnas and Myllyntaus, 2009), so in respect of the dominant source of energy used during the waves, Finland jumped straight from the first to the fourth wave.

The use of fossil fuels in Finland subsequently began to increase rapidly. During the energy crisis in the 1970s, the pace of fossil fuel growth slowed down, and even came to a halt, but Finland continued to be heavily dependent upon them. Most of the country’s electricity in the 1960s was still generated by hydro power. Thermal power was generated initially by coal and oil, subsequently by peat and natural gas, and then by nuclear power from the late 1970s onwards (Statistics Finland, 2007).

2.2.2 The mechanism of change in the long waves:
Schumpeter’s creative destruction

Joseph Schumpeter identified technological and organizational change as the essential features of long waves (Papenhausen, 2008). The Schumpeterian world economy goes through “waves of creative destruction” (Schumpeter, 2010, 81), successive waves of industrial revolutions of 50–60 years’ duration, which are characterized by shocks and disequilibria. This view was adopted from Kondratiev. Schumpeter’s long-wave chronology was rather similar to what Kondratiev had posited, but he gave each wave a name (Industrial revolution, Bourgeois, Neomercantilist) and divided each one into four phases instead of two (Maddison, 2007). The long-term economic cycles are driven by the growth of one of several leading industries, but what drives growth in one era will not be equally important in the next (Moe, 2010).

According to Schumpeter (2010), economic growth is based on technological innovation, knowledge and human capital. The Schumpeterian perspective involves three basic tenets, as noted inLovio et al. (2011). First, it argues that technological and organizational changes are central to and necessary for capitalism. Second, change is examined as a battle between the old and the new, and third, there are temporal variations in the process of change: sometimes change is slow and sometimes violent. In large technological systems, such as energy systems, the change is usually slow because implementation requires
large investments. The struggle between the old and the new is particularly forceful because the end products (heat and power) remain unchanged. The competition between the old and the new is therefore characterized by the dominance of price factors and externalities (ibid.).

In Schumpeter’s work, with a change of technology, new firms and industries emerge when opportunities for new products and new techniques of production arise, and some of the old firms and industries vanish. This is what Schumpeter calls creative destruction (Lovio, 2009; Sandmo, 2011; Schumpeter, 2010). As he pointed out, “This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in” (Schumpeter, 2010, 83). The current energy system is characterized by path dependence on the old, dominant technology, which turns into forces of destabilization, thereby leaving considerable space for new technological paths to emerge (Lovio et al., 2011).

In neo-Schumpeterian thinking, economic history is a succession of separate techno-economic paradigms, where long-term growth is driven by a key general-purpose technology. The new disruptive technology is firstly confronted by the previous techno-economic paradigm, and the powers and interests that relate to it. That causes the “slowness” of the long waves, and only gradually can the new socio-technical paradigm of the new wave be formed (Perez, 1983).

2.2.3 Summary: The long waves – a structural change

This historical framework section presented insights from evolutionary economics: the long cycles identified by Nikolai Kondratiev, and the notion of creative destruction introduced by Joseph Schumpeter. Although the Kondratiev waves are situated in a historical context here, they are also an important concept that fundamentally relates to change and transition, the core concept of futures studies. The development of the different waves has been employed to show that a structural change occurs in cycles ranging from 40 to 60 years.

Past energy transitions might not be the best templates for a future low carbon energy transition, however. Indeed, we can distinguish some differences from past energy transitions compared to the one we are facing now.

First is the fact that the present energy transition is highly different from the previous ones. The past was characterized by technological breakthroughs and discoveries of new sources of energy, and both producers and consumers benefited from switching to new energy sources and technologies, whereas this is not as obvious in the low carbon transition (Fouquet and Pearson, 2012) where environmental pressure preceded the new technologies.

Second, the future transition is primarily geared towards mitigating climate change, which is no mean feat. There is a tendency to free-ride, which implies
that there is a clear need for a deliberately managed or engineered transition because of the urgency of climate change (Fouquet and Pearson, 2012). In order to limit global warming to between 1.5 and 2°C, urgent and unprecedented changes are needed, including a tenfold jump in the use of renewable energy sources and large-scale deployment of negative emissions technologies (Manoli et al., 2016). This calls for a top-down initiative that is dependent on political will on a global scale.

Third, energy transitions have thus far been accompanied by major increases in energy consumption (Fouquet, 2009), as the transition to a new energy source has still entailed using ‘left-over’ resources while benefiting from the new ones (Fouquet and Pearson, 2012). Hence, a shift to low carbon energy might not guarantee a reduction in fossil fuel consumption. Instead, it might promote overall greater energy consumption while nevertheless potentially leading to a transformation of the economy and a new phase of major economic growth (Fouquet and Pearson, 2012).

Fourth, each past energy transition has taken 40–60 years and the ongoing energy transition is expected to take the same amount of time. It is possible, however, that future energy transitions could also be accelerated because they can benefit from improved knowledge and analysis of how transitions occur, coupled with newly developed policy mechanisms together with many newer energy technologies. Future transitions might also be influenced by scarcity, rather than discoveries of new, significant, and affordable forms of energy (Sovacool, 2016). After all, the previous waves were high carbon industrial revolutions, while the present transition is a low carbon transition (Pearson and Foxon, 2012).

The low carbon transition leads to the destruction of old firms and industries but it also creates new ones. In effect, it is a struggle between the old and the new. Both creation and destruction must, however, be allowed to occur if a country is to be economically successful in the long run. When the core industries of the past no longer succeed in the way they once did, the country needs to move on with new industries (Moe, 2009; 2010). Inevitability is often an important driver of change: in the type of forced change that the low carbon transition obliges, the state has a significant role because market mechanisms are less effective than in the case of lucrative innovation-driven change (Lovio et al., 2011).

As already noted, the fifth wave of computerization of the economy has begun to shift to the sixth long wave of economic development characterized by information and communication technology (ICT), smart technology, or more precisely ‘smart resource effective technology’ (Wilénius, 2015), but has recently started to turn more towards the key characteristics of robotization and artificial intelligence (AI). The low carbon transition could also potentially
become the sixth long wave of economic development (Fouquet and Pearson, 2012), driven by the technological surge associated with renewable energies, particularly in China (Mathews, 2013). Drawing on the characteristics of past energy transitions, a shift to renewable energy is consistent with the pattern of historic substitution dynamics of primary energy sources (Sadorsky, 2011), but whether this will fully play out depends on the developments in the other two tenses in the landscape.

2.3 Present tense frameworks: Structure, agency and framing

While I relied in the historical overview on Kondratiev waves and the neo-Schumpeterian approach to understanding transitions, in the next part of the thesis transitions are examined from multiple perspectives, particularly the multi-level perspective (MLP) of transition studies, combined with a social structurationist approach, a theory of strategic action fields (SAF), the advocacy coalition framework (ACF), and framing. The chapter follows the triangle of structure, agency and framing.

2.3.1 The theory of structuration and the social structuration approach

As the development of transition studies has been heavily influenced by the theory of structuration (Grin et al., 2010; Hermwille, 2016), I begin this section by presenting the concepts of structure and structuration, which I have also drawn on in my conceptual framework. Anthony Giddens (1984) formulates the linkages between human actors and structures within society and the state in his structuration theory. Human actors are embedded in structures; they are enabled and constrained by the structural positions they occupy at a given time, and structure is conceptualized as organized sets of rules and resources. Rules refer to cognitive, interpretive frames and to cultural norms. The constitution of agents and structures represents a duality. They are not two independently given sets of phenomena: While actors are embedded in structures, they also reproduce them. Hence, the structures are both a medium and the outcome of the practices that actors engage in. Without structures, action would not be possible. In this sense, structures are not only constraining, but also enabling (Aalto et al., 2013, 4; Giddens, 1984, 25; Grin et al., 2010, 42–43).
Table 2. The Duality of Structure. Source: Giddens (1984, 25).

<table>
<thead>
<tr>
<th>Structure(s)</th>
<th>System(s)</th>
<th>Structuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules and resources, or sets of transformation relations, organized as properties of social systems</td>
<td>Reproduced relations between actors or collectivities, organized as regular social practices</td>
<td>Conditions governing the continuity or transmutation of structures, and therefore the reproduction of social systems</td>
</tr>
</tbody>
</table>

Drawing on Giddens’ structuration theory but also on Alexander Wendt’s constructivist IR theory (1999), Aalto et al. (2013) have developed a social structurationist model that has been used to theorize energy policy formation in Russia (Aalto et al., 2013) and Russian nuclear energy diplomacy (Aalto et al., 2017b), as well as in the political economy structures of energy transitions (Aalto et al., 2017a). Diverse actors are involved in the field of energy policy, and these actors can act purposefully but also unintentionally. Actors develop interests that guide their behaviour, and interests and frames are the driving forces of energy policy (Aalto et al., 2013). Understood in this way, the system produces outputs that can have knock-on effects for both actors and structures. An adapted version of the social structurationist model is illustrated in Figure 3. This is a simplified version of the Figure that appears in Aalto et al. (2017a, 5).

![Figure 3. The social structurationist model. Adapted from Aalto et al. (2013; 2017a; 2017b).](image_url)
Theoretical frameworks: From the past to the future and beyond research traditions

The structuration theory is widely acknowledged as a pillar in contemporary sociological theory, but has also received much criticism. The theory lacks several critical elements, one of which being that there is no theory of collective action, and another being the lack of a conception of the arena of social action (Fligstein and McAdam, 2011, 27). To overcome these shortcomings in this work, the structuration approach is complemented with some key concepts taken from the theory of strategic action field.

2.3.2 Transition studies – a socio-technical approach

As already discussed, we need a completely new paradigm for organizing our economy and energy production, and the paradigm shift ought to happen soon (Wilenius and Kurki, 2012, 11–12). Yet transitions are usually long-term processes of change during which a society or a subsystem of society fundamentally changes (Rotmans et al., 2001). Energy transitions are not just technological shifts but power struggles and socio-cultural changes (Loorbach et al., 2017). The actors involved have vested interests and when the system is threatened, push-back is likely to occur (Sovacool et al., 2016, 4). Transitions take place through structuration in a complex web of social and economic institutions, political systems, cultural meanings, structural arrangements and human action (Markard et al., 2012).

Transition studies is a school of thought that focuses on generating systemic transitions to sustainability in response to the grand challenges of our time (Raven et al., 2010). The concept of transitions emerged as a novel concept to generally address large-scale societal change and sustainability during the 1990s. Transitions research investigates how complex societal systems could make a structural qualitative shift from persistent unsustainability towards a more sustainable state (Loorbach et al., 2017). The field of transitions research has its roots in two major clusters: the broad category of innovation research, including science and technology studies, history of technology, evolutionary economics, and innovation policy (e.g. Rip and Kemp, 1998), and the fields of environmental studies and sustainability sciences, including environmental assessment, integrated assessment, sustainability governance, and environmental policy (e.g. Kemp, 1994; Loorbach, 2007; Rotmans, 1998). The initial focus of transitions research was on analyzing transitions in socio-technical systems, such as energy, mobility, and agriculture. The focus was then broadened towards socio-ecological, socio-economic, and socio-political systems (Loorbach et al., 2017). This thesis applies the socio-technical perspective in particular.

The socio-technical transitions approach draws on insights from several disciplines, such as evolutionary economics, innovation studies, and institutional
theory. Schumpeter’s waves of creative destruction derive from evolutionary economics, for instance. Deriving from innovation studies are insights into innovation being a social process that is based on interactions between multiple actors, the idea that the diffusion of new radical innovations and systems into markets and society is a contested and a negotiated process, and the notion that sustainability transitions are socio-technical because they involve changes in technologies, but also in markets, cultural meaning, policy and politics. Assumptions stemming from institutional theory point to actors’ preferences, ideas, interests and identities being shaped by different kinds of institutions, and institutional change often including power struggles between vested interests and new entrants (Geels, 2018, 45–46).

The multi-level perspective (MLP) has become widely used in transition research. It is intended to provide a more general theory for identifying processes of change (Köhler, 2012). The MLP is a process theory that explains outcomes as the results of a series of events structured through underlying mechanisms (Geels and Schot, 2010). It borrows from a mix of disciplines and draws a distinction between three analytical concepts: a niche, regime, and the landscape (Geels, 2002; 2005; Geels and Schot, 2007b; Rip and Kemp, 1998; Schot and Geels, 2008). The main contribution of the multi-level perspective is the insight that transitions only occur through the fruitful coupling of developments at all three levels of regime, niche and landscape (Raven et al., 2010).

The niche refers to a ‘space’ or ‘location’ that is protected from the dominant regime, the micro-level of technological and social change, or a radical innovation that is emerging to gain diffusion or adoption. The regime is the central concept, since a transition refers to a major shift in the regime (Raven et al., 2010). The regime refers to the incumbent sociotechnical system that the niche is potentially affecting or replacing (Geels, 2004). The third concept, landscape, is “a metaphor for the background setting and background developments for regimes and niches” (Raven et al., 2010). It refers to “exogenous developments of shocks (e.g. economic crises, demographic changes, wars, ideological change, major environmental disruption like climate change) that create pressures on the regime” (Sovacool and Hess, 2017). These concepts are further integrated into the conceptual framework of this thesis and provide a platform for systemic innovation.

Different kinds of interactions among the niche, regime and landscape result in different kinds of alignments. Geels and Schot (2007b) have constructed a typology based on combinations between two dimensions: the timing and nature of multi-level interactions. Four transition pathways have thus been identified: 1) technological substitution, 2) transformation, 2) reconfiguration, and 4) de-alignment and re-alignment. In a recent thesis, Lauttamäki (2018) combines
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MLP with futures studies in a case study on ground-source heat in the facilities’ heating market in Finland, and notes in his thesis that these transition pathways share similarities with the phases in which transitions occur.

Geels (2018) characterizes four phases of transitions by different actors and core struggles. During the first phase, radical innovations emerge in niches, which may take a long time and are characterized by experimentation and trial-and-error learning. Niche innovations do not pose a threat to the existing regime at this point. The second phase of transitions includes innovations breaking out of protected technological niches, and establishing a foothold in one or more market niches. Learning processes stabilize and focus on functionality and performance rather than cost. Technological stabilization and emerging economic opportunities urge actors such as the government, firms, and the financial community to invest. Innovations may at this point be opposed by special interest groups or citizens that experience negative side-effects, which may result in controversy and stalemate. During the third phase of diffusion and breakthrough, the innovation diffuses into mainstream markets and competes with the existing technology and wider socio-technical regime. The third phase is characterized by struggles between niche innovations and existing regimes in multiple socio-technical dimensions. The fourth phase is characterized by technological substitution and broader socio-technical adjustments in user practices, infrastructures, regulations and cultural meanings (Geels, 2018, 51–56).

Various important lock-in mechanisms have also been identified: 1) economic lock-in mechanisms that include sunk investments that create vested interests against change and better price/performance characteristics for existing technologies, 2) social lock-in mechanisms that include cognitive routines and shared mindsets, 3) political lock-in mechanisms that include active opposition to change from groups with vested interests (Geels, 2014), as well as existing regulations and a policy network that favour incumbents and create an uneven playing field (Walker, 2000).

In addition to MLP, two specific transition studies frameworks that seek to understand the dynamics in the emergence (and formative) phase are strategic niche management (SNM) and the technological innovation systems (TIS) approach (Geels, 2018, 52). Strategic niche management investigates how the experimental introduction of sustainable innovations in niches can benefit the wider transition process. The entry point for SNM is often technical: “the development and implementation of technical innovations are not seen as a goal as such, but as a means to enable the shift towards new (and hopefully more) sustainable practice” (Raven et al., 2010). The level of analysis is often experimental projects and the research question is usually why a certain innovation journey was a success or a failure. This explanation often emerges
through analysis of the interaction between what has been labelled the ‘three internal niche processes’ (Raven, 2005).

The technological innovation systems framework was developed to analyze the development, production and deployment of new technologies from a socio-technical systems perspective (Bergek et al., 2008; Hekkert et al., 2007). The TIS framework is apt for studying barriers and drivers at different stages of a technology’s development (Bergek et al., 2008, 2015; Markard et al., 2012), predominantly in the processes of development, production and deployment together, or by paying less attention to deployment than to development and production (Dewald and Truffer, 2011). However, Palm (2017) applied TIS exclusively to the deployment phase of solar PV in Sweden.

Besides the more theoretical MLP, SNM and TIS approaches, more practice-oriented approaches, such as transition management (TM), are also included in transition research. Transition management is an approach that addresses challenges for the governance of sustainability transitions, namely directionality, demand articulation, policy coordination, and reflexivity (Geels, 2018, 63). It was originally developed for the Dutch government in 2000 by Rotmans, Kemp and others (e.g. Rotmans et al. 2001), and it “consists of a deliberate attempt to bring about structural change in a stepwise manner” (Rotmans and Kemp, 2003). An overall outline of the key features in transition management is provided for example in Heiskanen et al. (2009), Kemp et al. (2007), Rotmans et al. (2001), and Voss et al. (2009). A key feature of the transition model is its focus on long-term thinking, and its explicit focus on the interconnectedness of technological and social systems. Transition management is based on multi-level, multi-domain and multi-actor thinking. According to the transition management approach, transition developments can be tracked at three different levels: micro, meso and macro levels, which are based on the multi-level perspective. The micro level comprises individuals or individual actors, such as companies and environmental movements (niche). The meso level comprises networks, communities and organizations (regime), while the macro level comprises conglomerates of institutions and organizations (landscape) (Loorbach, 2007, 20; Rotmans et al., 2001). Transition management emphasizes both top-down and bottom-up processes and aims to design policies for long-term sustainability through systems-level innovations (Rotmans et al., 2001).

In the transition management approach, a new governance community or arena between government and market is proposed and has been used in the Netherlands in particular. The transition arena model can be seen as a meta-instrument for the theoretical considerations of transition management. It is the multi-actor context in which the transition management process takes place. The transition arena is, in its first phase, a small network of innovators and strategic thinkers from different backgrounds who come together to discuss the
transition problem and outline the transition goals. The network will expand later to include less strategically oriented actors. Short-term experiments and actions are finally derived from the goals and paths, and more practically oriented organizations and actors will be involved (Loorbach, 2007, 137). As an example of a transition arena, an experimental transition arena together with the Finnish Innovation Fund Sitra and the Smart Energy Transition project was created in Finland in 2017 to identify shared visions, agenda and transition paths (Hyysalo et al., 2017).

2.3.3 Summary of the structure

To conclude, transition studies is a relatively new research field that has been developed over the last two decades around topics that address sustainability challenges. Transition research has a strong core based on historical socio-technical case studies (Raven et al., 2010). It duly touches upon the same issues of socio-technical transitions in a historical context as Kondratiev waves, but it distances itself from the long wave theory (Wilenius and Kurki, 2012, 26). Figure 4 adapts the systemic transformation framework to the Kondratiev wave theory. It situates the sixth wave as part of the evolving landscape where rapid changes cause pressure and destabilization for the regime and create a window of opportunity for the niche innovation to enter the regime (ibid, 27). Figure 4 is a simplified version of the Figure in Wilenius and Kurki (ibid.) without the forest industry as an example.

The two conceptual frameworks address the same topic of structural change and provide a similar description of the development of the new technologies. Both have the concept of lock-in to a particular technological solution. They both argue that socio-technical changes are social processes that take a long time and have a strong path dependence in the existing technology. They also emphasize the creation of new markets through niches (Köhler, 2012). However, while the neo-Schumpeterian theory explains long-run patterns of macroeconomic growth in industrialized society as successive waves of development of socio-technological paradigms, the MLP considers a single technological system change. Transition theory considers developments in society as a whole, but from the point of view of specific change in a transition in a particular sector (ibid.). Moreover, in the neo-Schumpeterian approach, according to Köhler (2012), there is no theoretical basis for proposing ways in which society can influence the development of a Kondratiev wave, which on the contrary can be regarded as a crucial factor in influencing a sustainable transition. Whilst the neo-Schumpeterian approach and transition theory could be regarded as competing with each other, they could just as easily be envisaged as complementing each other (ibid.). Although I see transitions as occurring
in cycles, and as continuing to do so in the future as well, this thesis focuses on the current energy transition (which could become the sixth Kondratiev wave) and addresses this structural change from the perspective of Finland, and specifically the case of solar PV.

The emerging field of transition studies is characterized by a wide variety of topics, approaches and methodologies (Markard et al., 2012). A general feature is that transitions towards sustainability are framed from a systems perspective, and socio-technical transitions involve a broad range of actors (Farla et al., 2012). In this thesis, the regime is part of the structure, but at the same time belongs to the agency section, as structure and agency are not independent of each other. Having introduced the core socio-technical approaches of transition studies, I will now examine the role of agency and framing in the theoretical approaches in greater depth.

2.3.4 Agency in transitions

The influence of actors on society is largely absent in the neo-Schumpeterian approach (Köhler, 2012). Yet the role of agency in transitions is crucially important since structural change is often not easy to combine with a concise and integral view of how change can be brought about (Grin et al., 2011). In general, there has been a lack of attention to the role of agency in sustainability transitions (Pesch, 2015). Several scholars have criticized the MLP for neglecting
agency (Genus and Coles, 2008; Meadowcroft, 2011; Smith et al., 2005) although it has, however, been recognized in the approach (e.g. Geels, 2011; Geels and Schot, 2007b; Geels et al., 2016). It has also been criticized for the hierarchical configuration of different levels (e.g. Shove and Walker, 2010), for being biased towards bottom-up change models, and for possessing a flawed epistemology and explanatory logic (a response to critics is provided in Geels, 2011) (Sovacool and Hess, 2017). The MLP has also been criticized for not always adequately explaining issues of politics, power and hegemony when elucidating how transitions occur (Smith et al., 2010). The MLP literature has mainly focused on technology producers and intermediaries, business and government actors (Geels, 2005; Geels et al., 2016), but during the past decade the role of civil society actors has also received increased attention (e.g. Seyfang and Haxeltine, 2012; Seyfang and Smith, 2007; Seyfang et al., 2010; Smith, 2010).

The MLP argues that there is direct competition between expanding niches and the incumbent regime. Niches and regimes are about networks of actors that subscribe to particular rules, but these are constantly shifting in their scope, scale, maturation, and effectiveness (Sovacool and Hess, 2017). Niche innovations often struggle against socio-technical systems that are based on existing technologies, regulations, user patterns, infrastructures and cultural discourses (Geels, 2004). The perceptions and actions of incumbent actors, such as firms, engineers, users, policymakers, special interest groups and civil society actors are shaped by socio-technical regimes (Geels, 2014).

Market competition between new and existing technologies and struggles between new entrants and incumbents emerge during the transitions. The struggles may follow different patterns: first, existing firms may collapse (Christensen, 1997); second, incumbent firms may try to defend themselves by buying up the new firms, hindering the innovations or improving their own technology; third, existing firms may shift their positions and reorient themselves towards new technologies (Geels, 2018, 55).

Further, political conflicts and power struggles over policy instruments emerge during the transitions. Struggles involve traditional policy actors but also many interest groups. Successful transitions are political processes where incumbent actors tend to resist changes and niche actors push for them. Changes in power relations are therefore needed in order to make a policy change (ibid., 56). In addition, cultural and discursive struggles that frame problems and solutions in certain ways arise (Geels and Verhees, 2011). As actors often organize themselves in coalitions that hold similar or shared beliefs and ambitions in order to further their agenda and objectives, I have turned to additional frameworks to complement the questions of structure and agency, namely strategic action field theory and the advocacy coalition framework. These will be introduced next.
A strategic action field (SAF) is a meso-level social order where actors interact with one another about the purposes of the field, the relationships of the field, the rules of the field and a situation where actors have frames that produce an understanding of what other actors’ moves in the field mean (Fligstein and McAdam, 2011, 10–11). It is dominated by incumbent actors who share a common belief with regard to what the field is all about (Fuchs et al., 2012). All collective actors are made up of strategic action fields, with smaller fields nested inside larger ones like Russian dolls. Action takes place in these meso-level social orders (Fligstein and McAdam, 2011, 9), which is missing in Giddens’ (1984) structuration theory. Nor does Giddens recognize a theory of collective action, so the motives of actors, their actual relationships to each other, and the desire to engage in collective action is not visible in the structuration theory, whereas this is provided in the theory of strategic action fields (Fligstein and McAdam, 2011, 27).

According to strategic action field theory, actors in the field have varying amounts of power (incumbents and challengers) depending on their position in the field (ibid., 11). They can form coalitions and, in order to gain an advantage, challengers must also create a larger collective identity (ibid., 14–16). SAF borrows key concepts from the social movements theory, but as the latter is ‘movement-centric’ in its focus, SAF emphasizes the critical interplay of the actors within a field, and between the field and the broader field environment, aiming to account for field emergence, stability and transformation (ibid., 30–31). In this way, fields can be seen as playing a crucial role between structure and agency.

Field stability is an ongoing game where incumbents, challengers and members of the political coalitions make moves and countermoves, and it is controlled by the existing structure of the field. The goal for incumbents is to preserve or expand their power in the field, but they are dependent upon the worldview and rules they have helped to devise. The emergence of a new field typically occurs through both an internal and an external process. Challengers seek to change the status quo of the field but an unsuccessful challenge could prove disastrous, which is why it would be in their interests to maintain their position in the system and wait for clear signs of incumbent vulnerability. However, they continue to test the stability of the field, leading to an ongoing threat. This produces shifts in the nature of the relationships, the tactics of the groups and the worldviews (Fligstein and McAdam, 2011).

The advocacy coalition framework (ACF) takes these ideas a step forward by focusing on actors and their beliefs, putting the emphasis on external shocks as a key mechanism for change. Policy actors are assumed to hold beliefs that are either deep core beliefs, referring to worldviews that are very difficult to change, or to policy core beliefs that reflect basic positions in a policy subsystem and
are almost equally difficult to change (Sabatier and Weible, 2007). Generally speaking, only an external shock can have a sufficient impact to change core beliefs. Two sets of exogenous variables can affect the constraints and opportunities of subsystem actors: 1) the basic constitutional structure, socio-cultural values, and natural resources of a political system, and 2) major socio-economic changes, changes in public opinion and in the systemic governing coalition, and policy decisions and impacts from other subsystems (Sabatier, 1998). In ACF, the definition of the policy subsystem and selection of key actors is a crucial step (Sabatier and Weible, 2007).

The integral elements of ACF are: 1) policy participants, or actors that are considered to be experts in a specific policy field, 2) a policy subsystem, namely a set of policy participants, and 3) advocacy coalitions, which are groups of policy actors that share similar belief systems and coordinate actions to translate their belief systems into a change in policy (Sabatier, 1998). The advocacy coalition framework views policy change over time as a function of three sets of factors: 1) the interaction of competing advocacy coalitions within a policy subsystem/community, 2) changes external to the subsystem, and 3) the effects of stable system parameters (Sabatier, 1991). The interaction between wide external shocks or shocks to the political system and the success of the ideas in the coalitions may cause actors in the advocacy coalitions to shift coalitions. This may occur just for tactical reasons, but also for evolutionary adaptation: New situations may deserve new arguments (John, 2003).

### 2.3.5 Interests, worldviews and frames in transitions

People have heterogeneous interests, values, and worldviews. In cultural theory (Douglas, 1970; 1978), the patterns of social interaction within which individuals prefer to live their lives form a series of worldviews that shape their beliefs, attitudes, and behaviours. A set of four worldviews have been identified: hierarchy, individualism, egalitarianism, and fatalism (Coyle and Ellis, 1994; Douglas, 1982; Jenkins-Smith and Smith, 1994). Different groups of people interpret reality based on distinct “thought collectives”, “paradigms”, “worldviews”, and “invisible colleges”, and even the most robust, reliable knowledge will be discounted if it does not fit within their worldview or assumptions (Sovacool and Brown, 2015). Worldviews often affect our action and go unpondered, but people can and do reflect upon their particular worldviews, and sometimes change them as a result. Worldviews are conditioned by other social, material factors and structures of society (Haukkala, H., 2008, 89).

Financial and even emotional commitments in respect of the existing structure create vested interests. The term ‘vested interests’ comes from Mancur Olson (1982). Vested interests seek to preserve the institutional status quo
that has served them in the past. They build up over time within the state, and lead to the silting up of rigidities in the economy (Moe, 2009; Olson, 1982). A growing industry that becomes affluent normally also acquires political influence through lobby groups and politicians who speak on its behalf. This makes it strong and unified. Thus, an economic policy that is controlled by vested interests is not interested in change and neither willing to do so, leading to a country that loses its ability to change and adapt (Moe, 2009; Olson, 2000). Therefore, a shock to the system is needed that will root out the existing vested interests and provide a fresh start for the country (Moe, 2009; Olson, 1982). Olson emphasizes the importance of structural change for long-term growth and development, and how the impact of vested interests on policy-making has an effect on political decision-makers’ capacity to implement policy (Moe, 2009; 2010; Olson, 1982). He further argues that societies that have reformed their institutions and dismantled old monopolies of power and economic vested interests have been the ones that have become prosperous (Olson, 2000), but a country that has done well within one set of technologies and industries may not be equally successful in the next industrial revolution (Moe, 2009). This structural change can also be seen as a form of Schumpeterian creative destruction.

Human beings also make decisions based on ideological frames (Sovacool et al., 2016, 4). Frames enable decision-makers to have differing conceptions of reality. They refer to how knowledge is shaped, conditioned, and digested. Different experiences, interests, and values can produce clashing attitudes concerning energy policy and technology, so there is no “one objective Truth” when it comes to perceptions and attitudes related to energy problems (Sovacool and Brown, 2015). At least five distinct meanings have been identified in relation to ‘energy’, namely the scientific, economic, ecological, social welfare, and energy security view (Stern and Aronson, 1984). According to Sovacool and Brown (2015), key questions about energy have less to do with facts and more to do with assumptions and frames.

The frame concept has been widely applied in the social sciences, especially in social movements studies. The verb framing denotes an active, processual phenomenon that implies agency and contention at the level of reality construction (Benford and Snow, 2000). Framing is something that actors do (Snow et al., 2014), and it serves to bring about societal and cultural changes through the “power of words” (Benford and Snow, 2000; Goffman, 1974).

For Goffman (1974), frames denoted “schemata of interpretation” that enable individuals “to locate, perceive and identify, and label” occurrences within their life space and the world at large. According to Goffman (ibid.), a frame establishes relatively clear-cut conditions for expectations and interaction, and
actors can articulate coherently with a frame, and decide on a suitable course of action. Frames can be competing or complementary.

Frames help to render events or occurrences meaningful, and hence they serve to organize experience and guide action (Benford and Snow, 2000). They are also used to make connections between a smaller and a larger issue. Collective action frames simplify and condense aspects of the “world out there”, but in ways that are “intended to mobilize potential adherents and constituents, to garner bystander support, and to demobilize antagonists” (Snow and Benford 1988, 198). Collective action frames are action-oriented sets of beliefs and meanings (Benford and Snow, 2000). In other words, skilled social actors frame “stories” by which they can get others to cooperate with them by appealing to their identity, belief, and interests, and by simultaneously using the same stories to frame actions against opponents (Fligstein and McAdam, 2012, 50–51). For instance, in a study on a case concerning a dispute over a car-free street in Tampere, Finland, the parties used versatile spatial reasoning as they justified their views (Salminen, 2018). The study identified three dichotomous pairs that consisted of opposite spatial logics: firstly, the parties wanted to protect the inside or value the outside opinion of the city; secondly, urban space was represented as a means to an end or as an end in itself; and thirdly, the city was advocated as a public forum or space, or as an arena for private competition (Salminen, 2018).

The importance of framing has also been recognized in the emergence of novel industries and technological fields. For instance, the concept of field frames has been introduced by Lounsbury et al. (2013) to refer to the shaping of socio-cultural meaning systems in the emergence of industries. This literature recognizes the dual character of the framing process, which is emphasized in both the field framing and social movement literature. Framing processes often include framing contests or struggles due to the varying interests and interest groups (Geels and Verhees, 2011; Ryan, 1991). These struggles over alternative initial framings, or challenging and reconfiguring old framings, culminate in a settlement of the most resonant frames as dominant field frames (Cornelissen and Werner, 2014).

2.3.6 Summary of agency and framing

A transition consists of multiple processes that occur as event chains, based on actions and interactions between a variety of social groups (Geels, 2018, 56). The role of agency is a crucial aspect in the transitions, although not omnipotent. Transitions are contested, conflictual and political and involve a range of struggles (ibid.). In the socio-technical transition literature, but also in the strategic action field and advocacy coalition framework, the focus of the actions
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diction of the different parts is on their struggles. Market competition, political conflicts and power struggles emerge, especially during the third phase of diffusion and breakthrough in transitions (ibid., 55). This is also a prerequisite for a transition. However, actors hold core beliefs that are very difficult to change. If one wants to influence other people and make them think in a different way, it needs to be understood that it is very difficult to change their worldviews. It usually takes an external shock to direct thinking in another way. Moreover, different kinds of lock-in mechanisms that include vested interests and shared mindsets, for instance, are difficult to overcome.

Furthermore, transitions are always about meanings, interpretations, beliefs, mindsets and sense-making (ibid., 56). Hence, it is not just about what the actors do, but in what kind of way: how the actors interact with each other, what they believe in and what kind of arguments they use in their communication play an essential role in understanding how and why a structural change takes place. The interaction between facts and frames is a crucial issue here. As Amory Lovins puts it, “underlying much of the energy debate is a tacit, implicit divergence on what the energy problem ‘really’ is. Public discourse suffers because our society has mechanisms only for resolving conflicting interests, not conflicting views of reality” (Lovins, 1978). There are plenty of subjective frames – differing conceptions of reality, or worldviews – available (Sovacool et al., 2016, 332). A skilled actor can convince others who do not necessarily share the same interests that what will occur is consistent with their identity and interests. If one is able to place one frame on the agenda, much of the battle has been won (Fligstein and McAdam, 2012, 51). While structure and agency represent a duality that cannot be divided, the interaction of actors is an equally important factor in the multi-actor process. In order to comprehend the big picture, aspects of framing need to be added to the mix in a holistic study of transitions.

2.4 Future tense: Futures studies and energy scenarios

Futures studies have been used widely in the field of energy analysis since the 1960s at least. Their basic purpose has been to display different combinations of energy demand and supply options, to generate insights for strategic decision-making in the private and public sectors. These have typically been collected under the term “energy scenarios” (Nilsson et al., 2011). A scenario is often a story about alternative possibilities for the future with different probabilities of occurring under various conditions. It often includes goals and values and a description of possible choices available with regard to human actions and their anticipated outcomes (Bell 1997, 31–317). Schwartz (2007[1991], 39–41) describes scenarios as “myths of the future”: the way people believe things to be,
the patterns of behaviour, belief and perception that people have in common. Van der Heijden (2010) defines scenarios as providing the whole cause-and-effect story, and as leading to an understanding of why things happen. In so doing, they do not offer a yes or no decision but require further judgements (van der Heijden 2010, 110).

In short, energy scenarios can be described as predictive, explorative or normative. A predictive scenario tries to answer the question “What will happen?”, while an explorative scenario and a normative scenario answer the questions “What can happen?” and “How can a specific target be reached?” (Börjesson et al., 2006). Lately, predictive scenarios have been abandoned and the mainstream scenario construction in futures studies is concentrating on explorative and normative scenarios.

There has been a rapid development over the last 40 years in the study of energy futures. The first “generation” of energy future studies comprised forecasts that typically looked at likely outcomes (what will most likely happen). It is much used today in energy planning and policy-making. After the energy supply crises of the 1970s, it became obvious that the future is fundamentally unpredictable, and decision-makers were left ill-equipped when it came to planning for alternative possible futures if they could only rely on regular forecasting approaches. Explorative scenarios were developed to meet these requirements. Such scenarios are concerned with alternative potential developments and plausible futures: what can happen. The third type of future studies was experimented with in the 1970s and 1980s and led to the development of backcasting. Such studies stake out a desirable future with certain end-points. Backcasting studies have provided suggestions on where to aim in terms of technology and costs, and how to get there in terms of pathways of behaviour and technology (Nilsson et al., 2011).

2.4.1 Energy scenarios for Finland

In 2012, VTT Technical Research Centre of Finland published a study entitled “Low Carbon Finland 2050”. The focus of the explorative study is on the national energy economy in Finland, assuming deep greenhouse gas reductions by 2050. VTT’s analysis methodologies include modelling future energy systems and markets, to which end three scenarios ensued that are described as ‘plausible’: “Tonni”, “Inno”, and “Onni”, which are compared to the business-as-usual scenario (VTT, 2012, 5).

The “Tonni” scenario aims at an 80% emission reduction in an assumed future where industrial structure and production volumes grow. In the “Inno” scenario, technological developments are assumed to be the fastest with new products and production processes. The “Onni” scenario includes significant
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changes in industrial structure and in regional and urban form. Industrial production is assumed to move in a less energy-intensive direction (ibid., 16–17). In the study, solar energy is presented as a wild card. The question of critical materials for cells is important in developing solar technology, according to the study (ibid., 43).

Conversely, an energy system scenario for Finland where electricity is produced fully by renewables by 2050 has been developed by Child and Breyer (2016). One of the key assumptions of their study was that the future energy scenarios should result in zero greenhouse gas emissions. They used the modelling tool EnergyPLAN and a reference model for 2012, as well as reference scenarios for 2020 and 2050. The EnergyPLAN system analysis tool is a deterministic input/output computer model that can assist in the design of energy systems at a regional, national or multi-national level. Electricity demand for Finland was assumed to be 95 TWh in 2050. The installed capacities (GW) needed for the 100% renewables scenario in 2050 are as follows: Wind onshore 30 (0.17 in 2012), wind offshore 5 (0 in 2012), solar PV 30 (0.01 in 2012), hydropower 3.5 (2.60 in 2012), combined heat and power – district heating 9.4 (3.49 in 2012), condensing 0 (2.04 in 2012), nuclear 0 (2.75 in 2012), Power-to-gas (CH₄) 23.5 (0 in 2012), Power-to-gas (H₂) 0.6 (0 in 2012) (ibid.). Within the same study, socio-technical scenarios were constructed in Breyer et al. (2017).

The researchers’ backcasting study argues that an energy system based entirely on renewable energy sources, which has electricity as an energy carrier, is possible by 2050. It has been seen as a highly competitive cost solution for Finland, as total system costs decrease through interaction between the power, cooling/heating and mobility sectors. High shares of solar PV were not deemed to be a wild card as in VTT’s (2012) scenario, but to be feasible when supported by various energy storage solutions and seasonally complemented by other forms of variable renewables. In addition, a high level of energy independence was envisaged as achievable for the Finnish energy system (Child and Breyer, 2016). However, as outlined in a separate publication (Child et al., 2017), it is not only technological challenges that must be overcome in order to facilitate such high shares of solar PV in Finland, but also a wide range of stakeholders with vested interests that must be taken into account as they may compete against or provide other barriers to change.

When it comes to the latter, Toivanen et al. (2017) have analyzed how key stakeholders in Finland envisage the Finnish energy system by 2030. They identified three views in their study, which consisted of a Q methodological analysis with 24 respondents from the Finnish energy companies, energy business lobbies, the public sector and NGOs. The three views are as follows: View I: international competition and smart solutions, View II: active consumers, and View III: national competitiveness and local solutions.
View I was endorsed by half of the respondents representing the energy industry, the public sector and NGOs alike. The main message is that international markets and competition should determine the sources of energy, so subsidies, for instance, should be technology neutral. The respondents did not back the idea to phase out nuclear power from the Nordic grid in order to increase the share of wind and solar power. They felt that wind and solar should be promoted by streamlining the bureaucracy involved. View II was supported by energy company and NGO representatives, who preferred to help Finnish customers to use electricity prudently. View III was supported by respondents from organizations in all sectors, who wanted to maximize the use of local energy sources, especially forest-based biomass, in energy production as the optimal way of using resources (ibid.).

The study reveals how key expert stakeholders stand firmly behind the decarbonization of the energy system, which will significantly influence some of the vested interests of incumbent actors as well as existing business models. In time, this will also break some of the existing path dependencies (ibid.).

2.4.2 Summary of the future tense

Anticipating the future is undeniably difficult, but the goal of futurists, at the most general level, is to contribute towards making the world a better place to live in by mapping pathways towards futures: “The purposes of futures studies are to discover or invent, examine and evaluate, and propose possible, probable and preferable futures. Futurists seek to know: what can or could be (the possible), what is likely to be (the probable), and what ought to be (the preferable)” (Bell 1997, 73).

Different kinds of energy scenarios have also been proposed for Finland, as described above. Scenarios are meant to provide new perspectives and offer alternatives, but they are also intended to be used as testbeds for envisioned futures. The decarbonization of the energy system is widely advocated but the different pathways are still being discussed, and groups with vested interests may be very active in the debates. Competing frames may be used, all of which need to be taken into consideration when deciding on future pathways.
2.5 Bringing it all together: The conceptual framework in this thesis

In order to approach and understand such a wicked problem, a phenomenon as complex as an energy transition in the era of climate change, it is necessary to examine it from an interdisciplinary and multifaceted perspective. In order to achieve this, my theoretical argument in this thesis has been developed step by step.

Firstly, I presented analytic eclecticism as an approach that encourages the construction of theories or narratives that generate ‘pragmatic engagement’ (Sil and Katzenstein 2010, 22). Figure 2 explained the basic division between structure and agency, and material and ideational factors, and how eclecticism straddles all of these elements. Secondly, the notions of structure, agency, and framing were elaborated. Now the first step in concluding my theoretical argument is to bring these concepts together, as illustrated in Figure 5, using energy transition as an example of eclecticism.

The rules and resources that make up the structure are divided here between material and ideational factors so that resources are located under the structure-material section together with technology and infrastructure, and the rules which, according to Grin et al. (2010), refer to frames and norms are placed in the structure-ideational sector. Resources in the case of energy comprise allocative types such as oil and natural gas (Aalto et al., 2013) or, in the context of the case studied, solar irradiation. Structuration occurs in the practices (processes) by which actors actualize the resources available in the social and material dimensions of structure by creating and following rules (Giddens 1984, 33). In the agency-material section, agency is needed in order to mobilize actors towards a change or a technological development from the resources available, in this case producing solar panels that capture solar irradiation. The structure-ideational section contains rules comprising the patterns that people may follow socially (Flietstein and McAdam, 2011, 27), such as laws, norms, interests and worldviews, but also frames, consistent with Giddens (1984). As framing is also what actors do, it has been placed under the agency-ideational section, but also because in order to influence other people one needs to advocate the frames, in this case persuade others to believe in certain frames. Interests are placed in both the structure-ideational section and in the agency-ideational section because interests may make people act in a certain way, for instance in relation to vested interests. The energy transition illustrates eclecticism in this Figure in that it combines but is also comprised of all four elements.
In the second step towards developing the conceptual framework in this thesis, the concepts of long waves and creative destruction have been applied to lay the evolutionary foundations and to explain the rigidities of the societies, structural change and the problems that occur with a structural change, such as resistance from the parts that hold on to the status quo. In order to delve deeper when explaining the ongoing energy transition, I have turned to transition studies from which I have adapted the three analytical concepts in the multi-level perspective (MLP) for the conceptual framework of this thesis. First, in this thesis, Kondratiev waves – currently the sixth wave – form part of the landscape. The regime is the present system: the incumbents, industry and politicians that together hold the status quo. The niche in this case comprises the challengers: the green-transition advocacy coalition consisting of representatives of the new hydropower and bioenergy, heat pump and geothermal business, and the wind and solar energy industry that are pushing for change. The relationship between the MLP model and Kondratiev waves illustrating the ongoing energy transition in Finland is shown in Figure 6.

Transitions entail various social groups with different interests, namely actors. Therefore, agency has been investigated through two frameworks: the strategic action field, to understand how actors in the field interact with each other, and the advocacy coalition framework, which explains the formation of coalitions and how important core beliefs are. What actors do and say is also paramount. How the actors see the current energy system and the alternatives to it, what they say about it, how they interpret it, and which frames they use, is an essential part of understanding where we stand and what we can do about the problem. The solution to the problem does not just entail providing facts
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Figure 6. The relationship between the MLP model and Kondratiev waves, illustrating the ongoing energy transition in Finland. Adapted from Geels (2004) and Wilenius and Kurki (2012, 27).

and more information because there are different kinds of perceptions of reality. That is why this thesis also examines *framing*.

To be able to understand the future, it is equally important to look back into the past, which is why an introduction to past energy transitions has been included in this thesis. Moreover, future aspects have also been taken into consideration in terms of examining possible alternatives, whether they can be achieved, and how.

All of these elements have been introduced, and hence the conceptual framework developed in this thesis is now encompassed within a holistic approach illustrated in Figure 7 and explained in the section that follows.

The Kondratiev waves form a part of the evolving landscape, which is in a constant state of change. At present, the sixth wave is taking place. It is affected by climate change, which can also be seen as an ‘external shock’ to the system, as in the advocacy coalition framework, but belonging to the landscape. The structure is defined according to Giddens (1984) as rules and resources, and both constraints and enablers. The regime is part of the structure section, but can also be seen as belonging to the actors section, as in challengers and incumbents. The niche consists of challengers. Within the actors section, all collective actors are made up of bigger and smaller strategic action fields, and actors can also form advocacy coalitions. The big strategic action field in the Figure is where the action takes place: the attempt to achieve a major shift in the regime. The big strategic action field combines structure and agency and is
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![Diagram of theoretical frameworks]

**Figure 7.** Holistic conceptual framework of the thesis, combining Kondratiev waves, Schumpeter’s creative destruction, the structuration approach, MLP, strategic action field theory, the advocacy coalition framework and socio-cultural framing, applied from the perspective of analytical eclecticism.

affected by the different interests, frames and worldviews that the actors have. The output of the whole process, in the case of energy transition, is a shift in energy policy and it also entails creative destruction. Path dependency towards the existing structures has an effect on the output.

To recap, the overall purpose of this thesis is to adopt a more holistic approach to transitions than is normally provided in transition studies, or other disciplines. I argue that complex societal phenomena that have real-world significance, such as transitions, benefit from being studied from an interdisciplinary approach using multiple methods. The thesis interweaves several strands of theories and frameworks from an analytic eclecticism approach. The thesis examines transitions from the perspective of the classic social science triangle of structure, agency, and framing, distilling these aspects into one study. It also combines past, present and future tense frameworks.
3. Extant literature: Key empirical findings

Before proceeding to the empirical analysis and findings of the thesis, an overview of what has already been discovered in the existing literature is in order. The key empirical findings are presented according to the triangle of structure, agency and framing. First, the barriers to and drivers of solar PV and renewable energy are identified; second, the role of incumbents and challengers is presented; and third, the way in which renewable energy has been framed in the literature is introduced.

3.1 Structure: Barriers to and drivers of solar PV and renewable energy

Barriers are “man-made factors or attributes of factors that operate in between actual and potential RE [renewable energy] development or use” (Verbruggen et al., 2010). More specifically, barriers to a larger deployment of solar PV and renewable electricity in general have been examined in studies worldwide, and are very much a global issue. Only some country- or technology-specific differences appear in the literature. However, the barriers are dynamically evolving as time passes, so the following findings may have changed to date.

3.1.1 Barriers to renewable energy in general

Painuly (2001) has developed a framework for identifying the barriers to renewable energy penetration and has grouped major barriers into seven categories. The first category concerns market failure/imperfection. These barriers include, for instance, a highly controlled energy sector that may lead to a lack of investments in renewables, and a lack of information and awareness that increases uncertainty, and hence costs. The second category comprises market distortions that include favouritism towards conventional energy production, which affects the competitiveness of renewables, and a disregard for externalities, which makes the cost of conventional energy less than it should be. The third category concerns economic and financial barriers, which involve economic inviability, meaning that a cost reduction in renewables is needed, and pointing to a clash of interests. The fourth category is institutional. This includes barriers such as a lack of research and development (R&D) culture, which may make the adaptation of technology difficult, and a lack of professional institutions, which means that producers’ problems and views on barriers cannot reach the
policymakers effectively. The fifth category, labelled technical, consists of a lack of skilled personnel/training facilities that can pose a constraint for producers. The sixth category comprises social, cultural and behavioural barriers. These include a lack of consumer acceptance of the product, which has the effect of shrinking the market size. The seventh category consists of other barriers, such as uncertain governmental policies, environmental impediments, a high-risk perception of renewables, and a lack of infrastructure.

Sovacool (2009) demonstrates that the impediments to renewable power in the United States are socio-technical. He further identifies three sets of interconnected and socio-technical barriers: economic, political, and behavioural. Economic barriers include financial impediments, market barriers, and market failures. Political barriers consist of regulatory challenges that include weak and inconsistent political incentives, varying standards, competition among utilities, and underfunding of research and development. Behavioural barriers include public apathy and misunderstanding, psychological resistance, and consumers’ perceptions about electricity.

When it comes to economic impediments, Sovacool (2009) finds that the existing system prices electricity in a manner that tends to favour conventional options. This makes utilities reject renewables and continue to rely on generators that guarantee them future profits. Additionally, the renewables’ relatively higher installed capital cost makes them too expensive for most residential customers, and too risky for most utilities and businesses. Moreover, the return set for investments cannot be met; they are substantially longer than most permit. Most small and large businesses resist investing in and using renewable power sources because they are not interoperable with the growth of the electric utility system. Lastly, renewable power sources directly threaten the market share of utilities, energy companies, and other power operators.

Political impediments play a significant role as well. Intermittent political support for renewable energy systems caused the American renewable market to collapse. There was public disinterest and contempt for renewable power, which enabled utilities and interest groups to fight against its adoption. The political environment in the 1980s, for example, made it difficult for companies to build and operate renewable power plants (ibid.).

Social and cultural factors are included under behavioural impediments. There is a lack of public interest in the electricity sector, which allows utilities and system operators to maintain their control and extract stable profits. The transition from an energy system based on wood, coal and oil inside homes, which prioritized human labour and direct interaction, to a more convenient and indirect system makes renewables more likely to be opposed. Power stations being constructed at a distance from most cities and neighbourhoods, and duly out of sight, contributes to public apathy and misunderstanding. This removal
of power plants is coupled with a strong belief that Americans are entitled to abundant energy sources, which makes the case problematic. People in the US also oppose renewable energy because of existing social conflicts that have little to do with electricity (ibid.).

In Finland, Ruggiero et al. (2015) have identified barriers to distributed energy generation, and suggest that there has been a general lack of understanding about the factors that will promote its growth, and the actual barriers that need to be overcome or removed. Half of the interviewees for their study were concerned about the possible impact of distributed power on the electrical grid, and other respondents, who were not from energy companies, believed that this type of concern was just a way to resist the diffusion of distributed electricity generation. Other technological barriers included the lack of standard procedures for grid connection, and issues with metering. Moreover, the low price of electricity was noted by most of the interviewees, and the low buy-back rates. When it came to the main administrative barriers, taxation and the variability and complexity of building permit procedures were identified.

Varho et al. (2016) also assessed obstacles to the growth in distributed renewable energy in Finland through a Delphi panel of 17 interviewees and 9 questionnaire respondents. Among the top five barriers to capacity growth were the underdevelopment of business concepts, difficulty in finding trustworthy information on renewable energy systems, insufficient availability of professional sales and installation services, difficulty or the lack of profitability in selling small amounts of electricity, and the price of production systems.

In a recent study, Hyysalo et al. (2017) identified the following barriers to energy transition in Finland: 1) lack of visionarity in strategies, 2) vested interests, 3) strategies are difficult to understand, and should be popularized for the public debate, and 4) tension between global change and domestic politics. They also identified drivers of energy transition in Finland, with the systemic character of energy transition being emphasized in the most significant drivers, namely: 1) regulation aimed at mitigating climate change develops and becomes stricter, 2) the role of cities is increasing in developing solutions for living and traffic, 3) cost competitiveness of new low carbon energy technologies is improving, 4) digitalization of energy systems, 5) new services and business models, and 6) citizens’ increasingly active role is starting to make itself felt.

### 3.1.2 Barriers to and drivers of solar PV

Margolis and Zuboy (2006) carried out a broad literature search to determine nontechnical barriers to solar energy use, including market, institutional and political barriers. More recently, Karakaya and Srivannawit (2015) conducted a systematic literature review based on the Web of Science database to find the
current barriers hindering the diffusion of PV systems. Their review covers 28 countries from four continents: Africa, Asia, Europe, and America. They analyzed the barriers in four dimensions: sociotechnical, management, economic, and policy. These dimensions have been found to be common to both low- and high-income economies, but otherwise the barriers should be evaluated in regard to a specific country or type of grid connection. The adoption of PV systems is a challenging process, and for a wide adoption, Karakaya and Sriwannawit (2015, 65) suggest that “the involvement of all stakeholders – adopters, local communities, firms, international organizations, financial institutions, and government – is still crucial. Without proper collaboration, effective marketing, and dedicated government support, the barriers to adoption will not be easily overcome. However, technology diffusion is context specific and so is the adoption of PV systems. Therefore, all stakeholders should understand the local conditions of the particular context in order to overcome the barriers”.

Based on extant literature, Timilsina et al. (2012) identified a range of barriers to solar energy that can be classified as technical, economic and institutional. The main technical barriers in their study include batteries and unresolved problems of storage. The economic barriers mainly consist of system costs. Cost comparisons are made with established conventional technologies that exploit economies of scale, have uncounted externality costs, receive public subsidies, and have accumulated industry experience. Institutional barriers include the lack of a skilled workforce. Path dependence and lock-in have also been identified as barriers.

Del Río and Unruh (2007) have identified barriers to and drivers of PV energy in Spain. The barriers in Spain at the time were high initial costs, lack of an accurate legal framework and insufficient support, administrative barriers, financial barriers, companies in the conventional electricity sector, training and skills of equipment installers, lack of information, connection to the grid and integration into buildings.

Barriers to solar PV deployment in Sweden have been studied by Palm (2017). The most significant barrier in this context was found to be the poor economic profitability of investing in a PV system. This was due to the fact that the Swedish PV market had been created and upheld by subsidies and electricity prices have generally been low in Sweden when compared internationally. Some barriers related to tax rules were also found (ibid., 42). Cultural and behavioural aspects were likewise identified, such as savings rates, homeowner mobility, accustomedness to third-party ownership (TPO) business models, and priorities regarding long-term versus immediate cost savings (ibid., 58).

On the other hand, the drivers of solar PV are mostly technological improvements, cost reductions and government policies. When it comes to the first, solar energy has experienced a major technological shift from small-scale
photovoltaic installations to large-scale PV systems that feed into electricity grids (Timilsina et al., 2012). Secondly, the costs have dropped over the last 30 years and are expected to continue to drop even faster than anticipated (SolarPower Europe, 2016). Thirdly, solar energy benefits from fiscal and regulatory incentives that have led to a rapid expansion of the solar energy market (Timilsina et al., 2012). While the declining support policy for PV is reducing the European market and stalling Europe in a transition phase, the implementation of new feed-in tariff policies has led to an increase in other countries such as China, which has become the leading global PV market with the largest share of total installed capacity (SolarPower Europe, 2016).

### 3.2 Agency: Incumbents and challengers

The role of agency in the energy field has been studied in Germany in particular, for example by Schmid et al. (2016), who have analyzed different actors in the electricity system in Germany. They note that the German energy transition, the *Energiewende*, constitutes a power struggle between a large variety of actors that differ with respect to their motives and underlying worldviews. In the German energy transition, civil society actors in general have played a significant role. The transition has been characterized by citizens’ mass protests against nuclear power from the mid-1970s, heightening public awareness and leading to bitter confrontations and demands that the government should invest in energy efficiency and renewable energy. Renewables in Germany have faced hostile incumbent utilities that were opposed to all small and decentralized forms of generation until the end of the 1980s and beyond. At the same time, a range of advocacy coalitions for wind and solar power were set up (Jacobsson and Lauber, 2006).

Kungl (2015) has analyzed German incumbents’ role in the *Energiewende* and found that they have shifted their attitude from ignoring the energy transition to reluctantly adapting to it. In order to study civil society’s role in the *Energiewende*, Fuchs et al. (2012) have studied how grassroots innovations (GI) have become crucial actors in the local governance of energy systems, while Blanchet (2015) has explored how civil society is organized and mobilized to participate in the local energy policy process in Berlin and the kind of impact it is having on the governance of local energy systems. The study finds that GIs can serve as political opposition by pushing local authorities to actively shape future energy systems and by forcing them to put energy-related issues on the political agenda. Hess (2013) has studied the transition to distributed solar energy in the US and notes that the incumbent organizations mobilize political resources to stop regulatory and policy efforts from favouring the challenger, while the
challenger may respond by developing coalitions with the countervailing power. These studies have applied the SAF framework.

Markard et al. (2016a) have studied actors and coalitions in Swiss energy policymaking, using the advocacy coalition framework. They note two coalitions: incumbent actors in the energy sector and a pro-ecology coalition of left-wing parties and environmentalists, but also new industry actors in the fields of clean-tech, energy efficiency, energy services, solar and wind. Advocacy coalitions in Switzerland have remained rather stable despite the Fukushima nuclear accident, but the heterogeneity of beliefs has increased. In 2013, a majority of actors supported an energy transition, indicating a major policy change, which occurred on 21 May 2017 when Switzerland voted to phase out nuclear power in a referendum (BBC, 2017). In Germany, after the Chernobyl accident in 1986, public opinion changed dramatically and was reinforced again by the Fukushima accident in 2011, leading to pressure in favour of renewables and finally being able to create a new alternative energy paradigm (Hakkarainen, 2013; Jacobsson and Lauber, 2006).

Recently in Finland, Heiskanen et al. (2018) applied SAF to examine how two leading Finnish energy incumbents have responded to the emergence of sustainable energy. The researchers found that the original justification for the provision of reliable and affordable energy by existing municipal energy companies has prevailed over the decades, and serves as a field-level rule that prevents challengers from promoting renewable and distributed energy sources. Furthermore, they found that internal challengers exist within the city administration and work to change the rules of the game by setting up experimental spaces where SAF rules are temporarily suspended.

Apajalahti (2018) has also explored the activities and strategies of large energy companies in Finland in her recent doctoral dissertation. Her findings show that a sustainability transition of the dominant energy field is not easy due to the rigidities caused by past commitments to technologies, infrastructures, organizational forms and resources, but also that there are ways to break free from these rigidities, such as being an early mover (Apajalahti, 2018, 96).

### 3.3 Framing renewable energy

The extant literature on framing renewable energy has mainly been studied from the narrative means of advocacy point of view. Protagonist narratives include themes such as technological progress, energy security, independence, jobs creation and a better society (e.g. Curran, 2012; Eames et al., 2006; Laird, 2003). The advocacy coalitions tend to present the novel technology as a natural part of future energy production (Barry et al., 2008) and claim that renewables have ample technical potential (Sovacool et al., 2016, 128). This has made it
more attractive and legitimate in the societal context (Eames et al., 2006). Advocates of solar energy have drawn on themes related to societal change and empowerment in particular, as well as overall business potential (e.g. Nissilä et al., 2014; Rosenbloom et al., 2016; Smith et al., 2014; Verhees et al., 2013).

Common themes give rise to competing storylines. One of the themes most favoured by antagonists is the perspective that renewables are not affordable on a large scale. In other words, they claim that renewables are intermittent, inequitably distributed, have social and environmental barriers that limit diffusion (for instance NIMBY, ‘not-in-my-backyard’ opposition to having solar or wind power in one’s vicinity), and that renewables are not cost-competitive (Sovacool et al., 2016, 120–125). The protagonists respond to these arguments with four key counter-arguments: 1) the cost advantage of fossil fuel technologies is artificial, meaning that they have received levels of government support, 2) sufficient renewable energy potential exists to meet demand, 3) renewables will become cost-competitive with conventional energy technologies, and 4) renewables have great potential for technological improvement (ibid., 126–131).

Rosenbloom et al. (2016) depict “multi-dimensional discursive interactions” in the emergence of solar energy and identify competing storylines in the field with respect to four aspects: economic development and innovation, operation of the electricity system, response to climate change mitigation, and a new paradigm for energy production. For instance, when protagonists frame solar as a contributor to the local economy through jobs, investments and growing markets, the antagonists frame it as a drain on the economy through increased energy prices and its foreign focus both on job creation and investments. As another example, arguments for solar being a complementary, efficient element in the energy system are countered with arguments about its inefficiency, small yield and fluctuation. In addition to such directly competing storylines, both Rosenbloom et al. (2016) and Curran (2012) draw attention to silent framings of resistance, which refer to implicit meanings delivered as a result of other framing activities or silent disregard. Curran (2012) has noted that they are used to divert attention to issues that portray renewables as an unrealistic or unreliable option and hence create an “uncertainty and knowledge gap” while not directly disputing their value altogether. Furthermore, antagonists tend to frame the protagonists of renewables as unreliable enthusiasts, duly feeding mistrust towards the facts and promises presented by them (Barry et al., 2008).

Cultural theory has also been used when attempting to understand how individuals’ worldviews can inform opinions and behaviour in relation to renewable energy. West et al. (2010) noted egalitarian and individualist discourses as the most diametrically opposed to renewable energy, while hierarchists were placed in a relative middle ground. These results can be used in policymaking and in tailoring incentives and measures to these
audiences accordingly, while at the same time bearing in mind that there are inconsistencies in people’s evaluations and their capacity to shift worldviews according to context and issue (ibid.).

3.4 Summary

In this chapter, I have reviewed existing studies on barriers to and drivers of renewable energy, and solar PV in particular, the question of agency in energy transitions, and research on framing renewable energy.

According to the previous literature, most of the barriers and drivers seem to be similar from country to country with only some country- or technology-specific differences. This is an interesting starting point in the case of Finland when it comes to finding out if there are any country- or technology-specific differences in relation to barriers to a larger deployment of solar PV. Further, agency in transitions has been a neglected topic and extant studies are either concentrated on incumbents or challengers, but sometimes also on both, including studies on advocacy coalitions. Such studies, especially on the role of civil society, have rarely been conducted for Finland, so in order to understand the changing field of energy policy, questions need to be raised about actors, their beliefs and positions, the kind of coalitions they form, as well as the frames that are used in energy debates. Previous framing studies have mainly focused on the narrative means of advocacy point of view and, as the examples show, the literature is by no means indifferent to how issues are being framed. In most cases the same arguments can even be used by protagonist and antagonist alike, and the framing that wins usually hinges on worldviews. In effect, it is not how things are in reality, but rather about the way they look. Hence, relying on the existing literature, I find that in addition to studying the structure and the structural barriers and drivers, as well as the actors and their positions in transitions, the importance of narratives and framing could also be emphasized in transition research. Bearing this in mind, the following chapter explains the methodological approaches adopted in this thesis.
4. Research approach and methods

This thesis seeks to understand the ongoing energy transition in Finland. It argues that the subject matter cannot be confined to just one discipline, and therefore several theoretical approaches have been adopted in an attempt to address the complex phenomenon in question holistically. Hence, the thesis is an interdisciplinary study that applies theories and methods from various disciplines: management studies, social science, policy science, futures studies, the theory of fields, and transition studies. To this end, energy transition in Finland is not examined solely from the perspective of multiple actors, but also in terms of what the actors practise or say about the transition. The analysis also draws on history and looks to the future. The perspective is therefore multi-temporal, multi-level, multi-domain, multi-actor and multi-framing. The transition as such is also examined from the bottom-up perspective, and not just top-down.

4.1 Case study as a research design

The thesis is grounded in qualitative research methods aimed at gaining an in-depth understanding of the studied phenomenon, and a desire to explain events by using existing or emerging concepts (Yin, 2011, 6–8). It applies case study as the research method in order to focus on a “case” and to retain a holistic and real-world perspective (Yin, 2014, 4). Case studies can be exploratory, descriptive or explanatory in nature (Yin, 1987, 15–16). The case study methodology is particularly appropriate for ‘how’ and ‘why’ types of research questions because these questions are more explanatory (Yin, 2014, 10). The case study relies on many of the same techniques as a history, but it adds direct observation and systematic interviewing to the repertoire (Yin, 1987, 19). Case studies can involve either single or multiple cases, and numerous levels of analysis (Yin, 2014, 18–19).

Notwithstanding the advantages, case studies have also been criticized for a lack of rigour, confusion with teaching cases, for providing little basis for scientific generalization, and for their unmanageable level of effort and unclear comparative advantage in contrast to other research methods (ibid., 19–21). However, the case study approach has become a common method in many scientific disciplines (ibid., 4). As Dubois and Gadde (2002) formulate it: “...what was previously regarded as a problem was now recognized as an opportunity. Learning from a particular case (conditioned by the environmental context)
should be considered a strength rather than a weakness. The interaction between a phenomenon and its context is best understood through in-depth case studies”.

The case study in this thesis is solar PV deployment in Finland. Solar energy is a major trend globally, and although the share of solar PV in Finland is relatively small, it is still an interesting case that needs to be placed on the research agenda. The thesis includes four articles, all of which contribute to the theme. Article A draws on policy analysis. It comprises a case study of supportive solar energy policy instruments in the EU countries compared with an analysis of Finland’s official energy strategies, combined with empirical material consisting of semi-structured energy interviews with different actors in the solar energy sector in Finland.

Article B builds primarily on futures studies, applying an advanced energy system analysis computer model, the EnergyPLAN simulation. This case study is an explorative scenario and a backcasting study of an energy system for Finland that would be generated wholly by renewables by 2050, and the role of solar PV and energy storage solutions in this system. Article B revisits the results of Article A and reinvestigates barriers to the implementation of high shares of solar PV in Finland, expanding on the results by making use of new data gathered by means of a structured survey conducted for Article C. Article B also describes the drivers of solar PV and outlines possible solutions for overcoming the barriers identified in order to be able to achieve the presented scenario.

Article C builds on transition studies, specifically the question of agency in transitions, and policy analysis. The case study examines the ongoing energy transition in Finland from the bottom-up perspective by studying the formation of a green-transition advocacy coalition in Finland. It also identifies coalition actors’ core beliefs by applying an advocacy coalition framework, and analyzes the coalition’s impact on policy change in Finland. A detailed structured survey with open-ended questions was conducted for this case study, and other material included semi-structured interviews and documents from the official websites of the studied actors.

Article D draws on literature on socio-cultural framing and field frames. The case study covers an eight-year period during which the changes occurring in the field framing activities of solar energy in Finland have been examined. A process perspective focusing on multiple actors was duly adopted. The emerging field of solar energy was followed in real time, main field configuring events were observed, key actors were interviewed, and extensive document and media analysis was conducted for the case study.
4.2 Research process and data collection

The thesis is based on four separate research papers of which three have been published in international peer-reviewed journals, and one of which is an unpublished manuscript. The papers draw on multiple data sources but some are based on the same data. The studied time period as a whole is between 2011 and 2018, with some data ranging from 2008. The main dataset consists of interviews that were conducted between 2013 and 2016. A summary of the data collection can be found in Table 3.

The actual research work commenced before embarking on my PhD studies. In 2009, I attended a year-long course of 30 ECTS credits called Master of Environmental Management and Responsible Business (MEMA) at Helsinki University of Technology, Lahti Center, which subsequently became part of Aalto University (Aalto Pro, Professional Development). I specialized in climate change there, thanks in part to Finnish Business & Society, which provided me with a research topic for my final dissertation during the course on climate change as a business opportunity (Haukkala, T., 2009). In 2010, I was invited to become involved in the work of the Committee of the Future at the Parliament of Finland by writing and editing a background report to be used as a response to the Government’s climate and energy policy future report. During 2010, I attended several committee meetings and served as an expert there. In the report (Haukkala, T., 2011), I briefly mentioned the possibilities of deploying solar energy which was, at the time, regarded as “utopian” by one industry representative. Hence, when I began my PhD studies in autumn 2011 with solar energy as my topic, the idea was often still greeted with amusement. Indeed, solar energy in Finland was regarded as a ridiculous idea.

The event observations for the doctoral dissertation started in earnest in December 2011 when I attended a solar energy summit organized in Helsinki with one of my co-authors on Article D. This was the first event of its kind to attract over 200 participants in Finlandia Hall. Since then, I have – both alone and with the other co-authors on that specific article – attended all kinds of field-forming events, and taken notes. Apart from the observer role, I have also had a participant role in some of these events. For instance, in October 2012, I was selected to be a member of the Finnish Innovation Fund Sitra Sustainable Economy Forum. This was a group of about 30 experts that were involved in either social, economic and/or environmental fields and who gathered together to discuss the challenges of transitioning to a sustainable economy in Finland, and to lay the foundations for a new sustainable economy political management course to be held by Sitra. We met frequently during a six-month timeframe and produced a report on the themes (Savaspuro and Jousilahti, 2013).
### Table 3. Summary of data collection

<table>
<thead>
<tr>
<th>Article</th>
<th>Observations of events</th>
<th>No. of semi-structured interviews</th>
<th>No. of structured surveys</th>
<th>Written material</th>
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Around the same time, interest in solar energy started to rise to a new level. In October 2012, I gave an interview about solar energy for Satmatic, a manufacturer of electrical and automation technology in Finland. After the Sitra Sustainable Economy Forum, I continued my public presentations about solar energy at different venues. These included research seminars, for instance at the Finland Futures Research Centre in February 2013, and a conference in Copenhagen in June 2013. That same month, I was also invited to speak about the current solar energy situation in Finland by the Committee of the Future at the Parliament of Finland. I also collaborated with the Finland Futures Research Centre and contributed to a report on solar energy in June 2013 for Turku Energia, which is the leading power supplier in southwestern Finland. In August 2013 I spoke about the future of solar energy in Finland as a keynote speaker at the Mynämäki Municipality Parliament, and held a presentation for a southeastern company about solar energy as part of my senior analyst work period for Oxford Research Finland. In addition, I wrote several newspaper articles and blog posts about the topic during 2012–2014 (e.g. Haukkala, T. and Kangas, 2014). While acting as a public debater, these events also enabled me to share thoughts with the key actors in the field and to gather tacit knowledge about the key actors’ perceptions of the field development.

From February to May 2013, I started the first round of interviews for Article A. The semi-structured interviews included many questions about the whole solar energy field both globally and nationally as I was trying to grasp the big picture and to gather material for other forthcoming articles at the same time. This proved to be a useful approach as the same material was indeed subsequently used for two other articles. The more people I interviewed, the more detailed the questions became as I noticed that many interviewees were paying attention to the same issues and I was trying to get to the bottom of these relevant issues. However, the structure of the questions (see Appendix 1) remained the same as I wanted to ask all of the interviewees the same key questions. The first round of interviews was conducted with 18 people, including representatives from all of the key actors in the field of solar energy. There were three politicians (members of parliament from different parties), three environmental non-governmental organization representatives, two of which were from the same organization, five representatives from small solar energy firms, two representatives of a solar energy association, three representatives from the administration, and three representatives of incumbent energy companies and the business community. All of the interviews were conducted face-to-face, apart from one that was carried out by email due to illness.

For Article A, I also analyzed the national climate and energy strategies in order to ascertain what they had to say about solar energy. In 2015, I went through all the material about solar energy on the websites of the two
environmental non-governmental organizations (NGO), Greenpeace and WWF Finland, the energy transition campaign Energy Renovation, a renewable energy association called the Finnish Clean Energy Association (FCEA), and all the political parties in Finland. Some of the parties did not post all of the content on their websites and therefore I contacted them by email and asked them to send me material that dealt with solar energy. This included party programmes, election campaign programmes, reports, blog posts, news articles, and other website material. The time period studied was from 2008 to 2015. This material was originally used for Article D, but part of it was subsequently used for Article C as well. I had some inside access to the Energy Renovation campaign, as I was added to their campaign group as an expert in the formation phase, although I did not actively participate as such but observed conversations and gained access to material in closed email and Facebook groups.

The second round of interviews was conducted in 2015 and 2016, and the findings were used for Article C. These interviews were more clearly focused on the formation of the advocacy coalition and on the ongoing energy transition. I also engaged in more detail-focused discussions afterwards with some representatives in order to check that the details provided were correct. I used the interviews from 2013 with two NGO representatives, one of whom I conducted a detail-focused check-up interview with later in 2016. Three representatives of the Finnish Clean Energy Association were interviewed, and I had detail-focused discussions with two of them during the process. I also conducted interviews with two founding members of the Energy Renovation campaign, one face-to-face, another by Skype. Two representatives of the New Energy Policy (NEP) project were also interviewed.

I conducted a structured survey for Article C in May 2015, but the material was also used for Article B. The survey responses were gathered from volunteer respondents from the Energy Renovation campaign and the Finnish Clean Energy Association. These were approached through their mailing lists where I asked volunteers to complete the structured survey by email (see Appendix 2).

From 2015 onwards, I focused increasingly on my research but I was still requested to write an article about solar energy in Finland based on Article A for an international PV magazine’s opinion and analysis section (Haukkala, T., 2015). I also gave an interview on solar energy in Finland for the United Nations Regional Information Centre for Western Europe (UNRIC Nordic, 2016) and participated in a panel discussion called Energy Game in 2016. These requests showed that there was international interest in the solar energy potential in high latitude countries as well.

All in all, I have taken on several roles during the PhD process, including the traditional researcher’s role as an observant, but also the observant-participant role and the role of an active public debater. Due to my acquired contacts, I have
been able to interview the most relevant key players in the field, and thanks to the access gained to inside material, the data collection has become richer than it might otherwise have been.

### 4.3 Data analysis

Data analysis refers to making sense of, or interpreting the data (Miles and Huberman, 1984). Case study data is examined closely in order to find constructs, themes, and patterns that can be used to describe and explain the phenomenon in question (Miles and Huberman, 1994). Data analysis consists of examining, categorizing, tabulating or otherwise recombining the evidence (Yin, 1987, 99).

The empirical material in this thesis has been categorized and analyzed using qualitative content analysis following Krippendorff (2004; 2012), according to whom (2004, 18), content analysis is “a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use”.

The analysis as well as the data collection has adhered to qualitative inquiry, drawing particularly on principles of systematic combining, which involves an iterative process between data analysis and the theoretical framework (Dubois and Gadde, 2002). The process of systematic combining has entailed finding correspondence between theory and reality, and directing and redirecting the study. Process research, which includes systematically constructing descriptions of the development processes, has also been applied (e.g. Langley et al., 2013).

First, I familiarized myself with the material. The documents, structured survey responses and observation field notes were scrutinized, and the interviews transcribed. The material was then coded. Coding refers to the identification of topics, issues, similarities, and differences that are revealed through the interviewees’ narratives and interpreted by the researcher (Austin and Sutton, 2015). Instead of using qualitative research software, the coding for this thesis was done by hand on the printed transcripts, by making notes in the margins and highlighting sections of the text. This has also been regarded as a suitable method by Austin and Sutton (ibid.).

Each respondent was allocated a code number to preserve their anonymity. After the coding process, I categorized the material according to different themes. Theming refers to the drawing together of codes from one or more of the transcripts to present the findings in a coherent and meaningful way (ibid.). As all qualitative research deals with interpretation in one form or another (Bengtsson, 2016), and as the data for the different articles has been collected from several different sources, and there have been a number of researchers involved in the process, the observations, document analysis and interviews
used for the co-authored articles have also been discussed and compared to ensure that the data has been interpreted in the same way.

The quality of a research design can be judged according to certain logical tests. Lincoln and Guba (1985) suggest that there are four criteria of trustworthiness: credibility, transferability, dependability, and confirmability. In Yin (2009, 40), these concepts as defined by the US Government Accountability Office include trustworthiness, credibility, confirmability, and data dependability. However, there are four tests that have commonly been applied to establish the quality of any empirical social research and these include construct validity, internal validity, external validity, and reliability (ibid.).

I have ensured the credibility, confirmability, and construct validity of the research through data triangulation. This has been done by using multiple sources and combining different data collection methods (interviews, observations, structured surveys, content analysis), and by comparing them and discussing them with other co-authors. My work has also been peer-reviewed. To ensure dependability, the interviews were recorded and transcribed and the structured surveys were administered by email, whereupon the respondents wrote their own answers to the open-ended questions. These were also printed. The development of a case study database has also ensured the reliability of the thesis. External validity or transferability has posed a major barrier when undertaking the case studies, and is also the most difficult part of case studies focusing solely on one country. Generalizations are not easy to make, but the findings related to the deployment of solar PV can under certain conditions be transferable to other high latitude countries.
5. Key findings and contribution of the articles

5.1 Article A

Article A is a single-author article entitled “Does the sun shine in the High North? Vested interests as a barrier to solar energy deployment in Finland”, which has been published in *Energy Research & Social Science* (2015, 6: 50–58).

5.1.1 Research focus

The motivation for this study was to shed light on the obstacles that solar energy was facing in Finland and to find the means to overcome them. Finland is one of the few countries in the EU that has taken hardly any direct subsidies into use for solar energy. Yet Finland’s irradiation is almost the same as that in Northern Germany, which has adopted solar energy to a much larger extent, also due to its successful support policy. The research questions addressed in the article were: Why does Finland have practically no support policy for solar energy? What kind of policy mechanisms, if any, would be needed to promote solar energy?

The article was based on an analysis of official Finnish government documents on climate and energy strategy from the years 2008 and 2013, coupled with semi-structured interviews conducted with key actors in the solar energy field in Finland in spring 2013. A comparative overview of the supportive solar PV policy instruments in the EU countries was provided based on the extant literature.

5.1.2 Findings

The issue proved to be more multifaceted than anticipated. The general attitudes towards solar energy that seemed to pose the main obstacles and challenges in Finland were somewhat surprising. The question was not really about technical issues but centred instead on the common belief that the sun does not shine in Finland in a way that would warrant the production of energy with PV or solar thermal. Moreover, the political will was questioned and this had to do with the lack of a public support policy. To my surprise, there appeared to be differing opinions about whether or not support was needed, and the kind of support that would best serve the objectives. The support measures envisaged...
Depended on the vested interests of the actors involved. In the end, some kind of support seemed to be required but a specific type of support was of lesser significance. Many respondents also considered that solar energy was bound to succeed in the domestic markets – regardless of the support policy.

What is more, the current energy regime based on nuclear power dominance was seen to influence attitudes towards solar energy. Clear resistance to change and to new ways of doing things emerged. The contradictory position of framing solar energy in particular as a substitute for nuclear energy has hindered the promotion of renewables. Solar energy cannot provide a single, overarching solution but rather a complementary source of energy in Finland, so framing solar energy as a definitive solution has either been unfortunate or intentional, depending on the aim.

The same occurred in Sweden: renewables were proposed as a substitute for nuclear power, which led to fierce resistance towards any policy measure benefiting renewables. In Germany, the resistance from utilities emerged in the first half of the 1990s when wind turbines had spread rapidly. That was, however, met by an increasingly powerful advocacy coalition in favour of wind energy (Jacobsson and Bergek, 2004).

Resistance from utilities or industry could be sensed in the Finnish debate. It usually surfaced in the context of path dependence and lock-in, and in the undermining of renewables. These attitudes, together with vested interests, hold the current energy system together and stand in the way of structural change. If examined from the perspective of the economy, it loses its ability to change, adapt and shift the status quo if it is controlled by vested interests, and the same applies to the energy sector: a lack of structural change results in a state that is incapable of providing new industries with sufficient power or an energy infrastructure that serves their needs (Moe, 2010). It can be noted that the state needs to actively protect and promote new technologies and industries, but only at an early stage – otherwise vested interests will be allowed to grow powerful again (Moe, 2010). Creative destruction must at times be assisted, but it must also be allowed to run its course. Following that, some support for solar energy at the beginning would seem to be plausible but if a support mechanism was introduced, it should be stopped at some point before the end of the technology’s or industry’s product cycle. A change is also difficult as it is not just new technology that helps to mitigate climate change, but a change of mindset as well (Wilenius, 2017, 206).
5.1.3 Contribution

The article sought to make two main contributions. The first was to address the lacunae of an under-representation of social scientific approaches and methods, the lack of interdisciplinary approaches, and the field of energy and energy policy studies being dominated for the most part by male authors, as addressed in Sovacool (2014). The second was to continue the scholarly debate on solar energy and energy transition in the European context, using Finland as a case in point. The article also filled the research gap in terms of studies on barriers to the larger deployment of solar PV in Finland.

5.2 Article B

The second article, entitled “The role of solar photovoltaics and energy storage solutions in a 100% renewable energy system for Finland in 2050” was a co-authored paper written in collaboration with Michael Child and Christian Breyer, both from Lappeenranta University of Technology. It was published in Sustainability (2017, 9: 1358).

5.2.1 Research focus

The purpose of this article was to revisit and combine the results of previous research, Article A and the work of Child and Breyer (2016), which has been briefly described in section 2.4.1. The aim was also to join forces and to combine PV economics and energy system modelling with social sciences. As the Finnish energy system needs a new direction to mitigate climate change as well as to meet the challenges of an aging system of power generation and goals regarding national energy security, an energy system based wholly on electricity generated by renewable sources of energy was introduced in Child and Breyer (2016). However, the study did not provide a description of how such a system would work in detail, or how such high levels of renewables, especially solar PV, could be achieved. Hence, a new approach was required.

The Finnish climate presents harsh conditions for high levels of solar PV penetration due to the dark winters but, on the other hand, the country enjoys very high volumes of solar irradiation during the summer. This points to the need for appropriate storage technologies. The barriers to achieving high levels of solar PV were previously analyzed in Article A. These barriers were revisited in Article B, new data gathered with a structured survey was analyzed, and the barriers duly reinvestigated. The drivers of solar PV and possible solutions for overcoming the barriers were then identified.
5.2.2 Findings

The barriers were categorized according to technological, economic, behavioural, institutional and political issues. The most significant barriers in each category were the lack of energy storage systems, cost comparisons with the conventional energy system, general attitudes towards solar energy, and the conflicting wishes and expectations of society, constituting vested interests. The drivers of solar PV globally, on the other hand, were mostly technological improvements, cost reductions and government policies. Surprisingly, and compared for instance with barriers to and drivers of solar PV in Spain as identified by del Rio and Unruh (2007), they did not differ much from those in Finland, despite the fact that Spain has the best solar resources in Europe. Hence, solar irradiation could not be the only explanatory factor, referring to the often-heard phrase: “The sun does not shine in Finland”.

Since Article A was published, interest has grown towards solar energy among the public at large in Finland. Despite progress being made with regard to some of the existing barriers, vested interests still remain. Energy and climate policy is often a domain of conflict, and solar energy is no exception in this respect, not least due to the fact that attitudes are difficult to change. In order to achieve the prospective installed capacities of solar PV in Finland, significant changes must take place in the Finnish energy sector. Most noticeably, storage solutions and batteries will play a key role in this kind of transformation. In addition, support policy, new business models and more information were seen as being key in improving possibilities to increase the capacities of solar PV in Finland. Such an energy transition will be by no means quick or easy to achieve, but is nevertheless attainable if the currently existing barriers are overcome with new policies, regulation and understanding.

5.2.3 Contribution

A scenario depicting a 100% renewable energy system in Finland by 2050, which would also be seen as highly cost competitive, has not been considered previously, and hence the study aimed to address this shortcoming. A technically feasible and economically competitive solution for Finland based on 100% renewable energy and high shares of solar PV was demonstrated. The aim of the study was not to direct policy in one particular direction, but to suggest several options available to decision-makers. However, as such a future energy system represents a complete transformation compared to what currently exists, it would meet resistance from groups with vested interests, and other barriers that need to be overcome first in order to be achievable. Many of the suggestions in the study could be applicable in other northern latitude countries as well.
5.3 Article C

Article C is a single-author paper entitled “A struggle for change – The formation of a green-transition advocacy coalition in Finland”. The article has been published in *Environmental Innovation and Societal Transitions* (2018, 27: 146–156).

5.3.1 Research focus

This article tackled energy transition from a bottom-up perspective. The motivation for the article stemmed from the notion that current renewable energy transitions, for example in Germany, are the cause of a long-lasting active civil society movement that has set in motion a series of activities leading to changes in worldviews, and that have influenced decision-makers in making a policy shift. I was interested in studying the civil society or grassroots-level situation in Finland to examine the motivations driving an energy transition in Finland, and to assess whether similar indications were to be found towards a possible policy shift.

The article examined the formation of a renewable energy advocacy coalition, which I called “the green-transition advocacy coalition”. The studied actors comprised two non-governmental environmental organizations, Greenpeace and WWF Finland, a newly established renewable energy association called the Finnish Clean Energy Association, a project entitled the New Energy Policy project, and an energy transition campaign called the Energy Renovation campaign. The focus was on describing how this green-transition advocacy coalition formation took place in the energy policy field and on examining the core beliefs of the advocacy coalition actors by applying the advocacy coalition framework. The research questions that were addressed were: What are the coalition actors’ core beliefs? What differences are there among the core beliefs? What impacts on policy change can be identified?

The article was based on some of the same semi-structured interviews conducted for the first two articles, and written material gathered for Article D was also used. In addition, new material, such as reports, newsletters, and Facebook public and closed group posts, was gathered from the Energy renovation campaign and the New Energy Policy project, and additional detail-focused discussions were conducted with four respondents to ensure up-to-date information.
5.3.2 Findings

The findings reinforced the big picture concerning the attitudinal problems related to the energy transition and larger deployment of solar energy in Finland in particular. Finnish energy policy is considered to be highly exceptional in international comparisons. It has a diverse primary fuel supply with a major investment in nuclear power, and is relatively dependent on foreign energy supplies. Its energy-intensive industry, especially the forest industry, together with a cold climate and long distances also make it highly energy-intensive. Traditionally, the energy system has been based on firm governmental control and regulation, with the presence of large energy firms. This has made Finland reliant on a small elite of energy producers, the main regulating authority and political parties to maintain the status quo. It has been very hard for other actors to try and topple the existing regime (Ruostetsaari, 2010). However, this is what the newly established green-transition advocacy coalition has tried to achieve.

The ongoing energy transition has created a new configuration of two energy political coalitions in Finland. One is formed by the energy producers and large industrial incumbents, and the other by proponents of the green transition, including the rising industries in green energy, researchers, NGOs and citizens. Balancing between the two coalitions are the administration and the government, not quite positioning themselves in either of the coalitions. They are, however, influenced by the stakeholders.

The green-transition advocacy coalition is actively pushing for major changes in Finland. The core beliefs of a shared worldview motivated most coalition members to participate in making the world a better place. The respondents saw the transition as benefitting the future generation and enhancing overall well-being. External developments, such as climate change coupled with an economic imperative, provided the biggest impetus for green-transition actors to support the energy transition.

These aims were, however, met with resistance by vested interest groups. Nevertheless, there are indications of change in Finland as incumbent actors are getting involved in the renewable energy field, especially solar energy. This is also a sign of adaptation to the new situation, and existing firms may duly shift their positions and reorient themselves towards new technologies (Geels, 2018, 55). This has been seen in Germany and Switzerland as well, as the challengers’ continued persistence in testing the stability of the field has tended to produce shifts in worldviews, leading to a struggle between established and emerging industries (Jacobsson and Lauber, 2006; Markard et al., 2016a; Schmid et al., 2016).

The weakness of the green-transition advocacy coalition lay in the fact that divergent opinions within the coalition were likely to hinder their ability to act in a united way towards the same goal. The coalition’s differing views in relation
to nuclear power and bioeconomy created fissures in their actions. This could affect the structure of the coalition in due course.

5.3.3 Contribution

The article contributed to the transition literature by investigating the neglected topic of the role played by civil society actors and coalitions in energy transitions. The article likewise served to fill a research gap vis-à-vis such studies in the Finnish context. The article also has practical implications in a real-world context as it provides useful information about the views of grassroots actors, while the results reveal signs of possible policy shifts that may affect the structure of the regime formation.

5.4 Article D

Article D, entitled “Interactive development of field frames and actor positions during the emergence of a novel technological field: The case of solar energy” is a co-authored unpublished manuscript written in collaboration with Tea Lempiaälä, Eeva-Lotta Apajalahti and Raimo Lovio. The paper is part of the Smart Energy Transition project funded by the Strategic Research Council at the Academy of Finland. The paper was first submitted in 2017 to Research Policy and was invited to be revised and resubmitted twice, to which end a new version was submitted in November 2018. It has now been accepted for publication with minor revisions. The first version of the paper is included in this thesis, however, as that version analyzed the way in which the actors shift their positions during the process, which is relevant in terms of agency in this thesis. As this aspect is no longer covered in the latter versions of the paper, the earlier version is more suited to the aims of this thesis.

5.4.1 Research focus

This paper draws together perceptions from the emerging field of solar energy in Finland during the eight-year period that we have been observing the field. The material was collected from various stages of the field emergence process and from several different sources by four different researchers. The empirical material includes observations made during central field-forming events concerning solar energy, document analysis of the key actors involved in the field emergence process, analysis of newspaper articles, and interviews with key actors. The research question addressed in the study was: How do field frames, interactions and actor positions change over time during the field emergence process?
5.4.2 Findings

The following findings emerged when analyzing the material. First, we identified three different time periods: Inertia, Movement and Breakthrough. We then discovered three overarching master frames (Temporal distance, Geographical distance and Systemic distance), which were sustained throughout the field emergence process. Further, we discovered that the movement was related to a shift from distancing to cultural relevance in the temporal, geographical and systemic aspects.

Significant changes in the field emergence occurred during the eight-year period, with the field moving from inertia to initial breakthrough in terms of interest and business activity. Despite the sustained small share of solar energy in the Finnish energy mix, the change in the field was notable.

The framings moved from presenting solar energy through the lens of future visions versus silent disregard in the time of inertia, to accentuating urgency of action versus disruptive and unwise for large-scale energy systems in the time of movement, to finally framing the breakthrough as given versus intensifying arguments on energy security and national competitiveness.

An interesting finding concerned the way in which the actors shifted their positions, along with the framings, during the process. Most of the literature on the framing struggles of novel technologies assumes rather stable coalitions of protagonists and antagonists, but the Finnish actors were in motion during the process. The advocacy position of different actor groups in the field in Article D is formed by both their positioning in terms of how strongly they argued for or against the deployment or support of solar energy, and how their framing activities contributed to cultural resonance. This combination makes the movements particularly powerful.

The most significant movement was depicted within incumbent companies that switched their position from antagonism to protagonism during the period of movement. This was due to two different aspects: forerunner energy incumbents shifted their position, but then new incumbents from the automation and construction industries also entered the field in a protagonist position. The trade association Finnish Energy maintained its antagonist position towards solar energy supported by public policy throughout the process. On the other hand, hardly any movement was discerned on the part of politicians. Individual politicians expressed protagonist or antagonist viewpoints, but as a larger group they remained predominantly silent and dispersed.

The study provided a more dynamic image of the framing process, both in terms of the frames and the actor positions in the emerging field. At the beginning of the process, the antagonist actors resisted the novel technology by isolating it from relevant debates and using distancing tactics as a means of indirect criticism. Further in the process, the debates were more related to
the new energy system and the economic effects of the new technology. Hence, constant adjustments of arguments and actor positions are key in generating movement in the field.

5.4.3 Contribution

The contribution of the study was twofold. First, it uncovered the way in which framing efforts interact in creating cultural resonance, and how this was negotiated over time as an interactive process. The study consequently contributed to the literature on the importance of cultural resonance in framing efforts (Benford and Snow, 2000; Koopmans and Statham, 1999; Meyer and Hölleren, 2010). Second, the study complemented current understanding of advocacy coalitions in field framing processes. It also enhanced understanding of the non-linear aspects of the process by discussing the unintentional consequences of framing efforts and the changing actor positions during the process. In this vein, it also contributed to the topic of agency in transition studies.
6. Discussion and conclusions

This thesis focused on the wicked problem of low carbon energy transition in Finland. It sought to deepen understanding of economic, social, and political lock-in mechanisms, namely barriers that stand in the way of structural change in terms of energy transition in general, and that hinder a higher deployment of solar energy in Finland in particular. It also sought solutions to overcome these barriers. In addition, the thesis emphasized the importance of agency and framings in energy transitions.

6.1 Recapping the research questions

The thesis addressed specific research questions related to three dimensions:

STRUCTURE: How do the old structures act as barriers? What are the structural barriers that hinder a higher deployment of solar energy in Finland and energy transition in general? How can they be overcome?

AGENCY: How have the advocacy coalitions been formed? How have the actor positions and interaction of the advocacy coalitions changed? How well have they achieved their targets?

FRAMING: How have the framings changed?

In this chapter, I bring these research questions together and aim to answer the questions.

6.2 Empirical contributions: Structure, agency and framing in change

As discussed in this thesis, a multi-actor process such as an energy transition involves three important aspects: structure, agency and framing. The thesis has identified these three dimensions in relation to a higher deployment of solar PV and the Finnish low carbon energy transition in general. This section will unravel the findings, highlight the main arguments of the thesis, and discuss their implications.

6.2.1 Structure: Creative destruction is needed to break the old structures and habits

Historically, energy transitions have been noted to take 40–60 years. Energy transition in Finland can be expected to take an equally long time, although it
could be accelerated thanks to enhanced knowledge and newly developed policy mechanisms (Sovacool, 2016), and should be accelerated due to the imperative need for climate change mitigation (IPCC, 2018; Manoli et al., 2016). In this vein, this thesis has discussed the prospects of attaining an energy system where 100% of electricity use is covered by renewable resources by 2050 in Finland, and the role of solar PV in such a scenario. In order to achieve such high installed capacities of solar PV, significant changes must occur in the Finnish energy sector. Such a future energy system represents a complete transformation away from what currently exists, and will by no means be easy or quick to achieve.

That said, the growth in solar power worldwide has been faster than anticipated. This is in line with the notion of temporal variations in the Schumpeterian process of change, where change is sometimes slow and sometimes violent (Lovio et al., 2011). The diffusion of solar PV seems violent from this perspective, although constraining factors do still exist.

Indeed, barriers currently exist that prevent solar PV capacity from increasing. However, these barriers have been diluted slightly, and can be overcome with new policies, regulation and behaviour, not least with the existing investment support that has been available for firms and communities, but also due to the law for tax exemption for small-scale electricity production to support firms in becoming energy producers. The law came into force in May 2015 and was the result of active lobbying by the Finnish Clean Energy Association. A new law for renewable energy support also came into force in May 2018, according to which, any electricity producer that has met the standards of a technology neutral tender and has been accepted in the premium system could be allowed to receive support according to the premium. This marks a step forward for solar energy in the sense that it was accepted in the tender, but can still be seen as a symbolic acknowledgement, however, as solar energy does not actually have a fair chance in competing against the bigger producers, in contrast to the law from 2015 that has indeed exerted a market creating effect.

The thesis finds that the constraining factors for the broader deployment of solar PV in Finland can be categorized as technological, economic, institutional and political, and behavioural barriers. These can also be seen as barriers that concern policy, business, and consumers. The most significant barriers concerning policy are the lack of political will and support policy, vested interests towards the current energy regime, and fossil fuel lobbying. Barriers that concern business include the low competitiveness of solar PV, module prices, a need for new electricity markets and rules, and inefficient markets for storage systems. Barriers that concern consumers are mainly general attitudes, psychological resistance, and module prices.

Surprisingly, the barriers identified in Finland do not differ that much from those identified in studies on other countries. Spain, for instance, which has
the best solar resources in Europe, has faced the same challenges currently confronting Finland: high initial costs, lack of an accurate legal framework and insufficient support, administrative barriers, financial barriers, companies in the conventional electricity sector, the training and skills of equipment installers, lack of information, connection to the grid, and integration into buildings (del Río and Unruh, 2007). This begs the question of whether explanatory factors other than solar insolation might be implicated. One of these is the fact that in Finland other renewable energy sources play a much bigger role in the energy mix, such as bioenergy, which can be seen as a barrier to a larger deployment of solar PV. It can also be assumed that some of the other barriers have already been overcome over the years. Nevertheless, the emergence of solar PV is a more recent phenomenon and the identified barriers still exist to a greater or lesser extent.

A common denominator can be found in the barriers concerning structure. Many of the barriers have to do with vested interests, path dependence and lock-in to the current energy system, combined with uncertain governmental policies. However, as Kivimaa and Virkamäki (2014) note, the governance of transition requires a mix of policy instruments. This is where the states should step in, according to Moe (2009): They need to pursue policies conducive to structural economic change and to prevent vested interests from blocking such change. PV still suffers from higher initial costs compared with other energy sources, and from higher installation prices due to higher workforce costs. Renewable sources have only recently entered the market with the help of subsidies that many object to. In Finland, subsidies for solar power have been practically non-existent, at least for consumers, and in light of the mixed messages, it is hardly surprising that it has been difficult for decision-makers to challenge the vested interests and make a decisive push for renewables, especially solar energy. Now this constraining factor has been acknowledged and fresh impetus has been given to renewables with the help of the new laws. However, it is important to note that the support packages should not exceed a certain period so that they do not form new vested interests. Creative destruction should also be allowed to happen to break the old structures and habits.

Climate change has been recognized as the biggest driver of the larger deployment of solar PV. There is a global need to reduce greenhouse gas emissions, and solar PV does not generate any direct carbon emissions. Technological improvements have made it more appealing, together with cost reductions and government policies. In terms of policy, del Río and Unruh (2007) note a number of key drivers similar to the solutions suggested in this thesis that would assist in overcoming identified barriers, including: expanding the solar PV market to promote scale and learning effects, supporting R&D, expanding financial support measures, mandating solar PV installations in new
Discussion and conclusions

buildings, establishing minimum competencies for PV installers, and raising awareness of the many benefits of solar PV, as well as the steps needed to begin enjoying them. Further, del Río and Unruh suggest awareness campaigns targeted at individuals, professional groups, and architects. These are in line with the possible solutions for Finland that my co-authors and I outlined in Article B, which include among other things: R&D allocated to storage solutions, easier access for small-scale producers, compensation for producers, new business models, a support policy of some sort in the initial phase, a more established and powerful solar energy advocacy coalition, more information and practical examples concerning successful installations. The aim of this thesis was, however, not to direct policy in any one particular direction, but to suggest several available options.

6.2.2 Agency: Pressure from the bottom up to transform the economy and the energy system

This thesis has also studied the formation of a new energy political coalition comprising proponents of a green transition (the rising industries in green energy, researchers, NGOs, and citizens), which has emerged to challenge the old traditional coalition of energy producers and large industrial incumbents, which together with the main regulating authority and political parties had formed a small elite to protect the status quo (Ruostetsaari, 2010). The administration and the government have been situated between the two groups, not really belonging to either side. In Switzerland, Markard et al. (2016a) have noted two coalitions in the country, the dominant “pro-growth” conservative coalition including incumbent actors from the energy sector and their representatives, and a minor “pro-ecology” coalition. This is similar to the coalition formation in Finland.

The thesis has taken a closer look at the Finnish green-transition coalition that shares a common vision of a country run entirely by renewable energy. Previously, the Finnish energy field lacked a strong advocacy coalition in favour of renewables, although there were independent actors in the energy field, such as the solar energy association, heat pump association, and wind energy association. This changed, however, when the rapid rise in renewables started to have an impact on Finland as well, and a new renewable energy association, the Finnish Clean Energy Association, was established uniting all the small associations and resulting in a coalition that could set about organizing the field. The new green-transition advocacy coalition, consisting of the new association and other energy campaigns by environmental NGOs, the energy transition campaign and the New Energy Policy project, has been able to attain a new position in the field. The FCEA has become an active participant in the public
debate and a relevant actor in energy political decisions. Visible policy changes emerged, indicating that the energy campaign had succeeded in adding some of its targets to the Government Programme and was able to get involved in the energy debate. The same applies to the New Energy Policy project and the two NGOs, Greenpeace and WWF Finland. One result of the green-energy coalition’s actions can be seen in the fact that the term energy transition has gone mainstream in Finland.

Climate change coupled with the economic imperative have provided the biggest motivation for green-transition actors to support the energy transition. This is in line with the notion in the advocacy coalition framework that envisages external developments as a key mechanism for change. Deep core beliefs in a shared worldview motivated most coalition members to participate in “making the world a better place”, most importantly for future generations. The transition was likewise seen to enhance overall well-being. Being a frontrunner was considered to improve Finland’s competitiveness, but being able to gain a competitive advantage was also deemed to be dependent on political will.

According to the strategic action field theory, incumbents are dependent on the worldview and rules they have helped to devise. In Germany and Switzerland, the challengers’ continued persistence in testing the stability of the field has tended to produce shifts in worldviews (Jacobsson and Lauber, 2006; Markard et al., 2016a; Schmid et al., 2016). In Germany, incumbents shifted their worldview from ignorance to adaptation (Kungl, 2015), while in Switzerland the energy transition has become a struggle of emerging vs. established industries, and a question of who will win or lose (Markard et al., 2016a). These developments are in line with the SAF theory (Fliedstein and McAdam, 2011). The indications of changes both in the actor base as well as in the policy issues in Finland affirm the SAF theory and tendency to produce shifts in worldviews. First, the formation of a green-transition coalition created a new situation where previously no strong advocacy coalition for renewable energy had existed, and whereby the new coalition steered the field of energy policy along a completely new trajectory. New industries were emerging and becoming a threat to the status quo, making incumbent actors shift their positions and reorient themselves in the renewable energy field, also in respect of solar energy. This has also followed the patterns identified as belonging to the third phase of transitions, wide diffusion and breakthrough, as noted in Geels (2018, 55).

Moreover, this thesis finds that the advocacy position of different actor groups during the solar energy field framing process was formed by both their positioning in terms of how strongly they argued for or against the application of solar energy, and in the way that their framing activities contributed to cultural resonance. The most significant movement on the protagonism axis stemmed from incumbent companies, which switched their position from antagonism
to protagonism during the period of movement. This was as a result of two developments: two forerunner energy incumbents shifted their position, but new incumbents from the automation and construction industries also entered the field in a protagonist position. This mirrors the notion that the interaction between wide external shocks, or shocks to the political system and the success of ideas in coalitions, may cause actors in advocacy coalitions to shift coalitions (John, 2003). The findings in this thesis also draw attention to the role of these more conservative actors (energy incumbents or the construction industry) that play an important part in achieving legitimacy for the field by creating bridges between the old and new regimes.

Other actor groups, however, maintained their overall positioning in either the protagonist or antagonist domain, although they may have strengthened their positions during the process. Finnish Energy maintained its antagonist position towards solar PV, supported by public policy throughout the process, although there was slight dilution towards protagonism when energy incumbents took a more positive stance towards solar energy. The solar entrepreneurs also maintained their level of protagonism. The politicians seemed to fall somewhere between the two in general. Some individual politicians expressed their protagonist or antagonist views, but as a larger group, they remained predominantly silent and dispersed towards solar energy.

6.2.3 Framing: Incumbents and challengers confront each other: Whose perceptions will prevail?

In relation to framings, the movement from cultural distance to local resonance represents a meta-level process related to the narrative themes that have been identified in the extant research (e.g. Barry et al., 2008; Curran, 2012; Eames et al., 2006; Nissilä et al., 2014; Rosenbloom et al., 2016), and connects them on a temporal timeline of a field framing process. Initially, all three master frames identified in this study (Temporal, Geographical and Systemic distance) interacted in reducing cultural resonance, as do both protagonist and antagonist actors.

Protagonist actors began by highlighting progressiveness, global promise and disruption. They were met with silent disregard by the antagonist actors, and thus ended up contributing mainly to the sense of a distant, albeit promising solution. As a consequence, the new technology was framed as belonging primarily to others (see also Barry et al., 2008; Curran, 2012), and was pushed into the future with frames that accentuated technological progress, societal change and a future energy system (also identified by e.g. Eames et al., 2006; Laird, 2003).
The protagonists then progressed to arguments concerning economic impact and security implications in the local context (also identified by Nissilä et al., 2014; Rosenbloom et al., 2016; Verhees et al., 2013). At this point, the antagonists became more vocal and began to offer alternative meanings for the themes raised by the protagonists, drawing particularly on the themes of energy security and the “foreign nature” of the technology. Towards the end of the process, the framing struggles moved towards competition with respect to defining the leadership positions in and definitions of the new field.

The findings demonstrate that, according to the narrative themes identified in existing research, technological progress, societal change and presenting the energy source as a natural part of the future energy system are particularly prominent at the beginning of the process, whereas job creation, energy security and economic promise become more central in the later stages. When a breakthrough is perceived as being imminent, the actors shift the focus of their framing activities from technology to their own role in the emerging field. The shift in framing renewables and solar PV away from environmental interests towards economic argumentation was also most visible in the fact that the incentives for energy transition in the semi-structured interviews entailed economic growth and new jobs that would be created due to transition. In comparison, in Switzerland, the energy transition is also associated with arguments about job creation and the independence of energy imports (Markard et al., 2016a). The economic argumentation in the Finnish debate did not imply that switching to renewables would be economically cheaper for individuals, but focused instead on the benefits for the macroeconomic level. This is in line with what has been said earlier about the transition contributing primarily towards mitigating climate change, and not necessarily being the most economically viable choice for producers and consumers (Fouquet and Pearson, 2012) – although if the transition was skillfully executed, it might prove to be economically sound as well.

The interactions between antagonists and protagonists moved from disregard in the early stages to high resistance in the mid-stages, and finally towards efforts to shift interpretations so that the new technology would be perceived as being more beneficial by antagonist actors as well. Disconnected framing activities occurred that allowed the antagonist actors to resist the novel technology by isolating it from relevant debates and by using tactics as a means of indirect criticism.

According to Fligstein and McAdam (2011), field stability is an ongoing game where incumbents, challengers and members of political coalitions make moves and countermoves. The master frame related to temporal distance appeared to be particularly challenging for such a novel, disruptive technology. Emphasizing future scenarios enabled antagonists to frame the new technology as a distant
promise, while protagonists’ efforts to highlight the threat of being late in the game might have pushed decision-makers to view the novel technology as an opportunity that was already lost in terms of gaining a competitive advantage. Moreover, accentuating the readiness of the technology to move from R&D to implementation invites counter-framings claiming that it is no longer in need of any societal support. The new technology thus tends to end up in a paradoxical position where it is simultaneously perceived as being both too early and too late.

At the same time, as the green-transition advocacy coalition exhibited different points of view within the groups, especially towards nuclear power and bioenergy, it has had the effect of weakening its impact. This study finds that divergent opinions within the coalition detract from the challengers’ ability to exert an influence. The green-transition coalition’s differing views in relation to nuclear power and bioeconomy created fissures in the actions of the coalition, which could affect the structure of the coalition in due course.

When the antagonist and protagonist actors shared the same arenas of negotiation, debates became more direct negotiations of meaning related to the new energy system and the economic effects of the new technology. In such a process, the constant adjustment of arguments and actor positions is key in generating movement in the field. Hence, examining the changing positions in the framing process uncovers important aspects of the interactions that underlie the meanings that are established in the field. The government’s decision to phase out coal (HE 200/2018), and the politicians’ shifting attitudes towards renewable energy being regarded as a business opportunity and a domestic source of energy, have also helped to pave the way for a take-off stage whereby a transition seems possible.

6.3 Theoretical contributions

Complex societal phenomena, such as transitions, benefit from being studied through an interdisciplinary approach using multiple methods. This thesis has aimed to adopt a more holistic approach to transitions than is normally the case in transition studies. First, it has extended the timeline from present or historical case studies to include a future perspective. As transitions are processes, they are not stable but in a constant state of change. Anticipating the future is difficult, but can provide interesting aspects to be considered, as can drawing on the past. Combining futures studies with transition studies is hence a new approach that has recently been introduced in another thesis (Lauttämäki, 2018). In my doctoral dissertation, I argue that in order to examine transitions as a whole, we need to study the big picture in the first instance,
take into account that we are looking at phases on a timeline, and sometimes
distance ourselves from the present moment to look back as well as ahead.

Second, this thesis has contributed to several theoretical strands and
frameworks. My theoretical argument has been constructed not only by
combining futures studies with transition studies, but also by combining
evolutionary economics, the structuration approach, the theory of fields, and
the advocacy coalition framework into one application, following the principles
of analytic eclecticism. This has resulted in the key theoretical contribution
of the thesis: a new conceptual framework (introduced in section 2.5) that
aims to explain transitions from a holistic perspective. The framework applies
the perspective of analytical eclecticism in its search for interactions among
theoretical principles in many disciplines: it combines Kondratiev waves,
Schumpeter’s creative destruction, the structuration approach, MLP, strategic
action field theory, the advocacy coalition framework and socio-cultural
framing, and aims to explain the relationship between them, and how they are
all intertwined with each other. In this way, the thesis has responded to the call
for a multi-sectoral, interdisciplinary analysis (e.g. Moe, 2015; Van de Graaf
et al., 2016). The thesis has also provided new empirical data on the ongoing
energy transition and deployment of solar PV in Finland. What has perhaps been
lost in parsimony has, it is argued, been offset by gaining a richer understanding
of the multitude of different factors at play in the multi-actor process of energy
transition. Indeed, the framework put forward in this study has enabled a more
multifaceted view into the process while allowing the identification of a set of
key actors and factors in the process.

Third, the thesis has contributed to transition studies by examining
transitions from the classic social science triangle of structure, agency, and
framing, and by bringing these aspects together in one study. The extant
literature usually applies structure and agency, but all three aspects of structure,
agency and framing have rarely been considered in the same study. I argue that
in order to fully grasp such wicked real-world problems as energy transitions,
it is necessary to examine the phenomenon from all of these perspectives.

Fourth, the thesis has contributed to the neglected topic of agency in
transitions, particularly by filling the research gap concerning the role of civil
society and advocacy coalitions in energy transitions in the case of Finland. The
study has aimed to do so by complementing transition studies with two other
frameworks: the strategic action field theory and advocacy coalition framework.
In so doing, the thesis has also sought to address a lacuna in the structurationist
approach.

Fifth, the thesis has responded to the topic gaining ground within socio-
technical transition studies (Geels and Verhees, 2011; Markard et al., 2016b;
Rosenbloom et al., 2016) as well as within institutional research on field
emergence (e.g. Granqvist and Laurila, 2011; Snow and Benford, 1988) concerning the creation of cultural resonance through socio-cultural framing of novel technologies. The thesis has drawn on these two fields of literature and placed emphasis on the socio-cultural framing perspective, duly providing a more in-depth analysis of the framings established in the field.

6.4 Policy implications

This study gives rise to the following implications for policymakers and practitioners: 1) it provides an alternative energy system vision for Finland in 2050 and outlines the role that solar PV will play in this vision; 2) it provides information about the actual lock-in mechanisms – barriers that concern policy, business, and consumers – that hinder the higher deployment of solar PV in Finland and suggests solutions for overcoming them; 3) it provides a bottom-up approach to energy transition, enhancing knowledge about what motivates Finnish citizens towards achieving an energy transition and what they think and believe in; and 4) it provides information about the framings used in the energy debate on the emergence of the solar energy field in Finland. This is all useful information for decision-makers when it comes to analyzing and determining the direction in which Finland should be heading.

These four implications will now be discussed in turn. First, it is obvious that a transition to a more sustainable energy system needs to be made. Whether this is a low carbon energy system based on nuclear power and renewables or an energy system generated fully by renewables, fossil fuels still need to be phased out in the first instance. The decision to phase out coal (HE 200/2018) and to halve the use of oil (VNS 7/2016 vp) can be seen as a radical policy implication of the actions of the green-transition coalition, and constitutes a good start. If Finland wants to opt for a system similar to that in Germany, and to phase out nuclear as well, political decisions will need to be made towards such a transition. This would need to be a top priority on the climate and energy policy agenda if a complete transition is to occur.

Second, there are several structural barriers that need to be overcome in order to increase the deployment of solar PV. These include policy, business, and consumer barriers. The need for an R&D allocation for energy storage systems still needs to be realized, although the support policy has been reconsidered. Cost comparisons with the conventional energy system and competitiveness have posed the biggest obstacle overall in Finland, for both business and consumers alike. For consumers, module prices and installation costs have been higher in Finland due to sales channel inefficiencies, very low market volumes, expensive labour, and less experienced installers. The conventional energy system has received subsidies in different forms historically, and has been able to grow
and stabilize its position in the markets. Meanwhile, solar PV has received hardly any subsidies in Finland, at least not for consumers, which has helped the conventional energy system to continue dominating the markets. A level playing field would be needed to prevent market distortion. A support system for a new type of energy has been noted as being most helpful at an early stage. However, it is important not to continue supporting established technologies after the early stage so that new vested interests will not take hold vis-à-vis the new technology, as they may serve to hinder the crucial structural change.

Third, the structural change in Finland is driven in part from the bottom up. There are indications of a civil society movement similar to the one that has been behind Germany’s energy transition. The green-transition advocacy coalition is still modest and not as strong as it could be, but if external developments continue to gain pace or new external shocks emerge, the situation might change rapidly. Policymakers would need to be ready for such a turnaround. A new effort to combine forces in a manner similar to the 2015 parliamentary election campaign presented in Article C would require an impartial transition arena for discussion and action, coupled with transition management steered by governments.

Fourth, although this thesis has frequently referred to “providing information”, according to Sovacool and Brown (2015), this is not always an efficacious mechanism for altering someone’s frame: given the potential for contestation, it could very well have the opposite effect, and further entrench it. They also note that decisions concerning energy are also justified by beliefs and worldviews so a more effective strategy than the provision of information might be to decipher the deeper underlying assumptions and values, and to search for common grounds. This is what makes a transition so difficult, but is also why this thesis argues for a transition arena. Experimental transition arenas have existed formerly (e.g. Hyysalo et al., 2017), which would need to be re-established and extended. All parties should come together in these arenas of negotiation to determine the extent to which they share a common vision, and the means that need to be implemented in order to reach the shared goal. This calls for an open-minded attitude where one’s old beliefs and worldviews will be tested. Policymakers have an important role to play as well, as the government needs to initially take on the role of mediator in the arenas, and subsequently the leading role in implementing ideas from the bottom up to eventual top-down rules and regulations.
6.5 Limitations

Despite the somewhat ambitious aim of addressing energy transitions at several levels and from the perspective of several actors, and of extending the temporal timeline to cover the past, present and future, choices had to be made in terms of narrowing down each of the perspectives. While the journal article format enabled the phenomenon to be addressed from different perspectives, it also entailed focusing the thesis on specific approaches due to limited time and space. Hence, the selected studies defined the content of the thesis, but inevitably resulted in other equally important aspects having to be omitted.

The initial focus of the thesis was on investigating the role of the state, market and civil society on the path towards a sustainable energy system, and the future of the solar energy industry in Finland. However, the iterative research process with the influence of other co-authors led to a different kind of study, where all of these actors have been covered in one way or another, but where a stronger focus on the role of each actor level would have contributed to understanding the part played by each actor in the transition in a more profound way. It is also questionable whether the three dimensions of structure, agency and framing are in equilibrium, or whether some of the aspects have perhaps been analyzed more than others. At the same time, it should be noted that this limitation is inherent in the scientific process, which invariably homes in on parts of the whole from particular angles.

Another limitation concerns the methodological choices for the research. Although the relevant actors in the field of solar energy were interviewed for this thesis, the sample is still relatively small. This is due to the fact that the field has practically been non-existent to date, and the key actors few. Material has also been hard to find on occasion. There were, for instance, missing documents on the websites of political parties and organizations, some of which I acquired through email enquiries. However, the role of solar PV in Finland should not be disregarded even though its share in the energy mix in Finland is admittedly modest.

Solar PV has risen to a relevant position worldwide, which makes it a worthy research topic in the case of Finland as well, but which also highlights the third limitation of this thesis, namely its geographical focus. The study centres exclusively on Finland, which precludes generalizations from being made. However, it is not too far-fetched to argue that the findings may be applicable to other countries in the northern latitudes, as solar PV faces the same challenges not only in relation to irradiation, but also when it comes to attitudes, as also noted in studies of solar PV in hostile environments (e.g. Verhees et al., 2013).
6.6 And so the story continues...

During the past ten years, I have closely followed issues related firstly to climate change, and subsequently to solar energy, particularly solar PV. My PhD journey has now come to an end. During this time, I have observed the ever-growing interest towards solar energy, seen its very rapid rise to a mainstream product sold in hardware stores, and witnessed incumbents embarking on the business of offering solar panels to be installed for private use.

I have found the PhD process both rewarding and encouraging, and hope that I have been able to make a contribution to the emerging field. To this end, I have attempted to identify barriers that solar energy faces in Finland and address gaps in the literature, contributing in particular to the discussion on agency in transitions and providing a Finnish and civil society perspective, as well as developing a new conceptual framework for the study of energy transitions.

I will be continuing my work in the field of energy policy at Tampere University, where I have been working since August 2018 for the EL-TRAN Consortium, whose mission is to rethink the totality of the electric energy system in Finland and draw comparisons with the energy transitions underway in the Nordic countries, Germany and beyond. The thesis in hand opens up new avenues for further research that could involve the question of power in energy transitions, for instance, and the role of market and public policy in such transitions. In addition, to complement the advocacy coalition study, the core beliefs of the other energy political coalition – energy producers and incumbents – could be studied for comparative research purposes. There is also a need for a follow-up study in relation to framings used in the energy debate. To sum up, as the landscape that follows long waves is gradually changing, the field of energy is also evolving and thus provides new exciting horizons – and wicked problems – for the researcher to explore.
References


References


References


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Interviews

First round, 2013:

Aurinkotekno 8 April 2013
Confederation of Finnish Industries 17 May 2013
Greenpeace 15 March 2013
Finnish Energy 8 May 2013
Fortum 18 March 2013
Ministry of Economic Affairs and Employment of Finland 15 May 2013
Parliament of Finland 8 April 2013
Parliament of Finland 9 April 2013
Parliament of Finland 15 April 2013
Solar Energy Association 17 April 2013
Sunwatt 17 April 2013
The Finnish Funding Agency for Innovation, Tekes 17 April 2013
Telog 25 April 2013
Utuapu 17 April 2013
WWF 22 February 2013
WWF 9 April 2013

Second round, 2015–2016:

Finnish Clean Energy Association 27 February 2015
Energy Renovation campaign 4 May 2016
Energy Renovation campaign 7 October 2016
New Energy Policy project 4 May 2016
WWF 2 November 2016

Structured survey, May 2015:

Finnish Clean Energy Association, 8 responses
Energy Renovation campaign, 23 responses
Appendix 1

The main semi-structured research questions for Article A (translated from Finnish):

1. How would you describe the role of solar energy (production capacity and potential) in Finland?
2. What part does the support policy play in promoting solar energy?
3. What kind of support would be needed, and what would be the most efficient support mechanism considering the different needs (private citizens, firms, etc)?
4. What kind of challenges or barriers to the growth of solar energy exist in Finland?
5. What kind of business opportunities might exist in the field?
6. How would you rate Finland’s competitiveness in the field?
7. What kind of a future do you envisage for solar energy in Finland?
Appendix 2

The structured survey questions for Article C (translated from Finnish):

1. Briefly describe your background – age, education, work, etc.
2. Why do you consider that an energy transition is needed in Finland?
3. What is your energy transition vision for Finland?
4. By what means can it be achieved in your opinion?
5. What are the most significant barriers to achieving an energy transition and what should be done to overcome them?
6. Why are you prepared to be active, or to campaign for the cause?
7. How did you enter the Finnish Clean Energy Association/Energy renovation campaign (choose one, or indicate if you are involved in both)?
8. In your opinion, what are the biggest successes regarding the actions of the FCEA/Energy renovation campaign and how were they achieved?
9. In what category would you place yourself in relation to the deployment of renewable energy? Please elaborate, if necessary.
   a) innovator/frontrunner
   b) early adopter/early majority
   c) late majority/laggard
The wicked problem of a low carbon energy transition

Structure, agency and framing in the multi-actor process of solar PV deployment in Finland

Teresa Haukkala