

THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Effects and evolution of institutions in sociotechnical change

Perspectives on market and state in the development of solar PV in Sweden

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Gothenburg, Sweden 2026

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ISBN: 978-91-8103-432-5

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Doktorsavhandlingar vid Chalmers Tekniska Högskola
Ny serie nr 5889
ISSN 0346-718X
DOI: <https://doi.org/10.63959/chalmers.dt/5889>

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Front cover: Illustration by Anna Blarr

Printed by Chalmers digitaltryck
Göteborg, Sverige 2026

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Abstract

The diffusion of renewable energy technologies is vital for achieving climate targets. While advanced technological solutions are already available, the diffusion depends on market and government actors, and prevailing beliefs and norms in society. To facilitate transformative change, it is therefore essential to understand the relation between actors and established institutional structures. Such understanding can support strategic action rather than reliance on external shocks to create windows of opportunity. This thesis explores how regulatory, cultural-cognitive, and normative institutions influence actor activities in sociotechnical change, and how actors, in turn, shape institutionalization. More specifically, this thesis aims to explain how institutional change unfolds across market and state sectors in sociotechnical systems.

To this end, the thesis employs a case study of solar photovoltaics (PV) development in Sweden and integrates theoretical lenses of business models and business collaboration within the market sector, policymaking and implementation in the state sector, and policy feedback to investigate co-evolution between the two sectors. The empirical basis comprises extensive qualitative data on Swedish solar PV development, traced retrospectively over the period of 1996 – 2025. The findings demonstrate that a combination of regulatory, cultural-cognitive, and normative institutions shape the activities of both market and state actors, resulting in heterogeneous responses based on organizational ownership, identity, and logics. The thesis further emphasizes the importance of comprehensive institutional support for sociotechnical change by comparison of two cases: the slowed diffusion of energy communities, characterized by limited institutional support and weak interaction between market and state sectors; and the successful case of solar PV, where actors created favourable institutional conditions, supported by extensive cross-sectoral interaction.

The thesis contributes to sustainability transitions research by offering a more balanced understanding of actor heterogeneity, not only within the market sector, but also in the state sector, and by demonstrating how co-evolution between the two shapes institutional change. Furthermore, it presents a rich empirical account of institutional dynamics, enabling the identification of action points for the transformation of sociotechnical systems. A key policy implication is the need to balance stable and transparent long-term policy direction with ongoing coordination and adjustment as system dynamics evolve.

Keywords: Sustainability transitions; solar photovoltaic; innovation; policy mix; government; institutionalization

List of appended Papers

This thesis is based on the work contained in the following papers:

Paper I

Altunay, M., Bergek, A., Palm, A. (2021) Solar business model adoption by energy incumbents: the importance of strategic fit. *Environmental Innovation and Societal Transitions*, 40, 501-520.

Paper II

Altunay, M. & Bergek, A. (2023): Interaction between energy incumbents and solar entrants: Relationship status complicated, *Environmental Innovation and Societal Transitions* 46, 100695.

Paper III

Altunay, M. (forthcoming) The mediating role of political debate in policy feedback processes: Discourse coalitions in the emergence of solar PV in Sweden. Manuscript submitted to the *Journal of Environmental Policy and Planning*.

Paper IV

Altunay, M., Bergek, A., Palm, J. (forthcoming): Energy policy in a fragmented state: The influence of dispersed processes on the establishment of energy communities in Sweden. Manuscript to be submitted to a peer-reviewed journal.

Acknowledgements

Thank you, Anna, for being an exceptional supervisor. You are not only rigorous and meticulous, but also pedagogical and warm-hearted. From the day we first met, you have understood me as a person. You supported my activism and listened patiently to my many complaints – yet another time moving apartments in Gothenburg. As you pointed out, this past half year required me to mature more quickly as a researcher. It required much more from you, and you fought it. I am deeply grateful for the opportunity to learn alongside you as a PhD student, and I very much look forward to what is yet to come!

I would also like to thank my supervisory team: Johanna Ulmanen and Alvar Palm before licentiate, and more recently Jenny Palm, Ksenia Onufrey, and Björn Sandén. A lucky turn in an unlucky situation, to be suddenly guided by three experienced, smart, and kind researchers, navigating their diverse expectations.

My time as a PhD student has also been profoundly shaped by the Environmental Systems Analysis group at TME. Thank you to all my colleagues; to my managers Helene and Hans; the study directors Rickard and Maria; and to my office mates Sara, Valentina, Marta, Elin, Daniel, and Maja. You made this time both meaningful and joyful.

Lisa, Amanda, and Stina, thank you for accompanying me across the finish line. I am grateful for the countless virtual co-working sessions over the past months. Writing this thesis as part of a supportive team, rather than in academic isolation, was a truly wonderful experience.

During the final phase of this work, I was located in Freiburg at the Öko Institut e.V. as a guest researcher, where I would like to thank Dierk Bauknecht and the entire team for a heartfelt welcome and insights into contemporary politics of the German Energiewende.

I also wish to extend my thanks to the professors at Karlshochschule International University, who first sparked my interest about sustainability transformation, electricity systems, and scientific rigor: Cordula Braedel-Kühner, Nurten Avci, Henk Van Elst, and Michael Zerr. Thank you to Anki Cordes for recognizing my potential to pursue an academic career, and to Lars Holländer for convincing me to apply for this position at Chalmers.

Finally, I thank my family who carried me through this journey. My son, who taught me how to be fully present in the moment, and Sever, my rock, *seni çok seviyorum*. This thesis would not exist without your love and support.

Maria Altunay

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1. Introduction

1.1 Background

Pressing climate and societal crises require fundamental transformation of established socio-technical systems including transport, water, food, and energy (Köhler et al., 2019). As the IPCC puts it in their most recent assessment report: “[Global] warming cannot be limited to well below 2°C without rapid and deep reductions in energy system carbon dioxide and greenhouse gas emissions” (IPCC, 2023). The energy sector corresponds to roughly three quarters of the global greenhouse gas emissions (World Resources Institute, 2026), including transport, electricity and heating, fuel combustion in industry, and off-road machinery and construction equipment. Electricity and heat only correspond to roughly one third of global greenhouse gas emissions (World Resources Institute, 2026).

In the Swedish context, electricity production is nearly fossil-free with large-scale hydropower (37.7%), nuclear power (29.3%), wind (23.5%), small shares of biofuels (4.1%), solar PV (2.4%), waste (2%), and minor amounts of coal, oil and natural gas (<0.2%) (International Energy Agency, n.d.). Nevertheless, fossil fuels still play a significant role in other sectors as oil and oil products account for roughly 20% of total energy supply in 2024 (International Energy Agency, n.d.). Therefore, the diffusion of renewable electricity is not only necessary to limit greenhouse gas emissions, but also to create a more resilient and independent electricity system (Xu et al., 2024), stimulate domestic industry (Hoppmann, 2018), and enable electrification of other, more fossil-dependent sectors (Ramsebner et al., 2021). From a competitiveness point of view, solar PV and onshore wind have become the cheapest electricity sources (Tachev, 2025) with a global average levelized cost of solar PV electricity (LCOE) of \$0.043 per kWh in 2024, about 41 percent cheaper than fossil fuel alternatives (Jowett, 2025).

Given the urgent need for transformation of the electricity system and solar PV technology’s cost-competitiveness, why has this, literally lifesaving, transformation not happened yet? One reason is that technology and society are intertwined and complex transformation processes need to happen at multiple dimensions and overcome resistance from established actors (Rip & Kemp, 1998). Therefore, the key for understanding electricity system transformation or stability does not lie in technological innovation alone, but in how technologies interact with actor networks and established structures.

Accordingly, explaining electricity system transformation or stability calls for a system-level perspective that explicitly integrates technologies, actors, and structures, as captured in the sociotechnical system concept. A sociotechnical system is specialised on fulfilling a particular (societal) function, e.g., provide electricity, and consists of technology, actors, and “the rules and institutions which guide actor’s perceptions and activities” (Geels, 2004, p. 898). These elements are connected and the connections become more stable over time, hindering transformative change, often resulting in incremental rather than radical innovation. While technological innovation can be spontaneous and rapid, institutions are the main stabilizing factor, as institutions are resilient social structures (W. R. Scott, 1992, 2010).

How does change occur in such, relatively stable, sociotechnical systems? One of the central and most frequently used approaches for analysing sociotechnical change processes is the Multi-Level Perspective (MLP), in which transitions “can be understood as arising from the alignment of processes at the sociotechnical landscape, regime and niche levels, whereby windows of opportunity enable radical niches to break through into mainstream markets.” (Geels, 2014b, p. 23). While innovation emerges at the niche level, regimes and landscapes represent established structures. One of the core ideas of the MLP is that innovations can grow at the niche level, because the level of structuration or institutionalization is lower. However, when an innovation leaves this ‘shielded’ space (Smith & Raven, 2012) and enters the mainstream market, it encounters established regime structures and must compete under existing selection pressures. Thus, to facilitate the diffusion of emerging technologies, it is essential to understand how institutions enable or restrict regime change, as such understanding can inform strategic action rather than reliance on landscape shocks to create windows of opportunity.

Despite the MLP’s focus on rather long-term and macro-level transitions processes, actors play a central role: “Although processes at different levels can converge and create windows of opportunity for regime change, *the actual linkages always need to be made by actors*” (Geels, 2005, p. 692, own emphasis). Two central groups of regime actors in sociotechnical change processes are firms and governments (Geels, 2005; Unruh, 2000). Following Avelino and Wittmayer (2016), this thesis conceptualizes firms and governments as actors in market and state sectors respectively. This terminology is chosen to avoid established transitions terms with their conceptual implications. Following (Avelino & Wittmayer, 2016, p. 637), the market sector is private and for-profit, consisting of organizations such as multinationals, small and medium size, or family-owned enterprises, and the state sector is public and non-profit and

consists of public agencies, such as governmental departments, municipalities and political parties. Such organizations in the market and state sectors are the objects of study in this thesis.

In the market sector, regimes are expected to be dominated by established incumbent firms, while niches consist of new entrants such as entrepreneurs and start-ups. Incumbents are the so-called ‘backbones of the regime’ (Karlton and Sandén, 2012, p. 67) and are often equalled with regime actors. The transitions literature therefore departs from a perspective of incumbents as villains, gatekeepers, and reproducers of existing regime structures (Altunay, 2022; Turnheim and Sovacool, 2020), resulting in a confrontation bias regarding these actors, assuming that interaction between the two is by default characterized by conflict, where small, innovative Davids fight big, powerful and resource-rich Goliaths (Altunay 2022). Goliaths’ power draws from the possession of resources such as capital, infrastructure, and relationships with policymakers (Geels, 2014b). Incumbents can use a range of institutional strategies to decrease the legitimacy of an emerging technology or actor (i.e. by blocking or reframing niches (Smink et al., 2015; Späth et al., 2016; Turnheim & Sovacool, 2020)), or increase their own legitimacy by ‘masking’ the full social or economic costs of a regime, forging ‘reinvention’, ‘capturing’ important political positions, or ‘securing’ their interests by connecting to a topic of national security (Johnstone et al., 2017).

Some empirical cases illustrate, however, that niche-regime interaction can vary on a scale between competition and collaboration (Kangas et al., 2021). Entrants would, for instance, try to link up to regimes to gain access to their resources in general (e.g., Bui et al., 2016; Diaz et al., 2013; Elzen et al., 2012; Ingram, 2015; Smith and Raven, 2012) or to drive novel business models more specifically (Wadin et al., 2017). Collaborative modes of interaction allow for a perspective in which incumbents are proactive and drive transitions (van Mossel et al., 2018), which has been illustrated in empirical cases where incumbents adopt renewable energy business models (Heiskanen et al., 2018), mobilize social legitimacy for emerging niche innovations (Smith et al., 2010), or engage at the niche level and the regime level simultaneously (Berggren et al., 2015; Galeano Galvan et al., 2020; Stalmokaitė & Hassler, 2020).

In the state sector, governments are assumed to take on a proactive and crucial role in governing transitions through policies (Haddad et al., 2022; Köhler et al., 2019), for instance by ‘empowering’ niches (Smith & Raven, 2012), engaging in institutional work (Vestergaard & Schmid, 2026), and driving mission-oriented innovation processes (Mazzucato, 2016; Wittmann et al., 2021). To this end, researchers have suggested how possible intervention points for policy in

innovation and transition processes can be identified (Bergek, Jacobsson, Carlsson, et al., 2008; Kanger et al., 2020; Klein Woolthuis et al., 2005), such as the facilitation of niche development by destabilizing existing regimes (Frank et al., 2024; Meadowcroft & Rosenbloom, 2023). The role of government or the state, is, however, contested (Vestergaard & Schmid, 2026). While expected to drive niche development (Fischer & Newig, 2016), it is simultaneously part of the existing regime and its reproduction (Braams et al., 2024; Johnstone & Newell, 2018; Unruh, 2002), for instance through routines, professional identity, and linkages to incumbent industries. Moreover, the state or government is not a homogenous entity but consisting of numerous actors at governance levels and policy domains (Meadowcroft, 2007). To nuance our understanding of the role of the state in sustainability transitions, it is of crucial importance to consider its horizontal and vertical division (Meadowcroft, 2007), the alignment of existing public administration traditions with transformative missions (see e.g., (Braams et al., 2021), and the diverse state actors driving policymaking and implementation processes (Oltmer & Löhr, 2025; Song et al., 2023). Recent debates on mission-oriented or transformative innovation policy are explicit about the central role of (coordinated) state actors, as they articulate: “[M]issions demand a systemic, ‘whole of government’ approach to policy making that engages multiple policy domains and levels of government (Uyarra et al., 2025, p. 4).

As becomes apparent from the above discussion, neither market actors, nor state actors, can be expected to behave in certain, homogenous, ways in transitions processes. The thesis departs from an understanding of heterogeneous actors in both sectors, influenced by normative, cultural-cognitive, and regulatory institutions. Due to different perceptions of those, the same institutional pressures result in different strategies and actions to secure legitimacy (Greenwood et al., 2010, 2011).

While sustainability transitions research has extensively examined market-based actors and innovation dynamics, its most influential frameworks have tended to treat the state as analytically separate. Policy and government are mostly considered as background conditions or institutional context (Lockwood, 2022). I argue that the relationship between state and market sectors should rather be characterized as closely intertwined and coevolutionary. Coevolution depends on interactions between evolving system elements (such as technologies, institutions, and business strategies) (Foxon, 2011). Such coevolution between technological development and policy change has been illustrated in empirical studies (Hedeler et al., 2023; Hoppmann et

al., 2014; Jacobsson & Lauber, 2006; Reichardt et al., 2016) and is conceptualized in the idea that they interact through policy feedback (Edmondson et al., 2019).

1.2 Purpose and research questions

The purpose of this thesis is to explain how institutional change unfolds across market and state sectors in sociotechnical systems. In detail, the thesis answers the following research questions:

- (i) In what ways do institutions influence activities by market actors, and how do these actors, in turn, contribute to institutional change?
- (ii) In what ways do institutions influence activities by state actors, and how do these actors, in turn, contribute to institutional change?
- (iii) How does co-evolution of state and market sectors shape institutional change?

This is investigated through extensive empirical research of solar PV development in Sweden conducted during 2019 – 2025. The purpose is met by a longitudinal, retrospective study of market actors' activities (business models and business collaboration), state actors' activities (policymaking and implementation), and policy feedback between the two sectors covering the period of 1996 - 2025.

1.3 Thesis outline

The thesis starts by outlining the theoretical points of departure in Chapter 2 by situating the theoretical concepts and framing them in the context of institutions and sociotechnical change. This is followed by a chronological description of the empirical context of market and policy evolution for solar PV in Sweden in Chapter 3. Chapter 4 describes the study design, methodological choices and a more personal research journey, followed by summaries of appended papers in Chapter 5. The research questions are synthesized in Chapter 6, which also constitutes the core of the thesis. After contributions, implications, and limitations in Chapter 7, concise conclusions are drawn in Chapter 8.

2. Theoretical points of departure

This thesis is positioned within the scholarly field of sustainability transitions, which encompasses a variety of different frameworks and approaches such as the Multi-Level Perspective (MLP), Technological Innovation Systems (TIS), Transition Management (TM), and Practice Theory. They all share a common interest in understanding sociotechnical change, despite different ontological foundations and epistemological approaches. This thesis departs from an understanding of sociotechnical change in line with Rip and Kemp (1998), who describe sociotechnical change as the co-evolution of technologies and the social environment, where technological development is shaped by norms, regulations, user behavior, industrial networks, and broader societal structures. Their foundational work on technological regimes and landscapes (Rip & Kemp, 1998), and strategic niche management (Kemp et al., 1998) was further developed in the MLP (Geels, 2002, 2004) and influenced the TIS framework (Bergek, Jacobsson, Carlsson, et al., 2008).

Chapter 2 introduces the theoretical points of departure of this compilation thesis. Business models and business collaboration are used to conceptualize activities of actors in the market sector; policymaking and policy implementation to conceptualize activities of actors in the state sector. The co-evolution between sectors is interpreted through the lens of policy effects and feedback. The chapter concludes with a final section titled *Résumé*, which visualizes the integration of the theoretical concepts.

2.1 The role of institutions and institutionalization in sociotechnical change

Institutions can be defined as: “social structures that have attained a high degree of resilience [and are] composed of cultural-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social life” (W. R. Scott, 1992, 2010). This concept of ‘three pillars’ is an established understanding of institutions in core transitions literature (Bergek, Jacobsson, & Sandén, 2008; Bergek et al., 2021; Geels, 2004, 2014a; Markard et al., 2016).¹

¹ The concept of institutional logics has become more prominent in transitions studies in recent years (cf., e.g., Frank et al., 2024; Hacker and Binz, 2021; Strambach and Pflitsch, 2020; van Welie et al., 2018), based on the influential work of (Fuenfschilling & Truffer, 2014). The two concepts are quite similar in their definition, even though applied slightly different. I share an interest in the semi-coherence of regimes with Fuenfschilling and Truffer (2014), while their work focuses on the assessment of structuration or institutionalization in sociotechnical regimes.

Regulative elements include clear directives, rules, incentives and control, and are formalized and explicit. Examples include formal policy and industry standards (Kivimaa & Kern, 2016). Normative elements emphasize social relations and intrinsic motivation. Choices are guided not just by instrumental reasoning but also by normative expectations about appropriate behavior in a given situation (W. R. Scott, 2010). Normative elements in sociotechnical change can include performance criteria and design principles for an emerging technology (Markard et al., 2016). The cultural-cognitive level represents one's worldview, or deeply entrenched beliefs and conceptions of 'the way the world is'. Examples of cultural-cognitive elements related to emerging technology include expectations and visions about their performance or transformative potential (Geels & Raven, 2006; Nissilä et al., 2014). The process of institutions emerging, changing, stabilizing, or dissolving, can be understood as institutionalization, emphasizing when, how and in which order things happen (W. R. Scott, 2010). This definition is broader than what is articulated in parts of the transitions literature focused on the structuration of sociotechnical regimes (Fuenfschilling & Truffer, 2014).

For understanding how institutions shape actor behavior, legitimacy is a central piece of the puzzle and can be defined as "generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995, p. 574). In other words, legitimacy is a judgement made by a certain audience (Suchman, 1995) and consists of an object which is perceived as legitimate, and a subject (actor) who legitimizes it (Beetham, 1991; Bitektine & Haack, 2015). Institutions ultimately have meaning because actors need to conform with them to be perceived as legitimate.

In the context of sociotechnical change, the object of legitimacy (what is perceived as legitimate) could be a certain technology (Binz et al., 2016; Markard et al., 2016), an organization (Geels, 2020), or an entire industry, sector, or sociotechnical system (Wesche & Skjølsvold, 2025). Scholars have, for instance, discussed the rise and decline of the legitimacy of nuclear power (Geels & Verhees, 2011), how legitimacy of agricultural biogas decreased through its association with different sectors (Markard et al., 2016), or how cultural resonance for solar PV was constructed in Finland (Lempiälä et al., 2019).

Regarding the subject of legitimacy (who perceives something as legitimate), different actor groups can be relevant 'evaluators' (Bitektine & Haack, 2015), including media, government and collective actors such as interest groups at the general societal level. In relation to specific

organizations, evaluators of legitimacy also include the organizational field or industry regime organizations are embedded in (Geels, 2014a; Kodeih & Greenwood, 2014); as well as regional or local communities (Greenwood et al. 2010). Organizational factors such as structure, ownership, governance and identity mediate how organizations perceive, interpret, and act to be perceived legitimate (Greenwood et al., 2011), with the goal to secure resources, support, or employee motivation (Bitektine & Haack, 2015). An organization's identity shapes what its members perceive they should do (Gioia et al., 2013) and consists of formal (i.e. written) and informal aspects (i.e. enacted in everyday work) (Gioia et al., 2000).

Actors also exert influence on evaluators of legitimacy on how the object of legitimacy is perceived, which is called legitimation. Legitimation is a key function for the successful diffusion of technological innovation (Bergek, Jacobsson, Carlsson, et al., 2008). Legitimation refers to episodes characterized by 'fluctuating legitimacy judgments and open contestation' (Bitektine & Haack, 2015) over the organization's, technology's, or industry's societal standing. Emerging technologies require actors to enter nascent markets and drive legitimation through framing activities (Bergek, Jacobsson, & Sandén, 2008; Smith & Raven, 2012). In the context of solar PV, examples confirm that media and parliament are two central evaluators of the technologies' legitimacy (Hirt, 2024), framing the technology in the context of the existing electricity regime. Incumbent actors also engage in framing solar PV, for instance using storylines to delegitimize it (Rosenbloom et al., 2016), or increasing legitimacy by funding external research projects and launching innovative business models (E. L. Apajalahti et al., 2018).

In relation to sociotechnical change, institutions can act both as barriers and enablers, as explained in the following. On the one hand, institutions can hinder or slow down sociotechnical change due to their stable and slow-changing nature. Due to this characteristic, institutions are at the core of stabilizing regimes in sociotechnical change. A regime is "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems" (Rip and Kemp, 1998, p. 338). Regimes play a central role in the conceptualization of sociotechnical change processes in the MLP as (re-)alignment between regime, niche, and landscape levels (Geels, 2011). At the niche level, there are "radical innovations that deviate from existing regimes. [...] Niches are crucial for transitions, because they provide the seeds for systemic change." (Geels, 2011). The niche level provides a shielded space (Smith & Raven, 2012), in which institutions are more fluid and provide room for experimentation. The

landscape represents broader societal structures, in which institutions are more rigid and institutionalized, beyond the reach of regime and niche actors. The landscape can be treated as an exogenous factor that influences the system in focus by slowly evolving contextual conditions such as demographic change or sudden shocks such as the oil crisis in the 1970s. Actors can creatively interpret the landscape to build or erode legitimacy and advance their interests (Rosenbloom et al., 2016).

On the other hand, institutions hold the potential to enable endogenous regime change. This is based on an understanding that regimes are not homogeneous or monolithic (Smith et al., 2005), but semi-coherent sets of rule-sets: “On the one hand, regimes have coherence, shared rules, and similarity, but on the other hand contain variety, disagreement on specific issue, debate, and internal conflict.” (Geels, 2011, p. 31). Acknowledging the semi-coherence of regimes, the existence of institutional tensions and contradictions² enables the possibility of endogenous regime change (Fuenfschilling, 2019; Fuenfschilling & Truffer, 2014; Runhaar et al., 2020), rather than being dependent on external shocks as windows of opportunity, and can contribute to regime destabilization (Frank et al., 2024).

Such institutional change processes, including the emergence and diffusion of institutions, their stabilization, and decline, can be driven by different forces. Two main perspectives on this can be distinguished: the first is an ‘agent-based view’ (Strang & Sine, 2002), which suggests that actors, as individuals or collectively, intentionally design and alter institutions to protect or promote their interests, also known as institutional work or institutional entrepreneurship (Lawrence et al., 2011; Leca et al., 2008). State actors can also engage in institutional work (Vestergaard & Schmid, 2026). This perspective emphasizes agency and the potential for changing established structures by individual and collective actors.

The second is a ‘naturalistic view’ of institutional change (Strang & Sine, 2002), which conceptualizes institutions as evolving incrementally over time through recurring interactions and the gradual development of shared understandings (Berger & Luckmann, 1967). As norms and interpretations circulate among individuals and groups, they become increasingly taken for granted and resilient (W. R. Scott, 2010). This is in line with understanding regimes as “stable but continually evolving configurations of artefacts, actors and institutions” (Scrase & Smith,

² The co-existence of different institutional logics is termed institutional plurality; when they stand in conflict or tension to one another, institutional complexity (Fuenfschilling, 2019)

2009, p. 709), in which institutional change is a central component of gradual regime change.³ It emphasizes the structural or structuration aspect of how institutions restrict actors and shape similar behaviour.

Scott (2010) emphasizes that most institutionalization processes do not fit neatly into one of these categories; rather, agent-driven and naturalistic forms of institutional change represent a “continuum of forces” (W. R. Scott, 2010, p. 10).⁴ In line with this, the Triple Embeddedness Framework conceptualizes actors in a bi-directional relationship with institutions, in which they respond to institutional pressures and simultaneously shape the environments they are embedded in (Geels, 2014a). I adopt this bi-directional perspective on the relationship between actors and institutions and expand the idea to state organizations.

The next section introduces business models and business collaboration as two central activities of actors in the market sector.

2.2 Activities of market actors: Business models and collaboration

It can be assumed that a core component of the market is economic activity driven by market actors. Rip and Kemp (1998, p. 339) argue that it is not the introduction of a novelty which should be of interest when studying sociotechnical change, but the “Implementation, adoption, use, and domestication of technology [that] create and maintain social and technical linkages that are hard to undo”. The implementation, adoption, and use of a novel technology depend, among other factors, on the creation of new business models by single firms or collaboration between firms. Collaboration between entrants and incumbents is crucial for the facilitation of emerging technologies such as solar PV (E. L. Apajalahti et al., 2018). Business models have been identified as drivers of transitions (Bankel, 2026), as they can be tools for realizing the value of novel technologies, helping to commercializing them in mainstream markets and potentially entering the regime (Bidmon & Knab, 2018; Bolton & Foxon, 2015; Wainstein & Bumpus, 2016).

³ The terms ‘regime’ and ‘institutions’ share the characteristics of stability and resilience and there are ongoing discussions, whether the stability of the regime is reproduced through institutions, or through the interaction of institutions, actors, and technology. As defined above (Scrase and Smith 2009, P. 709), this thesis departs from the latter description.

⁴ These two perspectives are also part of ongoing debates on structure and agency (cf. e.g., Kern 2015; Koistinen and Teerinkangas 2021), based on Giddens (1984) structuration theory, and out of scope in this thesis.

A business model describes the business logic of an organization (Osterwalder et al., 2005), i.e. how it creates, delivers, and captures value (Osterwalder & Pigneur, 2010). Business models conceptualized in the business model canvas consist of four dimensions, which can be further divided into nine components (Osterwalder & Pigneur, 2010): value proposition, customer interface (customer segments, channels, and customer relationships), infrastructure management (key resources, key activities, and key partnerships), and financial aspects (cost structure and revenue streams).⁵ A firm's decision on which business models to engage with depends on a combination of both external factors such as regulation and stakeholders, and firm-internal factors such as path dependency and resources (Karlton & Perez Vico, 2025; Provance et al., 2011; Sump & Yi, 2021). In the following, first internal and then external factors are discussed.

Internally, adoption is influenced by the fit with existing business models and the firm's overall strategy. It seems reasonable to assume that incumbents are more likely to engage with innovations which are more similar to their existing way of doing business and do not require radical reconfiguration of existing value creation and capture processes and networks (Wainstein & Bumpus, 2016). In other words, energy incumbents are expected to choose business models which entail centralized, large-scale production (Lehmann-Ortega, 2011). Business model dimensions playing a central role in the adoption of new business models include value proposition (Bolton & Hannon, 2016), key resources and complementary assets (Smith et al., 2005), and key partnerships (E. L. Apajalahti et al., 2018). In general, solar PV is regarded as a misfit for incumbent firms, as its small-scale, decentralized nature opposes the conventional business logic of large-scale, centralized production (Huijben & Verbong, 2013; Rosenbloom & Meadowcroft, 2014). However, it has also been shown that electric utility incumbents experiment with a wide range of solar PV business models (Horváth & Szabó, 2018; Huijben et al., 2016). On the corporate level, the overall organizational strategy provides direction through goals and objectives, business scope, and strategic orientation (Wadström, 2019). Societal legitimacy is a key factor of success beyond economic performance (Geels, 2020) and can facilitate customer retention (Richter, 2013).

To assess the fit or alignment of a novel business model with external influences, both the task environment and institutional environment can be assumed to shape business firms perception and strategic action (Bergek et al., 2021; Provance et al., 2011). Such influence is important to

⁵ A detailed description of the business model canvas and its components can be found in Paper I, Table 3.

understand as firms, including incumbents, respond heterogeneously to external pressures (Bergek et al., 2021; Karltorp & Perez Vico, 2025; Näyhä, 2020; van Mossel et al., 2018; van Welie et al., 2018). The task environment refers to market-related aspects such as profitability, customer preferences, or industrial networks (Bergek et al., 2021). The institutional environment (W. R. Scott, 1992) refers to the general socio-political or industry-specific context of the firm (Geels, 2014a). Empirical cases on incumbent actors of the electricity regime emphasize external factors such as adopter preferences (Overholm, 2015) and industrial configurations (Strupeit & Palm, 2016) shaping the task environment, and political goodwill, regulations, and subsidies shaping the institutional environment (Burger & Luke, 2017; Huijben et al., 2016; Karneyeva & Wüstenhagen, 2017; Richter, 2013).

Business models can also be used to describe a more generic model for creating and capturing value from an emerging technology (cf. Zott et al., 2011). In this understanding, several actors can play key roles as they form a network for realizing a business model (Bankvall et al., 2017; Palo & Tähtinen, 2011). In this respect, several authors have investigated the importance of collaborations between electric utilities and niche actors in developing business models for emerging technologies such as solar PV (Pereira et al., 2022; Wadin et al., 2017; Yang et al., 2021). The Industrial Marketing and Purchasing literature offers approaches for understanding business collaboration between several actors and how these are influenced by their surrounding networks (Håkansson & Johanson, 1992; Håkansson & Snehota, 2017).⁶ They conceptualize collaboration as business relationships between two or more actors that aim at creating value together. Håkansson and Snehota (2017, 1995) conceptualize the substance of business relationship as activity ties, resource links and actor bonds (ARA) between two partner firms. The three layers, activity links, resource ties, and actor bonds, are interrelated and should be interpreted as a whole.

In the first layer of the ARA model, activity ties, administrative, technical, and commercial activities are tied together and coordinated. The activity layer is commonly understood as the division of labor between two firms and therefore readily observable. Factors which have been discussed in relation to niches and regimes regarding their activity ties include shifting actor roles and changing interactions within networks (Bui et al., 2016; Elzen et al., 2012). The second layer, resource links, concerns how resources are combined, including tangible and

⁶ The following two paragraphs are taken from the licentiate thesis (Altunay, 2022).

intangible resources. A core assumption of the ARA framework is that interactions in successful business relationships increase the value of resource exchanges (Laage-Hellman et al., 2021; Sundquist & Melander, 2021). Incumbents typically hold a significant amount of resources, which they can use to amplify the limited resources of niche actors (Kangas et al., 2021; Wadin et al., 2017). The third layer, actor bonds, investigates how actors form bonds by aligning goals and agendas. This human aspect of the business relation is the most difficult to observe, as it often comprises qualities that are hard to measure such as trust and social capital (cf. Arvidsson and Melander, 2020; Finch et al., 2010; Hartmann and Herb, 2015; Holma, 2012). The interaction between niche and regime actors can be challenging on this layer, as they are likely to have diverging visions, beliefs, cultures, or institutional logics (Ingram, 2015; Pekkarinen & Melkas, 2019; Smink et al., 2015).

After introducing business models and business collaboration as activities of actors in the market sector, the following section moves on to policymaking and policy implementation in the state sector.

2.3 Activities of state actors: Policymaking and policy implementation

The *state* concept encompasses the wider societal context (Silvester & Fisker, 2023), while *state apparatus* puts emphasis on the “core of the state apparatus [which] comprises a distinct ensemble of institutions and organizations whose socially accepted function is to define and enforce collectively binding decisions on the members of a society in the name of their common interest or general will” (Jessop, 1990, p. 341).

The state apparatus can be structured along two axes: governance levels on the Y-axis (vertical) and domains on the X-axis (horizontal) (cf. e.g., (Bahn-Walkowiak & Wilts, 2017; Matti et al., 2017; Meadowcroft, 2007). Governance levels, on the one hand, commonly include local, regional, and national levels (cf. e.g., (Borrás & Edler, 2020; Meadowcroft, 2007)). The nation state with its agencies has often been described as the central node or key decisionmaker (Cherp et al., 2017), but the supranational level can also play a vital role, especially in the energy domain which is guided by the legislation of the European Union (Palm, 2025). The concept of multi-level governance describes how responsibilities are transferred from the national level - upward, downward, or outward (to actors outside the state apparatus) (Matti et al., 2017, p. 665). Domains, on the other hand, represent the segmentation of activities into sectors or themes – for example, government ministries or departments – through which responsibilities

are assigned to policy implementation agencies (Cunningham et al., 2013). This structure shapes the policy process, of which the output is comprised by policy instruments and policy mixes that intervene in socio-technical systems. Within innovation policy, such instruments are designed to stimulate the creation, diffusion, and implementation of new technologies, products, processes, and business models (Borrás & Edquist, 2013; Edler & Fagerberg, 2017).

The division of the state apparatus in domains and levels makes comprehensive and exhaustive ex-ante coordination of policies complex, if not impossible (Peters, 2018). Recent studies point out that the focus on policy mixes resulted in a lack of attention to the process and actors producing policy mixes (Oltmer & Löhr, 2025; Song et al., 2023). To elevate the policy process as an equally important factor for the diffusion of innovation, we suggest that the policy process should not be included in the definition of a policy mix, in contrast to Rogge and Reichardt (2016), but defined as policymaking, policy implementation, and policy impact (see Fig. 1 in Paper IV).

Policymaking is a continuous problem-solving process (Reichardt & Rogge, 2016), involving problem analysis, consideration of alternatives, and a formal decision (May, 2003), and possibly parts of policy design on the programme level (Howlett, 2009). Responsible for policymaking, or the ‘macro-politics’ are elected ministers and politicians (Janssen et al., 2023). The policy design aspect can take place in ministries or agencies, depending on the national context and the division between policymaking and policy implementation (Edler & Fagerberg, 2017).

Policy implementation includes policy design on the micro-level, and the decisions and tasks required to execute a policy (Lundin, 2007; Montjoy & O’Toole, 1979; Rogge & Reichardt, 2016; Tosun & Treib, 2018), such as allocating financial and human resources (e.g., formulation of research agendas or distribution of funds). While it is often downplayed as a purely administrative branch of the state apparatus and has not received sufficient attention in innovation policy studies (Flanagan et al., 2011, p. 706; Song et al., 2023), policy implementation influences the outcome or effect of policymaking significantly (Braams et al., 2021; Matti et al., 2017; Reichardt & Rogge, 2016; Song et al., 2023). The bureaucrats in policy implementation hold vast resources and power (Olsen, 2009), can shape policy ideas as they enter policymaking (Normann et al., 2024), or dilute ambitious policy targets (Rodríguez-Barillas et al., 2024).

Policy impact is the delivery of policy in the target system. The reviewed literature often considers policy impact as part of policy implementation, except for Janssen et al. (2023) referring to it as the “performance arena”. The organizations of the state apparatus which are responsible for policymaking and implementation are not represented in the delivery. Policy impact can, however, involve employees employed by the state, such as teachers or hospital staff. Distinguishing between the processes in the state apparatus and the wider societal context is important in the context of state fragmentation, as it affects the stages and actors of the policy process differently.

After addressing the market and state sectors in the two preceding sections, the next section turns to how these sectors interact and co-evolve, through the lens of policy feedback.

2.4 Co-evolution across sectors: Policy effects and feedback

As described above, the output of policymaking and implementation by actors in the state sector is policy goals and instruments, i.e. policy mixes. These policy mixes create impact in the delivery stage in the sociotechnical system (or market sector), which can also be referred to as policy effects. Pierson (1993) distinguishes between two kinds of policy effects. *Resource effects* occur when policies expand or restrict certain groups’ access to resources such as funding or information. Resource effects can also be generated by the structure of the political system itself, defining or constraining the alternatives available to actors (Pierson 1993, p. 598).⁷ *Interpretative effects* are cognitive, shaping how individuals or societies understand and make sense of issues. Both types of effects can generate either satisfaction (support) or dissatisfaction (opposition) with a policy, which in turn motivates efforts to influence subsequent policy developments (Oberlander & Weaver, 2015). This interaction creates a continuous loop between policy and society - an ongoing process that Pierson (1993) refers to as *policy feedback*.

In research on socio-technical transitions, the notion of policy feedback is commonly used to capture the processes through which public policies give rise to socio-technical effects (for example, resource mobilization or the creation of markets), which in turn shape future policy decisions. Such dynamics were demonstrated by Jacobsson and Lauber (2006) in their analysis of renewable energy technology diffusion in Germany. They showed that even limited and hesitant early political support made it possible to initiate experimentation and learning within

⁷ The understanding of policy feedback adopted here is a broader than in Paper III.

a protected niche for wind and solar power. Establishing and sustaining this protected space was characterized by significant political contestation (Lauber & Jacobsson, 2016). Similar dynamics of interaction and mutual adjustment between policy and the sociotechnical system were shown, for instance, for solar PV in Germany (Hoppmann et al., 2014; Sandén, 2005), offshore wind in Germany (Reichardt & Rogge, 2016), the housing sector in the UK (Edmondson et al., 2020), biogas in Sweden (Hedeler et al., 2023), or lighting and smart meters in the UK (Geels & Ayoub, 2025).

A conceptual framework that illustrates the above described dynamics was suggested by Edmondson et al. (2019), describing how changes in the policy mix trigger changes in the sociotechnical system (policy effects) and incentivize actors in the sociotechnical system to influence the future policy mix (feedback mechanisms). The framework also acknowledges that exogenous conditions can drive both policy mix changes and sociotechnical developments. Its contribution to the sustainability transitions literature lies in specifying distinct categories of policy effects and feedback mechanisms drawn from policy studies, while incorporating exogenous conditions inspired by the concept of landscape pressures. The latter examples (Edmondson et al., 2020; Geels & Ayoub, 2025; Hedeler et al., 2023) draw on this framework and contribute to further conceptualization. Aspects which deserve further attention include the role of politics and policymaking (Geels & Ayoub, 2025).

2.5 Résumé

This résumé brings together the theoretical building blocks and explains how they relate to each other, as illustrated in Fig. 1:

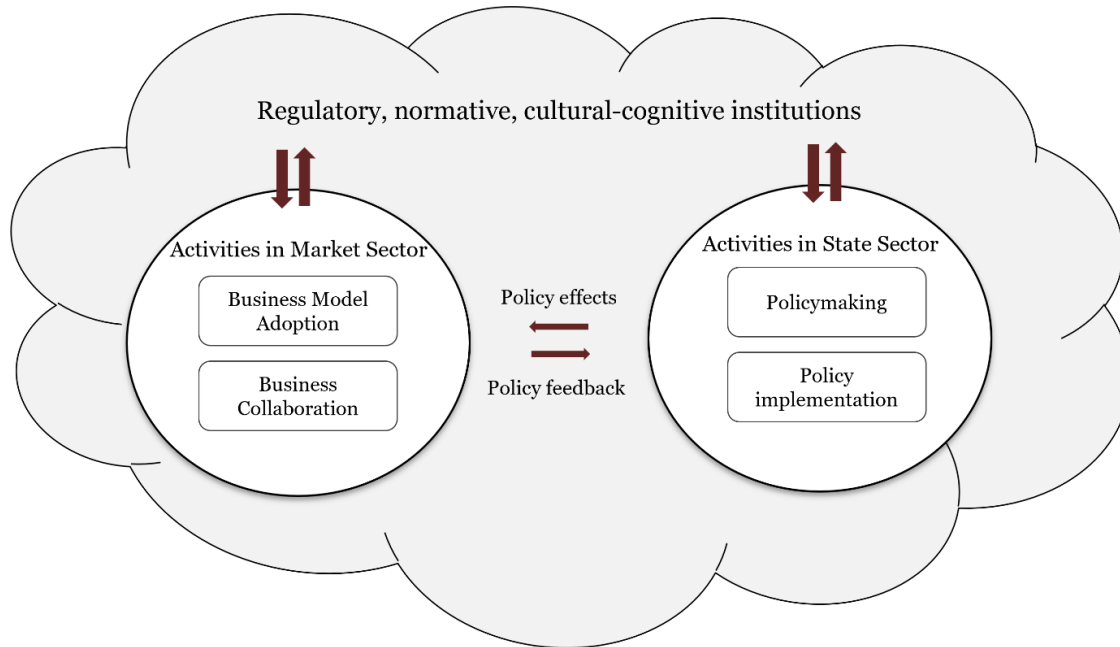


Figure 1 Schematic illustration of the theoretical building blocks.

Actors' activities in both market and state sectors experience a bi-directional relationship with institutions: being influenced by institutions and simultaneously influencing them, as represented in arrows in both directions.

Activities in the market sector (on the left) are conceptualized as business model adoption and business collaboration, by incumbents and entrants, addressing research question (i): in what ways do institutions influence activities of market actors, and how do these actors, in turn, contribute to institutional change?

Activities in the state sector (on the right) are studied in terms of policymaking and policy implementation by actors of the state apparatus, answering research question (ii): in what ways do institutions influence activities of state actors, and how do these actors, in turn, contribute to institutional change?

The interaction between the two sectors conceptualized through the lens policy effects and policy feedback allows answering research question (iii): how does co-evolution of state and market sectors shape institutional change?

3. Empirical context

The empirical context first introduces general characteristics of the market and the state in relation to the electricity system and then provides an overview of the market and policy development for solar PV in Sweden. All information which is taken from sources other than the IEA-PVPS reports (see full list in Appendix of Paper III) are marked as such.

In the market sector, the electricity system is characterized by high fragmentation after the liberalization of the electricity market in 1996, with around 144 active electricity retailers.⁸ Of those, three core firms hold the vast majority of hydro- and nuclear power production and the majority of customers: Fortum (owned by the Finnish state), Vattenfall (majority of stocks held by Swedish state), and E.ON (private). The majority of the remaining firms are municipal energy companies, mostly operating local combined-heat-and-power plants with district heating. In addition, a few private electricity retailers operate without any production of their own. This structure (without the private firms) is also represented within the distribution system, which is regulated in local monopolies and overseen by the Energy Market Inspectorate. The transmission system is owned by Svenska Kraftnät, owned by the Swedish state (Svenska kraftnät, 2026). As the energy transition evolves, incumbent firms face strategic and financial pressures, while new solar-focused entrants seek to scale their operations in a competitive environment.

The Swedish state sector, generally, is characterized by high trust in public institutions and democracy (SOM-Institutet, 2023). Over the period examined, Sweden experienced several shifts in government coalitions, beginning with a minority government led by the Swedish Social Democratic Party until 2006, followed by a liberal-conservative coalition from 2006 to 2014, a coalition between Swedish Social Democratic Party and Swedish Green Party governing between 2014 and 2022, and, most recently, a conservative coalition supported by the right-wing Sweden Democrats from 2022 until today (2026). Independent agencies and autonomous municipalities play crucial roles in executing national energy policy, which is increasingly shaped by EU regulatory frameworks (Paper IV). The Swedish policy process is formalized

⁸ Description based on Paper I; “retailer” (“elhandelsbolag”) as used in Paper I specifies that the organizational unit is independent from the grid operating unit. The thesis uses the more general term “energy company”.

and, to a certain degree, participatory, illustrated by established procedures such as 'remissrunda' in which stakeholders may submit formal reactions to suggested policy changes.⁹

The oil crisis of the 1970s acted as a potential landscape shock, raising interest in alternative energy sources and led to the introduction of the first policy support for renewable energy in Sweden. During the early development of solar photovoltaics in Sweden (before 1996), the technology was mainly adopted in small off-grid applications such as summer houses, where early adopters, often technically inclined enthusiasts, installed panels themselves. At this stage, solar energy lacked strong regulatory or institutional support and was shaped instead by widespread use of solar heating collectors, and R&D. The first dedicated policy instrument for solar cells was introduced in 1996: targeted research and development (R&D) funding, launched as part of the national program for energy transition. Yet, widespread cognitive barriers persisted, including the common belief that solar PV does not work in the Nordic Climate. The Swedish Social Democratic Party remained hesitant to introduce broader policy support measures for solar.

Between 1996 and 2010, the Swedish solar PV market entered a formative phase in which the foundations for a future market began to take shape. Inspired by Germany's rapidly expanding PV program, the Swedish Green Party pushed for national support measures, resulting in the introduction of an investment subsidy in 2005. Initially, municipalities were the main beneficiaries of this subsidy scheme, but it was widened to include industry and agriculture in 2007 and private households in 2009. Among market actors, a growing vision manifested that solar would gain a stronger foothold in Sweden, encouraging the creation of a downstream market characterized by new actors, emerging networks, and increased professionalization. Companies previously focused on solar thermal technologies began entering the PV market, while installation firms emerged as important new intermediaries. Toward the end of this period, energy companies started receiving inquiries from customers interested in solar, prompting them to explore partnerships that would enable them to offer PV solutions. Despite increasing global activity and competition along the value chain, Sweden still held several domestic manufacturing firms and diffusion remained relatively small-scale. On the regulatory side, the introduction of renewable energy certificates in 2003 did little to stimulate solar uptake, as the

⁹ Explanation of the term from: <https://www.regeringen.se/remisser/>: "The government may, through public consultations, ask relevant authorities, organizations, municipalities, and other stakeholders to submit comments on a proposal. Responses from those who have been asked to respond to a consultation are published on the website."

administrative burden was too high for small-scale installations, and the cost compensation (certificate value) was too low compared to PV cost then. Similarly, Guarantees of Origin offered limited benefit to PV producers. Overall, solar diffusion advanced, but at a modest pace (see Fig. 2), with few regulatory adjustments deemed necessary as the market was still in its early stages.

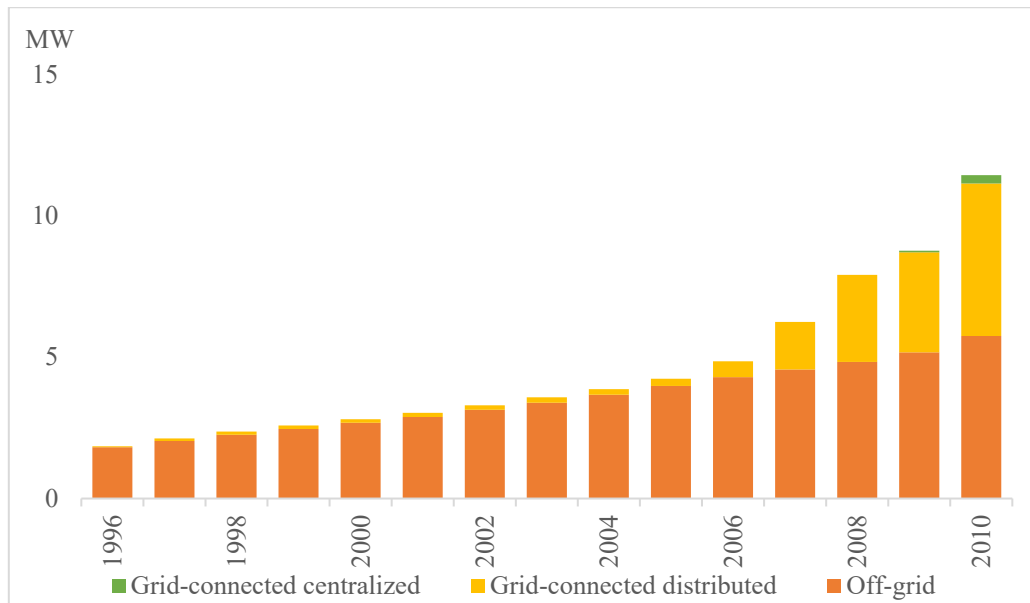


Figure 2 Cumulative installed PV capacity in Sweden (MW) 1996 – 2010 (own illustration based on (Lindahl & Öhgren, 2025)).

Between 2011 and 2022, the Swedish solar PV market entered an expansion or ‘blossom’ period, both in the market and policy sectors. While the value chain experienced the collapse of domestic production firms unable to compete with cheaper international imports, especially from Asia, the downstream market grew as the number of installations increased year after year across two segments: grid-connected and centralized PV parks (see Fig. 3).¹⁰ Municipal energy companies faced rising demand from customers interested in solar solutions and began searching for ways to respond. Through collaborations with entrant solar firms, these municipal utilities helped develop innovative business models, such as turnkey installation services and leasing arrangements, which broadened market access and accelerated diffusion. However, long waiting times for investment subsidies created uncertainty during periods of high demand. The evolving regulatory environment contributed to enabling growth; the investment subsidy was

¹⁰ Note that Fig. 2 and Fig. 3 use the same colour scheme but have different max. MW-values on the Y-axis, as the off-grid segment is no longer visible in Fig. 3 given the exponential growth of the other two segments (cf. year 2010 in both Figures).

expanded repeatedly and accompanied by simplified grid access and reimbursement rules introduced in 2011, various tax adjustments, exemptions from building permit requirements in 2016, and the national solar strategy launched the same year. Although Sweden still lacked a comprehensive regulatory framework for energy communities, the first such initiative emerged as early as 2009. The end of the period is marked by the phase-out of the investment subsidy. Altogether, this period represented a decisive shift, transforming solar PV from a niche technology into a mainstream component of Sweden’s evolving energy system

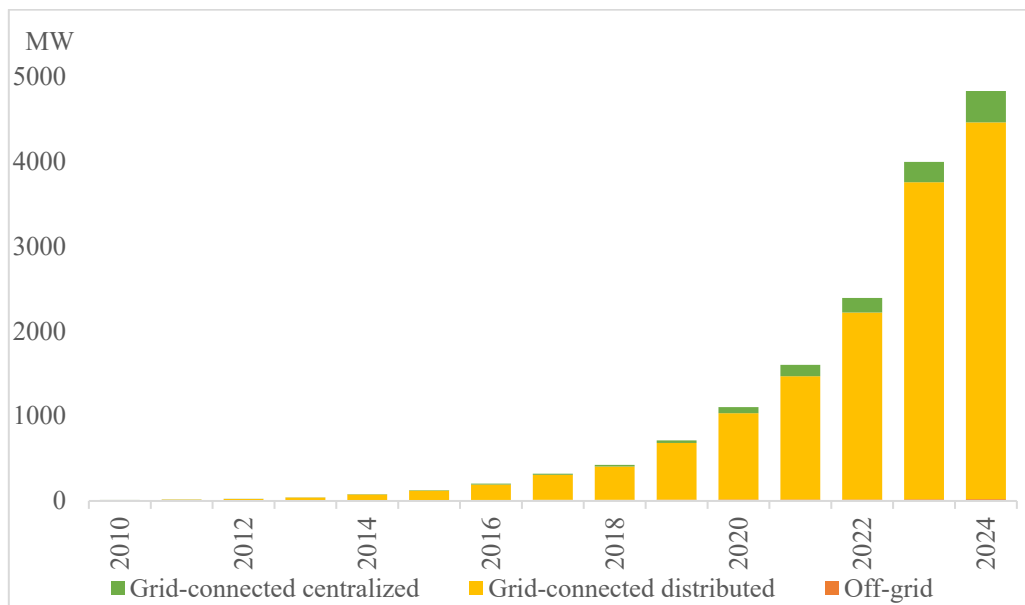


Figure 3 Cumulative installed PV capacity in Sweden (MW) 2010 – 2024 (own illustration based on (Lindahl & Öhgren, 2025)).

From 2022 to the time of writing (early 2026), the Swedish solar PV sector entered a phase of growing (in-)stability characterized by both consolidation and new uncertainties.¹¹ By this time, a well-established downstream market had formed, yet for the first time since the early 2010s, installation numbers declined in 2024, as reported in the 2025 IEA-PVPS report. This can be connected to the previous peak in electricity prices given the shortage of natural gas supply from Russia, pushing interest for residential solar PV (Werner, 2025). Despite this slowdown, market actors continued to predict a “second boom,” arguing that Sweden is still on the verge of a major market shift (interview, Paper III). The contours of a new phase are emerging, shaped by the increasing integration of PV with batteries, the expansion of large-scale solar plants, and rising technical challenges associated with hours of surplus production on the grid.

¹¹ This paragraph is not based on Paper III, but added recently based (Lindahl & Öhgren, 2025).

Policy developments have created both stability and new sources of uncertainty: the green tax deduction¹², which replaced earlier subsidies and offers a 20% tax reduction for solar installations (reduced to 15% in mid-2025), has provided a predictable support mechanism.

Moreover, since the beginning of 2026 (at the time of writing this thesis), micro producers (but not members of energy communities) do not longer receive an income tax credit of 0.60 SEK per kilowatt hour for surplus electricity fed into the grid, which functioned as a de facto feed-in premium, formally regulated under fiscal law.

¹² The green tax deduction reduces the purchase price directly on the invoice and is administered by the Swedish Tax Agency rather than by an energy authority.

4. Method

The method chapter starts with outlining the relevance of the Swedish solar PV case, continues with describing methodological choices and study design, and closes with a personal reflection and limitations. The diffusion of solar PV in Sweden was the empirical context of my PhD work, with energy communities as a particular sub-case. While the policymaking and implementation context in Papers III and IV concerns wind energy communities as well, the discussions revolve around the actors, activities and policies specifically targeting solar PV technology.

4.1 Case study approach and relevance

Case study research aims at generating a holistic understanding of how social processes unfold in real-world settings. This thesis incorporates multiple facets of ‘case study’: as a research strategy, which is well-suited for exploratory research of emerging phenomena (Priya, 2021); as method in Paper II; and as a highly iterative research process which is tightly linked to empirical data (Eisenhardt, 1989). Such an iterative back-and-forth between data and theory building is also known as systemic combining (Dubois & Gadde, 2014) and captures the essence of the presented work, both in the compiled Papers and in the kappa as a whole. The emergent nature of case study research is described in this quote: *“The strength of the case method is that it allows these decisions to emerge in the course of the research process as the nature of the phenomenon and its context become clearer.”* (Dubois & Araujo, 2005, p. 208).

The emerging phenomenon or central case is solar PV development in Sweden, with energy communities as a sub-case. The systems boundary is wider than the case, including the electricity regime in Sweden, as described in the empirical context in chapter 4. Solar PV development in Sweden provides a fruitful case for studying institutions and institutional change. The studied period between 1996 – 2025 was characterized by technology diffusion and experimentation, during which the installed PV capacity grew manifold, accompanied by new laws and regulations, changing discourses, business models and networks. Actors worked towards destructing the belief that solar PV is not technologically or economically feasible in the Nordic climate. This sociotechnical change process provides a sound basis for studying the effect and evolution of institutions. Energy communities were chosen as a sub-case to illustrate diverging patterns of sociotechnical change.

4.2 Study design

This chapter explains how the research questions and framing relate to the papers included in this thesis. At an overarching level, the thesis consists of two studies, of which the first covers the market sector, and the second the state sector. The thesis synthesises insights from these two studies and discusses them in relation to the research questions by reframing the findings in relation to institutions and institutional change, as described in the résumé.

Table 1 Study design

	Study 1: Market sector		Study 2: State sector	
	Paper I: Business Models	Paper II: Business Collaboration	Paper III: Policy effects and feedback	Paper IV: Policymaking and implementation
(i)	In what ways do institutions influence activities of market actors, and how do these actors, in turn, contribute to institutional change?			
(ii)			In what ways do institutions influence activities of state actors, and how do these actors, in turn, contribute to institutional change?	
(iii)	How does co-evolution of state and market sectors shape institutional change?			

As outlined in the analytical framework, Study 1 approaches the strategic actions of actors in terms of business models (Paper I) and business collaboration (Paper II) to investigate how institutions shape actor strategies and are shaped by them (research question (i)). Study 2 investigates the effect of institutions on policymaking and policy implementation (Papers III and IV) and vice versa to answer research question (ii). The combined perspective of Studies 1 and 2 and the aspect of co-evolution of market and state sectors through policy effects and feedback (Paper III) provide an answer to research question (iii). While Paper III investigated system-level phenomena, the findings from Papers I, II, and IV) need to be aggregated from organizations to the sector level to answer question (iii). The term ‘organization’ is used synonymously with ‘actor’.

4.3 Overview of studies

Study 1 on the market sector resulted in two publications (Paper I and Paper II). Paper I assesses the overall ‘strategic fit’ of novel solar PV business models with internal and external factors influencing incumbent energy companies. To this end, secondary data from the 30 largest energy companies’ websites and annual reports are combined with nine in-depth expert interviews. The strategic fit is assessed on three levels: horizontal alignment (novel business model and existing business model), vertical alignment (corporate strategy and identity), and environmental alignment (task environment and institutional environment). Paper II applies case study research to investigate business relationships according to the ARA framework (activity ties, resource links, and actor bonds). The case studies concern six dyadic relationships of incumbent energy companies and entrant solar firms and are based on primary data from ten expert interviews with managers holding central positions in the respective relationships. In both Papers, content analysis is the main method for analyzing primary, qualitative data.

Study 2 on the state sector resulted in Papers III and IV. Paper III combines perspectives on state and market using the concept of policy feedback, for which the Swedish parliament debate from 1996-2022 is analyzed to identify storylines by liberal-conservative and progressive-center discourse coalitions. Market development is investigated using market reports by IEA-PVPS and three expert interviews. The two sides are combined by creating a timeline and tracing policy effects and feedback for two specific cases: the investment subsidy for solar PV and energy communities. Paper IV conceptualizes the influence of a fragmented state apparatus in governance levels and policy domains, combined with stages of the policy process, on policy outcomes. This is illustrated with the policymaking and implementation process in the case of energy communities, based on content analysis of publicly available policy documents.

Table 1 summarizes the appended papers, empirical material, method, and levels of analysis in the two studies. A detailed description of the method can be found in each paper. The overall methodological approach adopted in this thesis is qualitative and exploratory, and grounded in a critical realist perspective (cf. Danermark et al., 2019; Easton, 2010).

Table 2 Overview of studies.

	Study 1: Market sector		Study 2: State sector	
	Paper I	Paper II	Paper III	Paper IV
Main analytical approach(es)	Business models, Strategic management	Business Collaboration, Industrial networks (ARA)	Policy effects and feedback	Multi-level governance, policy processes
Case study	PV business model adoption 30 largest energy companies	Four collaborations for turnkey sales business model	Solar PV development and energy communities	Policymaking and implementation in energy communities
Empirical material	<ul style="list-style-type: none"> ○ Interviews ○ Company websites and annual reports 	<ul style="list-style-type: none"> ○ Interviews 	<ul style="list-style-type: none"> ○ Parliamentary debates ○ Policy documents ○ Market reports ○ Interviews 	<ul style="list-style-type: none"> ○ Peer-reviewed publications ○ Policy documents
Method	Content analysis	Content analysis	Discourse analysis, content analysis	Content analysis

4.4 Data analysis

The theoretical concepts used to analyse the activities of actors in the market and state sectors are described in detail and operationalized in the respective papers (e.g., business models in Paper I). This thesis reframes the findings of the appended Papers in the context of institutions, which requires additional elaboration. While regulative institutions define the boundaries of actor activities, normative institutions shape what is perceived as desirable and morally aligned (what should be done), and cultural-cognitive ones what actors deem viable (what is possible). Table 3 provides examples of the three pillars of institutions in the context of sociotechnical change, based on the text in section 2.1. In addition, it specifies the basis of legitimacy based on Scott, (2001).

Table 3 Operationalization of institutions.

	Description	Example for sociotechnical change	Basis of legitimacy
Regulative	Rules, laws, sanctions	Policy, industry standards	Legally sanctioned
Normative	Social relations, intrinsic motivation	What function a technology is supposed to fulfil, e.g. design principles	Morally governed
Cultural-Cognitive	Worldview, beliefs	Expectations, visions	Culturally supported, comprehensible

As the objects of study in the two sectors are organizations, a central aspect of operationalization is how institutions are filtered and interpreted at the level of organizations (Greenwood et al., 2010, 2011). The resulting decision or activity depends on an organizations ownership, identity, and logic on the one hand, and by whom the organization seeks to be perceived as legitimate on the other hand. Table 4 exemplifies how institutional pressures can be interpreted by organizations in the market and state sectors. At the regulative level, organizations need to comply with rules and regulations. Normative institutions relate to “What are we supposed to do?”, and cognitive ones to “Who are we?”.

Table 4 How institutions are interpreted at the organizational level.

	Organizations in market sector	Organizations in state sector
Regulative	What are we allowed to do? (rules, regulations, code of conduct)	What are we allowed to do? (rule of law)
Normative	What products and services are we supposed to sell? What do customers and stakeholders expect from us?	What policy are we supposed to design and implement? Is it in public interest?
Cultural-Cognitive	Who are we? What is manifested in our mission, vision, goals, and strategy? Is it in line with the organizations or groups values?	Who are we? What are the mission and goals specified in government directives?

4.5 Research journey, methodological choices and limitations

While electricity production from solar PV sources was still marginal (<1%) and not visible in the Swedish Energy Agency’s statistics around 2018, there was diverse market activity in terms of business model development, collaboration, increasing number of prosumers, and removal of regulative hurdles in the decade between 2011 and 2022. In this context and given the knowledge from another project on intermediation in wind and solar PV projects (see, e.g., (Aspeteg & Bergek, 2020; Aspeteg & Mignon, 2019)), Anna Bergek initiated a project investigating the strategies and critical trade-offs energy companies faced with solar power diffusion. Given my academic background in energy and management studies combined with the eagerness to learn Swedish, I joined the project as a PhD student in early 2019. Study 1 (Papers I and II) are mainly based on this project funded by the Swedish Energy Agency, “Electricity retailers and solar power diffusion: strategies and critical trade-offs”. Based on the work and results of this first project and Study 1, I became more interested in the legislation driving and hindering the diffusion of solar PV in Sweden, and whether and how the legislation favoured individual PV plants over collective ones. Thankfully, I was able to work on this question in two projects (both funded by the Swedish Energy Agency): “Innovative business models for a large-scale diffusion of solar PV” with Ingrid Mignon and Amanda Bankel, both at the same department at Chalmers, and “Community solar: participation, organisation, and regulation” with my supervisor Anna Bergek and Jenny Palm at IIEEE Lund, who became my new co-supervisor. The result of this work is part of Study 2 and mainly presented in Paper III, but it also provided the basis for the conceptual work on the state (apparatus) and the policy process.

The conceptual work of Paper IV was funded by Chalmers Energy Area of Advance and Adlerbertska Research Foundation.

The PhD process was emergent, where the first project only lasted until my Licentiate in 2022. While this allowed great freedom in shaping the direction of my PhD and following ideas sparked by early work, it simultaneously created challenges for creating a coherent thesis retrospectively. On the one hand, having a PhD project outlined from the start can be easier, as one can return to the red tread in confusing times. An emergent research strategy, on the other hand, enabled me to develop as a researcher, identify critical and relevant research avenues, and successfully apply for project funding together with my supervisor.

Another limitation and enrichment were the shift of focus from market to state sector. With a background in management studies and the energy sector, and experience with interviews from my master's thesis, Study 1 on the market sector was quite inside my area of previous competence. This was quite different for Study II. For Paper III, I embraced discourse analysis as a theory and method, and for Papers III and IV, I delved deep into political science literature. Over the past years, I learned what interdisciplinarity means; I learned about systems, sociotechnical change, and politics; but still, the more I learn, the more I realize how much I don't know.

The methodological choices also pose limitations. Study 1 is mostly based on interviews, and interviewees are prone to different biases (e.g., social desirability (Fisher, 1993)). My personal experience was that interviewees shared surprisingly much, almost as if the interview was a closed space where they could be anonymous and share concerns and stories of conflict. While interviewees can be expected to avoid sharing details which would put them into a negative light, this limitation was counteracted by triangulation (Eisenhardt, 1989), for instance, comparing interview content with other types of data, such as annual reports, market reports, policy documents.

Study 2 (policy feedback and policy processes) used publicly available political documents, such as transcripts of the political debate, budgets, and formal legislation. To further improve the understanding of the co-evolution of policy change and sociotechnical change, such a study could be enriched with societal discourses from news articles and other publicly available sources. This was, however, not in focus, as the purpose of Paper IV was to enrich the understanding of the *political* system in sociotechnical transitions. Moreover, Study 2 is based

exclusively on secondary data. Primary data from semi-structured interviews would allow for a more nuanced understanding of state actors' perception of institutions and institutional work (e.g., aspects they experience as enablers or hinders for transformation).

Considering the elements of a sociotechnical system – actors, technology, and institutions – the focus in the empirical work was very much on the social, or actor side, rather than the technical (resources, infrastructure) side. Developments along the supply chain in Sweden and worldwide, such as the decline of domestic solar panel production (Andersson et al., 2021) or decreasing panel prices are only mentioned in side notes. Nevertheless, the focus on actors aligns well with the purpose of this thesis and the empirical and conceptual work of the compiled papers. Embedded in a critical realist perspective (Danermark et al., 2019), a meeting point between constructivist and positivist approaches, the activities of actors are embedded in, and limited by, the bio-physical reality surrounding them.

In addition, this study attempts to combine a micro-level and a macro-level analytical lens. Specifically, the analysis simultaneously treats organizations as strategic actors while also examining sector-level dynamics and processes of co-evolution. While this integrative approach offers a more holistic understanding of sociotechnical change, it inevitably involves trade-offs. Emphasizing micro-level organizational practices and decision-making restricts the emphasis that can be devoted to broader structural and institutional dynamics shaping sectoral change. Simultaneously, attention to macro-level patterns and interactions between sectors constrains the depth of analysis of intra-organizational processes and actor-specific mechanisms.

Finally, the selection of sub-cases embedded in the broad case of solar PV development in Sweden, was inspired (and limited) by the contemporary relevance of certain incidents or debates. The thesis tells a story based on primary and secondary data I collected and analysed, conference visits, and interactions I had as a PhD student.

5. Summaries of appended papers

Chapter 5 provides short summaries of the four Papers in this compilation thesis. Short descriptions of the author contributions, conference presentations, and review/publication processes are provided at the end of each section.

5.1 Paper I: Business models

Altunay, M., Bergek, A., Palm, A. (2021) Solar business model adoption by energy incumbents: the importance of strategic fit. *Environmental Innovation and Societal Transitions*, 40, 501-520.

The first paper is an exploration of the drivers and challenges energy incumbents experience in adopting solar business models. The purpose of this paper is to identify and explore potential explanations for the business strategies of electric utility incumbents in relation to solar PV technology. More specifically, the paper maps the solar business models adopted by the 30 largest electric utilities in Sweden and analyses to what extent these models strategically fit, i.e. are aligned with the incumbents' existing business, corporate strategies, and external environment in order to answer two research questions: "What characterises the solar business model adoption pattern of Swedish electric utility incumbents?" and "To what extent can strategic fit explain the adoption pattern?"

Based on analysis of company websites and annual reports of 30 energy companies (i.e. retailers) and semi-structured interviews with nine of those, Paper I explores the adoption patterns of solar business models and the firms' motives for (not) adopting. Five business models are identified: PV turnkey sales, premium reimbursement, solar electricity sales, community solar intermediation, and PV plant leasing. A framework of 'strategic fit' is developed, explaining the adoption patterns based on three levels of alignment: Horizontal alignment with the existing business model; vertical alignment with corporate strategy; and environmental alignment with the task environment and the institutional environment. The work is explorative and inductive, meaning that the framework is a result of the data analysis, rather than pre-defined. Each solar business model is described in terms of the dimensions of the Business Model Canvas (Osterwalder et al. 2005; Osterwalder and Pigneur, 2010) and the levels of alignment assessed based on our own conceptualization presented in Table 4, p. 508. Overall, we find that not one single level, but a combination of the three levels of strategic alignment (horizontal, vertical and environmental) explains solar business model adoption.

Contrary to earlier findings, horizontal alignment with existing business models is not a decisive factor in our study. While the infrastructure dimension seems to have a higher importance than other dimensions, misalignments can be managed, for instance, through outsourcing. In relation to vertical alignment, organizational goals are central for business model adoption and highly depend on whether the energy company is public or private. For instance, only municipally owned energy companies, which have social and environmental goals next to economic ones, are the ones adopting (or facilitating) community solar.

In relation to environmental alignment, the task environment presents quite traditional incentives and pressures, such as profitability and high competition. The premium reimbursement model, for instance, is adopted by basically all companies, despite a short-term lack of profitability, because of the high competition in the industry and the need to retain customers. The institutional environment is mainly characterized by perceived regulatory uncertainty.

Paper I was written in collaboration with Anna Bergek and Alvar Palm. I was the main responsible for the collection of empirical data (interviews, websites, annual reports), analysis, and writing of the results section. Anna was mainly responsible for the theory section, and Alvar for the empirical context. The conceptualization, writing and reviewing the manuscript were a collective effort. The idea for this article was presented at digital NEST and IST conferences 2020 during Covid-19. It was submitted to and published in EIST after constructive reviewer comments and a major revision.

5.2 Paper II: Business collaboration

Altunay, M. & Bergek, A. (2023): Interaction between energy incumbents and solar entrants: Relationship status complicated, *Environmental Innovation and Societal Transitions* 46, 100695.

The second paper is very much a continuation of the previous work, inspired by the collaboration between energy companies (incumbents) and solar installation firms (new entrants) in the PV turnkey sales business model. It was, at first, surprising to us (the project team) that those firms would collaborate to offer PV turnkey sales which, as a business model, could function well without the involvement of energy companies and seems detrimental to their established business model by turning consumers into prosumers. The purpose of the paper is therefore to study the evolution of business relationships between incumbents and new entrants, in order to contribute to the conceptualization of niche-regime interaction, and answer the following

research question: “How do activity links, resource ties, and actor bonds evolve in business relationships between new entrants and incumbents, and what types of interactions result from the interplay between them?”

To understand the company’s motives for entering this business collaboration and its evolution, interviews were conducted with representatives of six firms engaged in four dyadic relationships, applying the ARA (Activity links, Resource ties, Actor bonds) framework. Based on the analysis, three types of interactions between niche and regime actors are derived: technology-related, network-related, and institution-related interactions.

A technology-related interaction describes how complementary resources were combined across entrants and incumbents: The solar firms brought delivery including installation of PV turnkey systems and contact with technology suppliers into the relationship, while the energy companies had trust in their brand and existing sales channels. While the value of solar firms’ resources increased over time, the incumbents’ resources decreased as the solar firms grew. The energy companies experienced a steep learning curve (trained by the solar firms) and took over increased project responsibilities over time: Developing sales teams and knowledge in-house, responsible for plant configuration and customer contact.

This change is intertwined with the other two interactions. Regarding institution-related interactions, the studied case didn’t start with misalignment of goals and visions (which has previously been described in niche-regime interaction), it rather started in co-creation. The dyads created actor bonds as they had a common vision to establish a solar PV market and expand sales channels (entrant solar firms) or retain customers (incumbent energy companies). As the solar firms grew in terms of customers and company size, however, they established a stronger position in the network, became more independent of the energy companies’ network and reputation, and started to circumvent them, describing a network-related interaction.

Interpreting the results from the worm-eye (or micro, actor-level) perspective to a bird-eye (or macro, system-level) perspective, Paper II finishes with a conceptual discussion of “niche” and “regime”. The terms as initially described in the MLP refer to the levels of structuration and sociotechnical configuration in a system. We recommend moving away from associating incumbents with regimes and new entrants with niches or using the terms “niche-actor” or “regime-actor” and encompassing the initial understanding of niches and regimes in terms of their structuration. Actors have heterogeneous strategies and organization-level goals, influencing

their behaviour – whether they are incumbents or entrants. Moreover, as the case study illustrates, the difference between new entrants and incumbents in terms of resources and power can decrease over time as resources and power positions shift.

In the process of Paper II, I took on more responsibility compared to Paper I. Besides the collection of empirical data (interviews), analysis, and results section, I was also mainly responsible for developing the theory section. Anna was responsible for the introduction. We together conceptualized the framework and discussion and wrote and reviewed the main draft. The idea for this article was presented internally at Chalmers and at digital NEST and IST conferences 2021 during Covid-19. It was submitted and published in EIST after constructive reviewer comments and a major revision.

5.3 Paper III: Policy feedback

Altunay, M. (n.a.) The mediating role of political debate in policy feedback processes: Dis-course coalitions in the emergence of solar PV in Sweden. Manuscript submitted to the *Journal of Environmental Policy and Planning*.

The purpose of Paper III is to investigate how political debate mediates feedback from the sociotechnical system and leads to policy change by answering the following research question: How is feedback from the sociotechnical system received by the authorities and under which conditions does it cause policy change?

To this end, a qualitative discourse analysis of political debate is conducted on solar PV technology in the Swedish parliament between 1996-2022. Two cases illustrate the mediating function of feedback, using storylines by liberal-conservative versus progressive-centre discourse coalitions: (1) the introduction and phase out of an investment subsidy and (2) the lack of policymaking for energy communities. The study overall confirms that policy feedback is mediated by political debate, which enables or hinders policy mix change.

Policy feedback could be identified when politicians refer to demands from actors in the sociotechnical system, such as reducing customers' waiting times for the investment subsidy, or wishing certainty about the future of the subsidy. The article discusses instances where policy feedback resulted in policy changes or was blocked by conflicting interests. Interestingly, the communicated willingness to support solar PV differed substantially between government

coalitions, but the implementation of supporting policies was relatively consistent across governments.

The discourse analysis reveals that political debate does not only mediate well-known types of policy feedback communicated by actors, but also techno-economic feedback. The understanding and vision of politicians in relation to solar PV in Sweden changed significantly during the studied period: While the initial period was marked by scepticism, the increased visibility of PV technology in Sweden moved the discourse towards communicating solar PV as a technology which works in Sweden and is a part of the energy system. It is reasonable to assume, however, that this shift was also facilitated by other types of policy feedback by market actors and networks, and exogenous factors such as the global rise of solar PV.

Paper III is a single author publication, developed with supervision, guidance, and feedback from my main supervisor Anna Bergek. An earlier draft of the manuscript was presented in a full-paper track at the Eu-SPRI conference 2024 in Enschede, Netherlands. The article was then submitted to a journal and rejected after review, in which two reviewers expressed strongly opposing opinions.

5.4 Paper IV: State apparatus

Altunay, M., Bergek, A., and Palm, J. (n.a.): Innovation policy in a fragmented state: The influence of dispersed processes on the establishment of energy communities in Sweden. Manuscript to be submitted to a peer-reviewed journal.

The last article was inspired by the work on political debates in Paper III, where it became apparent that the political system is not well conceptualized in transitions and innovation policy studies, with many policy recommendations targeting ‘the government’ as if it was a unitary actor. The purpose of Paper IV is to conceptualise the state apparatus as a multi-level, multi-domain organisational structure, to answer the research question: How does the fragmentation of the state apparatus affect innovation policy mixes?

The paper therefore shifts the analytical focus from policy mixes to the fragmented state apparatus that produces them and proposes a framework of the state apparatus for innovation policy, distinguishing between vertical governance levels (e.g., national, regional, local), horizontal governance levels (e.g., policy domains), and a novel distinction of the policy process: policy-making, implementation, and impact.

This conceptualization is based on reviews of the literature on the state and government in innovation policy and sustainability transitions and draws on concepts from political science. The suggested conceptual framework is then illustrated by the case of policymaking and implementation in the context of energy communities in Sweden.

The Swedish case illustrates how policymaking on energy communities unfolds within a fragmented state apparatus, where responsibility and interpretive authority are distributed across ministries and agencies with diverging institutional logics. At the policymaking-level, horizontal fragmentation is illustrated through a controversy, where disagreement between the ministry of finance and the ministry of trade and industry resulted in political non-resolution. Vertical fragmentation is discussed at the example of the national government failing to implement EU-level regulation on ECs, illustrating diverging expectations and a lack of political leadership. At the implementation level, the work of two agencies is discussed to illustrate another horizontal (domain) fragmentation: The Energy Market Inspectorate who was mandated to translate EU-regulation into Swedish law had a focus on regulatory compliance and equality between market actors, hindering the Swedish Energy Agency's more transformative understanding of citizen engagement. Overall, the case illustrates how fragmentation of the policy process resulted in a policy mix leaving project developers without clear guidelines, slowing down the diffusion of energy communities in Sweden. Paper IV contributes to a more nuanced understanding of the effect of the policy process on policy mixes by illustrating the fragmentation of the state apparatus both conceptually and empirically.

Paper IV was developed in collaboration with Anna Bergek and co-supervisor Jenny Palm, with me as a lead author. An early version of this manuscript was presented and discussed in a full-paper track at the IST conference 2025 in Lisbon.

6. Synthesis

This chapter synthesizes the findings from the four papers in order to answer the research questions. Sections 6.1 and 6.2 describe the effect and evolution of institutions in the market and state sectors, while section 6.3 investigates the co-evolution between the two sectors. Each section corresponds to the respective research question.

6.1 Effect of institutions on market actors' strategies and their influence on institutionalization

This section synthesizes how institutions shape market actors' activities and vice versa, related to RQ (i). The findings illustrate that regulatory institutions provide the conditions or the playing field in defining the roles and responsibilities of market actors and can provide incentives or barriers for firms to adopt business models or enter new collaboration. Cultural-cognitive and normative institutions influence actors and result in different strategies based on company identity, ownership, and logics, as described in the data analysis.

The investment subsidy for solar PV is an example of a law (regulatory institution) functioning as an incentive, as its resource and interpretative effects helped to establish a common vision (cultural-cognitive institution) for solar PV in Sweden and enabled the first industry associations (see Paper III). It is notable that all collaborations studied in Paper II emerged around 2011, shortly after the investment subsidy was extended to all actor groups. This market opportunity was specifically mentioned in the interviews in Papers I and II. The subsidy also created tangible customer demand for PV rooftop plants which is evident from customers inquiring with their respective energy companies (interviews Paper I), who – at that time – had no knowledge or experience in the field.

Interestingly, the collaborations are simultaneously a result of regulation functioning as a hinder: municipal energy companies are restricted in Sweden to selling products and services which are not readily available on the market (Paper I), which forced them into partnerships for the PV turnkey sales business model. This regulatory hinder, was, however, interpreted differently by the municipal energy companies in Paper I. The most outstanding example was a firm who had previously received negative publicity after announcing plans for constructing a controversial electricity production plant and therefore interpreted existing regulations most narrowly. Other municipal energy companies interpreted the regulation more widely and were from the beginning more involved in the PV turnkey sales business model. The example

demonstrates how a single institutional pressure can lead to different responses among market actors, as organizational identity shapes how the pressure is interpreted, prioritized, and enacted.

Combined with external factors, organizational identity and business logic shape which business models are viable. For energy companies, the core business model is to produce and sell large-scale electricity. PV turnkey sales have a low alignment with this existing business model (see Paper I), as it turns customers into prosumers, and requires service aspects such as site visits and individual configuration. Shifting corporate identity to accommodate business models which are fundamentally different would require rather time-intense, non-material investments, and was only observed at one single, municipal, energy company in Paper I, which sold PV leasing contracts at the time of the study. This firm acquired intense training and consulting at strategic and operational levels to accomplish this shift. In Paper II, however, which investigated the collaboration in the PV turnkey sales business model in more detail, we found out that the division of labour shifted over time, so that the energy companies took over more responsibility for plant configuration and customer service. In order to be successful at this, the energy companies had to learn a service business logic and often created a new sales division to this end. I argue that creating a new division allows for the co-existence of different institutional pressures, rather than forcing the whole organization to change, which has been identified previously as an organizational response to institutional complexity (Greenwood et al., 2011).

Ownership was also a decisive factor influencing the business collaboration between energy incumbents and solar entrants in Paper II: the incumbents in this study were municipally owned energy companies, with strong local anchoring and municipal sustainability goals (hybrid firms in between public, non-profit and private, for-profit).¹³ The solar firms, however, were private companies, aiming mainly at expanding company growth (private, for-profit). We observed a clear clash between the public state sector logic and private market sector logic, as the companies had different goals in the long term: municipal energy companies had much stronger determination for customer satisfaction due to their local embeddedness, experiencing stronger (normative) pressures of social legitimacy (as suggested by Greenwood et al. (2010)). Contrary

¹³ Municipally owned firms can be classified as ‘hybrid organizations’ (Pache & Santos, 2013), influenced by both market and state sector logics.

to the literature on niche-regime interaction (e.g., Bui et al., 2016; Diaz et al., 2013; Elzen et al., 2012; Ingram, 2015), the goal alignment did not increase through interaction and adaptation, but the opposite: the joint ventures started with well-aligned goals, decreasing over time, as resources and network positions shifted. Several of the solar entrants ‘piggybacked’ on the incumbents’ resources (well-established brand and customer channels) to grow their own networks, until they showed misconduct in ways which destroyed the relationships at the level of actor bonds and incumbents searched for alternative business partners (Paper II). In other words, the solar entrants drew on the legitimacy of their municipal collaboration partners, until they had grown their own brand and networks.

Considering the latter aspect of research question (i), the following paragraphs illustrate how market actors influence institutional change. In line with understanding institutions as highly resilient, cultural-cognitive, normative, and regulative social structures (W. R. Scott, 1992, 2010), I argue that the collaboration of incumbents and entrants established the PV turnkey business model as an institution in the market sector. To reach this, they needed to alter a cultural-cognitive institution, concretely to discontinue customers’ and policymakers’ belief that northern, dark Sweden is not suitable for solar PV, and create an optimistic vision instead (Papers II and III). In other words, solar PV was not considered a legitimate technology for Sweden (see also economic arguments by opposing discourse coalition in Paper III); and incumbents and entrants re-framed it in a collective effort to build legitimacy for solar PV technology. The emergence of the PV turnkey business model as an institution is indicated by a variety of factors. In regulative terms, policy changes addressed bottlenecks caused by the diffusion of the business model and the increasing number of micro-producers, and the investment subsidy became more independent from yearly budgets as a general green tax deduction (Paper III). In normative and cultural-cognitive pillars, I observed that other collaborations copied the business model; that the number of electricity companies adopting the business model increased, as it spread from a few to 42 firms at the time of writing Paper II; that companies outside the energy sector imitated it (e.g., IKEA); and that customers demanded turnkey systems from their local energy companies, expecting them to deliver (Paper I).

An example of institutional continuity, reinforced by (municipal and other) energy companies, is the core business logic of centralized electricity provision. While many energy companies needed to create service divisions to provide customer support, this activity was added to their existing core business logic of centralized, large-scale electricity production, rather than

replacing it. Most energy companies in Sweden are in municipal ownership and responsible not only for electricity sales but also combined-heat-and-power plants with district heating. Despite growing numbers of micro-producers, this underlying market structure has not changed with the institutionalization of the PV turnkey sales business model (yet).

The findings demonstrate that institutions shape actions of market actors and can act both as an incentive and a barrier. The response is mediated through factors such as organizational identity and business logic. Market actors, however, also contribute actively to altering institutions by legitimation of new technologies and business models, i.e. engaging in institutional work (Leca et al., 2008).

6.2 Effect of institutions on state actors' activities and their influence on institutionalization

This section answers RQ (ii) by discussing the effect of institutions on state actors' activities, investigated through policymaking and implementation, and how they in turn influence institutional change.

Regulatory (or political) institutions define how policy processes look like and how policy change (i.e. policy goals and instruments) become effective (Hall, 1993). More concrete regulatory institutions emerging in the solar PV development in Sweden are described further below.

Diverging cultural-cognitive and normative institutions shaping political ideologies and activities of actors in the state sectors was observed at policymaking and implementation stages, across governance levels (e.g., EU versus national) and policy domains (e.g., ministries). While ownership of organizations in the state sector is homogeneous, identity also acts a filter and interpretation of institutional pressures, resulting in certain activities to be perceived as legitimate (as described in data analysis). Actors in the state sector simultaneously play an important role as legitimacy evaluators of technologies or market actors.

The first example concerns policymaking for solar PV: When the technological and economic viability of solar PV was accepted by most parties around 2014, it led to different suggestions in terms of policy support (Paper III). The government coalition (Swedish Social Democratic Party and Swedish Green Party) argued for continuation of the investment subsidy, while the liberal-conservative opposition argued that the technology was ready to stand on its own feet

– using the sales of PV turnkey systems by IKEA as an argument. This is because the party positions on solar policy are influenced by broader (energy) politics, such as norms of free markets and technology neutral policies (Paper III). Despite the same cultural-cognitive institution – solar PV is a viable technology in Sweden today – the political parties responded in different ways, illustrating the heterogenous responses of actors based on organizational identity and resulting understanding of legitimacy.

The second example covers policy domains for energy communities in 2008, when the minister for industry and trade¹⁴ promised to solve a tax issue concerning energy communities and was blocked by the finance minister (Papers III and IV). While the minister for industry and trade supported citizen engagement in the energy transition and promised finding a solution, the finance minister favoured equal terms for existing actors of the electricity market. The ministers' arguments were based on different normative and cultural-cognitive institutions, such as democratic participation and collective problem-solving, versus market-neutral and status-quo oriented institutions. In the latter understanding, fairness is understood as identical rules and conditions for all market actors, and state intervention that favours specific actors is seen as inappropriate (normative); on a cultural-cognitive level, electricity markets are taken for granted as dominated by professional incumbent actors, and citizens are cognitively framed as consumers, not co-producers. This is also an example of institutional stability or regime continuity, as the finance minister's decision resulted in continuation of the existing tax legislation.

Similar tensions could be observed in policy implementation in 2021, when agencies interpreted the potential role of energy communities differently (Paper IV). The Energy Market Inspectorate, on the one hand, prioritized regulatory neutrality and competition. The Swedish Energy Agency, on the other hand, articulated a broader understanding of energy communities as part of the energy transition, emphasising their potential to support experimentation, flexibility, and new forms of citizen participation. The Swedish Energy Agency, however, did not have a mandate for implementation at the time. The Energy Market Inspectorate formulated the law in ways which contributed to regulatory stability and continuation, rather than transformation and new forms of citizen engagement. Two different instances illustrate how actors

¹⁴ The main government coalition was conservative at the time, in which the Centre Party's position (represented here by the minister of industry and trade) supporting renewable energy was an exception.

in the state sector drew on different cultural-cognitive and normative institutions to legitimize their decisions. In both cases, the dominant actor defended the status quo.

The Energy Market Inspectorate's suggested formulation, however, never became effective in law (regulative institution) – it was stopped by the same government coalition who earlier directed the agency to formulate the law (Swedish Social Democratic Party and Swedish Green Party). The Swedish government thus failed to implement legislation for energy communities of the European Union's Clean Energy Packages 2018 and 2019 (regulative institution). At the time of writing this thesis (early 2026), a regulatory framework that can guide energy communities in Sweden is still lacking. The legitimation of energy communities as actors in the electricity market failed, not only due to the absence of a regulatory framework, but also because of the government's central role as an evaluator of legitimacy. Based on the analysis in Paper III (e.g., the government decision in this case including opinions of different stakeholders, 'remissvar'), I conclude that lobbying efforts by core actors of the electricity regime (grid operators and retailers) were successful in undermining energy communities' legitimacy. Their main arguments to delegitimize energy communities are that local energy sharing causes grid instability and increases cost for remaining grid users, aligning well with the normative and cultural-cognitive institutions discussed above (i.e. market-neutral and status-quo oriented).

Moving on to the latter part of the research question on the contribution of state actors to institutional change, the clearest example covers the numerous regulatory changes as described in the empirical context, with the most notable ones being the first R&D funding for solar cells in 1996, the investment subsidy from 2005 – 2021, and the measures connected to the solar strategy in 2016. The introduction of the investment subsidy was a success of the Swedish Green Party (Paper III), pursuing a completely renewable electricity system, and illustrates the institutional work of an actor in the highly institutionalized state sector. The Swedish Green Party was involved in all the above examples as a collaboration or coalition partner to the Swedish Social Democratic Party. This example makes the "actorness" of the state tangible (Edler & James, 2015), highlighting that policy changes do not happen out of the blue, but are driven by actors in the state sector. The policy support for solar PV adopters continued over two decades and opposing government coalitions. I argue that policy support for solar PV was institutionalized to a higher degree through the incorporation into the regular tax system when the investment subsidy was phased out and replaced by a green tax deduction (ROT avdrag) in 2021, and its reach increased from a limited number of customers (initially limited by the subsidy budget

and to those who apply and are granted the subsidy) to homeowners in general. While a law or policy is always a regulative institution, I would argue that there are different degrees of stability. To give an example: constitutional law, on the one extreme, is very difficult to change and therefore has a high degree of stability. The investment subsidy, on the other extreme, was initially dependent on annual budgets – without a new budget the following year, end of the subsidy. Even though the policy support for solar PV seems to have been relatively stable in retrospective, firms and customers in the market perceived considerable uncertainty (Papers I + III). Incorporating solar PV support into the green tax deduction system increased its stability; even though tax deductions can still be subject to change, it has been a rather stable system and is also perceived by market actors as such.

Another institution emerged with the governments' solar strategy in 2016 and the recognition of the value of data and statistics (Paper III). While the initial period of PV development was characterized by a lack of publicly available data and statistics, the main source of information for solar PV customers was “Bengt's villablogg”, an unofficial blog by University Lecturer Bengt Stridh (<https://bengtsvillablogg.info/om/>). As part of the governments' solar strategy (regulative institution), the Swedish Energy Agency established the “solar portal” (solelportalen), providing official data for prospective customers and replacing the former unofficial blog as a first point of reference (interviews Paper III). Simultaneously, the IEA-PVPS reports became a valuable source of information on the development of market and policy for solar PV in Sweden. Since the above-described data sources are central points of information for customers and market actors alike, signalling legitimacy of solar PV technology as an electricity source (cultural-cognitive and normative), I would argue that the routine of collecting and publishing statistics on the solar PV market in official sources became an institution.

The synthesis in this section illustrates that cultural-cognitive and normative institutions shape actors in the state sector, and that these actors can take on different roles in sociotechnical change: as change agents on the one hand, empowering solar PV technology through regulation and legitimation, and as proponents of the existing electricity regime on the other hand, hindering the diffusion of energy communities.

6.3 Co-evolution of state and market sectors

While the previous section approached the market sector and state sector separately, this section integrates the findings and discusses the co-evolution of market and state sectors through policy effects and feedback, thus answering research question (iii).

On an overarching level, the findings from the appended papers demonstrate that regulative (formal and written) institutions provide formal conditions for actor behaviour in both sectors by defining policy processes and the boundaries of market actors' activities. Regulative institutions also encompass policy goals and instruments which can create resource and interpretative effects (policy effects), incentivize or restrict actors, and result in attempts to influence future policy (policy feedback).

The findings from the case of energy communities illustrate the importance of normative and cultural-cognitive institutions in constraining their diffusion and reveal parallel evolution of market and state sectors with minimal interaction. The diffusion of energy communities was slowed by a lack of political leadership and failed policy implementation, despite repeated socio-political feedback from actors within the sociotechnical system. Regulatory institutions were characterized by path dependence and political unwillingness to adjust long-established laws. Conflicting cultural-cognitive and normative institutions across political ideologies hindered progressive policymaking, while diverging ambitions regarding implementation blocked transformative ideas.

Overall, energy communities did not receive institutional support. Across several legislative periods and different government coalitions, conflicts within the policy process and the resulting lack of policy change (and its subsequent effects) sent strong normative signals that energy communities were neither wanted nor supported by the Swedish government. As discussed in Section 6.2, incumbent actors from both the state and market sectors delegitimized energy communities as actors in the electricity market. Nevertheless, some actors, primarily citizen groups and municipal energy companies, continue to establish new energy communities and navigate an uncoordinated policy mix. While it can be surprising that municipal energy companies were involved in both energy communities and PV turnkey sales, it needs to be pointed out that the former requires significantly more effort with lower profitability and was pursued mainly in the interest of citizens. It is, thus, an action to increase (or retain) the organization's perceived legitimacy by acting in public interest. Furthermore, the relatively small number of energy communities limited their capacity to exert sufficient pressure for policy change, even

though their interests were represented by industry associations such as Svensk Solenergi. Policy feedback literature emphasizes the greater influence of organized industry associations in generating policy feedback compared to unorganized citizens (Burroughs, 2017). As a result, the state and market sectors evolved largely in parallel, with limited interaction. The case suggests that coevolution between state and market actors requires sustained interaction and a supportive institutional context. In the absence of these conditions, energy communities remained marginal, and their potential to contribute to broader system transformation was constrained.

In contrast, the development of solar PV is a case of co-evolution with manifold interactions between state and market sectors through policy effects and feedback.¹⁵ This is illustrated with the example of how the cultural-cognitive belief that solar PV is not technologically or economically feasible was destructed, and an alternative belief constructed.

In the beginning of the studied period, around 2000, a widespread cultural-cognitive belief was that the Nordic Swedish climate is too dark and cold for solar PV (Paper II customers, Paper III policymakers). The ideas of the Swedish Green Party were an early political driver of policy support, convincing the Swedish Social Democratic Party, governing with a minority at the time, to introduce a subsidy for municipal buildings in 2005. The subsidy created policy effects and incentives for market actors (Paper III), including the collaboration of incumbents and entrants in the PV turnkey model, in which they also helped customers applying for the subsidy (Papers I and II). The market actors in this collaboration (starting around 2011) were strategic in their vision for a demand market and the necessity to convince customers of the technological viability of solar PV in Sweden. With the diffusion of turnkey PV plants, regulatory adjustments became necessary to resolve bottlenecks in the sociotechnical system, where several policy changes were induced by policy feedback.¹⁶ The policy changes in turn facilitated further diffusion.

While it is difficult to pinpoint the dissolution of a cultural-cognitive institution to a certain date or event, several turning points serve as indicators (Paper III): the position of the Moderate Coalition Party (the largest party in The Alliance government) regarding solar energy suddenly turning before the elections in 2014, after which the right-wing Sweden democrats remained

¹⁵ Interaction between state and market sectors does not only happen through policy effects and feedback; more mechanisms exist, which were not part of this study.

¹⁶ The institutionalization of this business model is described in 6.1; the institutionalization of laws and regulations in 6.2.

the only party sceptical of solar PV. The dominant storyline in the parliament became ‘solar is a reality in Sweden today’, which can be seen as the creation of a new cultural-cognitive institution. This institutional change was not only influenced by market and state actors, but also by the increased diffusion and visibility of PV technology in Sweden (described as techno-economic feedback in Paper III), rapid decrease of PV module prices, and expansion worldwide.¹⁷

While market and state actors did not collaborate explicitly towards destructing old and constructing new beliefs on solar PV, they implicitly worked towards a common goal and provide an example of an agent-based institutionalization process through ‘institutional work’ (cf. Lawrence et al., 2011). This process, however, also shows ‘naturalistic’ characteristics (Strang & Sine, 2002), influenced by technology diffusion and economies of scale. Moreover, while market and state actors notably increased the legitimacy of solar PV (for the technology the entire sector) by shaping a cultural-cognitive institution in Sweden, this was reinforced by a simultaneous cultural-cognitive shift at the global level, in which Swedish actors only played a minor, if any, role.

Discussing change and stability in sociotechnical systems more broadly, the co-evolution of state and market in the development of solar PV illustrates that regulative, normative and cultural-cognitive institutions are closely intertwined and favourable conditions are needed at all three pillars to foster sociotechnical change. This is confirmed by the successful case of the investment subsidy¹⁸, and the failed case of energy communities in Sweden, lacking comprehensive institutional support.

¹⁷ The influence of developments on the world market is an exogenous condition in the policy feedback framework.

¹⁸ Note that the understanding of ‘investment subsidy’ here is much broader than the policy instrument, referring to the first case presented in Paper III, including institutional changes and market development.

7. Contributions and implications

Based on this synthesis, the chapter outlines the implications of the thesis. It first presents the contributions to the scholarly field of sustainability transitions and related research areas. This is followed by practical implications for policymakers and practitioners engaged in (electricity) system transformation. Finally, the chapter discusses limitations and identifies avenues for future research.

7.1 Theoretical contributions

Together, the appended papers and the Kappa make several contributions to the sustainability transitions literature. The empirical account in this Kappa adds rich examples of both institutional continuity and change in the development of solar PV in Sweden, responding to the call for exploring both of these dynamics (W. R. Scott, 2010). On an overarching level, both agent-based (DiMaggio, 1988) and naturalistic (Berger & Luckmann, 1967) processes of institutional change occurred simultaneously. Moreover, the bi-directional relationship between institutional structures and embeddedness of actors confirms existing theories, suggesting that actors in sociotechnical change processes experience regime pressures, but also actively engage in regime change (Kern, 2015; Koistinen & Teerikangas, 2021).

Regulative, normative, and cultural-cognitive institutions shape actor activities across state and market sectors. Their effect depends on subjective perception and enactment, as actors interpret institutions differently, leading to heterogeneous responses (Geels, 2010, p. 499 ff). Institutions meet an interpretation filter at the actor level, depending on characteristics of the organisation, including its structure, ownership, and identity (Greenwood et al., 2011). Such organization-level factors mediate business model adoption (Paper I), business collaboration (Paper II), and policy processes and outcomes (Paper IV). This confirms that legitimacy of organizations is a fruitful addition for understanding how actor strategies are shaped by institutional pressures in sociotechnical change processes. The legitimacy of technologies is illustrated through the deconstruction of the cultural-cognitive institution (or ‘bias’) that solar PV does not work in the Nordic (cold, dark) Swedish climate, in which incumbents and entrants collaborated to create technology legitimacy across state and market sectors and spread the PV turnkey sales business model (Papers II, III). Regarding legitimacy of the industry or sector, one could argue that the positive development of solar PV in Sweden was also thanks to the experimentation with

different PV business models by municipal energy companies, who are perceived as highly legitimate by society and government.

Regarding the market sector, the findings highlight the influence of business logic and ownership (public, non-profit versus private, for-profit) on business model adoption and business collaboration. Paper I reveals that business model adoption depends on a combination of firm-internal and external pressures (institutional and task environments), nuancing the view on homogeneous industry collectives steered by a common logic (Geels, 2014a). While previous work has discussed potential influences on business model adoption (see 2.2), Paper I introduces a novel framework for assessing strategic fit of a business model by combining factors on the horizontal, vertical, and environmental levels. The heterogeneity of actor strategies depending on organization-level factors also stands out between incumbents and entrants in Paper II. While a niche-regime dichotomy (Elzen et al., 2012; Ruggiero et al., 2021) is useful when referring to the level of structuration in sociotechnical systems (Fuenfschilling & Truffer, 2014), actors are strategic and heterogeneous and can be active at both levels. As resources and network positions change, it cannot be clear beforehand who is a “David” or “Goliath” in a sociotechnical change process. While incumbents have been a central theme in transitions research (E.-L. Apajalahti, 2018; Johnstone et al., 2017; Turnheim & Sovacool, 2020), this work adds nuance to the conceptualization of entrants. As a whole, Study 1 on the market sector contributes with micro-level business perspectives to the understanding of entrants and incumbents in sociotechnical change.

Regarding the state sector, the findings emphasize differences in how cultural-cognitive and normative institutions result in policy change or continuation of the status quo based on political parties, ministries, and agencies. Consequently, not only market actors, but also state actors are characterized by heterogeneity. This is evident in Paper IV, which conceptualizes the government as a distributed system of actors (Edler et al., 2016; Flanagan et al., 2011; Wittmann et al., 2021), contrary to the tendency to treat government as a unitary or homogeneous actor in transitions studies (see critique in e.g., Oltmer and Löhr, 2025; Song et al., 2023). A fragmented state apparatus is conceptualized in Paper IV to illustrate the difficulties of dispersed policy processes and the importance of policy implementation for reaching transitions goals. Paper III explores the co-evolution of policy change and sociotechnical change through the lens of policy feedback. It connects policymaking in the parliament debate with concrete policy changes (e.g., introduction of policy instruments) and sociotechnical changes (e.g., market

growth). The article contributes to theory development by suggesting that the concept of policy feedback originating from political science (Pierson, 1993), should be expanded with techno-economic feedback (inspired by techno-economic tipping dynamics by (Geels & Ayoub, 2023) when studying sociotechnical change.

The novelty of this Kappa lies in combining perspectives on state and market sectors and their co-evolution and framing them in a bi-directional relationship with institutions. The findings indicate that actors are influenced by institutions from both sectors. Market actors' activities, for instance, are restricted and incentivized by regulation; state actors' policy implementation is influenced by private sector logics through efficiency rationales (i.e. new public management). Such simultaneous influence by normative and cultural-cognitive institutions from different sectors can potentially lead to actors experiencing institutional complexity (i.e. conflicting institutions) (Fuenfschilling, 2019). Institutional plurality (i.e. the co-existence of different institutions) allows actors to draw from alternative institutions to legitimate transformative actions and can therefore enable endogenous regime change (Runhaar et al., 2020) as an alternative to being driven by niches or enabled by windows of opportunities. As became evident in the discussion of co-evolving sectors, agent-based change processes through institutional work were an important driver in the development of solar PV in Sweden. The rich empirical illustration in this thesis of the influence of institutions, their co-existence, and evolution informs future strategic action for regime destabilization.

7.2 Implications for policymakers and practitioners

This thesis offers several implications for policymakers and practitioners concerned with governing sociotechnical transitions, particularly in the context of renewable energy and solar PV deployment. By empirically tracing solar PV's development from an emerging technology to a minor yet established component of the Swedish energy mix, the thesis highlights the intertwined roles of state and market actors, institutions, and policy processes over time.

A first implication concerns the role of policy in shaping investment conditions and expectations (Papers I and II). The findings show that policy instruments can function both as enabling mechanisms, through financial incentives (e.g., investment subsidy driving the PV turnkey sales business model) and as constraining factors when uncertainty or ambiguity dominates (e.g., regulation for energy communities). This is particularly consequential in early-stage or relatively less profitable technologies, such as solar PV 20 years ago, where diffusion is

necessary to reach national energy targets, but firms are hesitant due to a lack of profitability. For policymakers, this underscores the importance of articulating a clear and credible long-term vision. Even before policies become binding legislation, market actors react to political signals (Paper III), adjusting investment strategies, business models, and networks in anticipation. Stable and transparent policy direction at the level of overarching goals and visions is therefore essential for reducing perceived risk and encouraging sustained engagement from market actors.

The analysis further suggests that policy outcomes cannot be understood solely through formal policy design or decisions made at the political level. Instead, outcomes materialize through policy delivery within a sociotechnical system (Paper IV) shaped by institutions, routines, and actor interactions (Kappa). This has implications for current policy evaluation practices, which tend to emphasize procedural aspects of policymaking and implementation rather than effects within the system being governed (Haddad & Bergek, 2023). Policymakers and civil servants should thus broaden evaluation frameworks to incorporate dynamics and impact in the sociotechnical system, recognizing that policies only reveal their full consequences once they interact with existing actors and organizational practices.

Continuing this line of thought, the thesis reinforces the idea that policies are unlikely to be perfectly designed *ex ante* (Peters, 2018). Based on historic evidence, it can be assumed that policy instruments need to be revised, especially facing the complexity and uncertainty inherent in sociotechnical systems (Hoppmann et al., 2014). Policy mixes are emergent, often evolving incrementally and without full coordination across sectors or levels of governance (Flanagan et al., 2011). Practically, this implies that coordination should be treated as an ongoing governance task rather than a one-time design problem (Paper IV), pointing to the need for increased capacity not only for policy design, but also for *ex-post* and continuous coordination, revision, and adjustment in mission-oriented or transformative innovation policy (Haddad et al., 2022). Embedding mechanisms for policy experimentation and learning at early stages can support adaptive governance, allowing policymakers to revise instruments as empirical evidence accumulates and system responses become more visible.

The actors responsible for policy implementation, such as bureaucrats and civil servants, emerge as central actors in shaping policy in practice (Paper IV). Their mandates, interpretations, and routines significantly influence how policies are operationalized. Recognizing them as co-constructors of policy, rather than mere implementers, allows for better alignment

between regulatory practice and broader transition objectives. This implies that effective transition governance requires early engagement with, and capacity building among, implementing actors, as well as policy designs that acknowledge and support their interpretive role.

Finally, the thesis highlights the mutual influence between actors and institutions. Some institutions facilitate change by lowering barriers and enabling experimentation, while others stabilize existing routines and expectations. Practitioners and policymakers alike would benefit from a reflexive stance, recognizing their own role as embedded actors within the system they seek to steer. Such reflexivity can make visible the “invisible” institutions, feedback loops, and assumptions that shape decision-making across sectors.

7.3 Limitations and future research

This section discusses core limitations of this work, each with suggestions for future research. The presented synthesis is limited by the two conducted studies and the four manuscripts included of which each manuscript has its own limitations, such as the selection of data sources, interviewees, and case studies. A general limiting factor is that the existing work was reinterpreted in the context of institutions; the initial work was only partly focused on institutions and institutional change. In addition, the focus in this thesis is the development of solar PV in Sweden, in which the broader electricity regime is only considered as a contextual factor. Future research could broaden the scope to consider additional emerging and established technologies and actors to provide a more holistic picture of stability and change between niches and regimes in the electricity system in Sweden.

Another limitation relates to the (regime) actor groups included in the studies and papers. Two actor groups largely missing are adopters and mass media. Users constitute an important part of the existing regime through their routines, practices, beliefs and norms (Geels, 2004). Study 1 initially included interviews with adopters which highlighted the strong local embeddedness and trust of customers toward their municipal energy companies, and the relationship was conceptualized in terms of ‘service triads’ (Holma, 2012; Karatzas et al., 2016; Wynstra et al., 2015). This data and concept, however, were ‘put on the shelf’ in the process of writing Paper II and could be revived in a future manuscript. Besides societal opinion and government, mass media is a central actor in legitimation processes (Bitektine & Haack, 2015). Previous literature demonstrates media’s importance in sociotechnical change processes (Hirt, 2024; Markard et al., 2021). Future research could complement the perspectives provided in this Kappa with an

analysis of mass media and technology adopters to provide a more nuanced understanding of the ‘politics’ of contested sustainability transitions (Meadowcroft, 2009).

The Kappa is further limited by its modest engagement with the structure–agency debate. While the synthesis primarily addresses legitimacy (Suchman, 1995) and legitimation processes (Bergek, Jacobsson, & Sandén, 2008), future research could examine how forms of agency emerge from, reproduce, or challenge institutional conditions in other structural dimensions, particularly domination and signification (Giddens, 1984). Although some scholars point to parallels between Giddens’ dimensions and Scott’s institutional pillars (Geels, 2014a), others argue for greater analytical attention to domination, specifically to resources and associated power positions (Stalmokaitė, 2021). Such an emphasis appears especially promising in the context of electricity system transformation, where large-scale infrastructures, such as grids, pipelines, and production assets, define power and influence of actors. While the findings in this Kappa acknowledge that certain incumbents continue to reinforce the status quo or resist change (Johnstone et al., 2017; Tilsted et al., 2026), they also present a counter-portrayal of incumbents based on municipal energy companies. At the same time, the results demonstrate that entrants can also dominate significant resources and be ‘on par’ with incumbents in different characteristics.

Finally, I want to reflect upon questions that extend beyond the concepts of this work and my time as a PhD student. While much policy and research attention remains focused on accelerating the supply-side transition of electricity systems, the results underscore the limits of such strategies that leave overall energy demand largely unquestioned (York & Bell, 2019). Addressing climate change and ecological degradation will ultimately require not only cleaner electricity supply, but also reduced energy consumption and a reconsideration of prevailing growth-oriented development paradigms (Hickel & Kallis, 2020). Personally, this insight has moved my own research interest toward questions of post-growth and degrowth, and toward exploring how institutional arrangements, actor configurations, and societal norms might enable sufficiency-oriented and less energy-intensive forms of social organization.

8. Conclusions

The thesis set out to explain how institutional change unfolds across market and state sectors in sociotechnical systems. The longitudinal and retrospective study of solar PV development in Sweden makes evident how regulative, cultural-cognitive, and normative institutions shape actor behaviour in market and state sectors, and how actors contribute simultaneously to agent-based change and regime stability. It is therefore crucial to move away from monolithic conceptualizations of regime actors, such as ‘incumbents’ or ‘governments’, and understand actors as fragmented, strategic and heterogeneous.

The activities of actors in the market sector (business model adoption and business collaboration) are influenced by regulatory incentives and restriction, and broader for-profit (market sector) and non-profit (state sector) goals. These actors simultaneously shape institutional change, with the intriguing example of deconstructing the cultural-cognitive institution across market and state sectors that solar PV does not work in the Nordic climate, and constructing an alternative, optimistic one.

The activities of state-sector actors involved in policymaking and policy implementation, despite being embedded in similar regulatory environments, illustrate diverging normative and cultural-cognitive institutions and sources of legitimacy across governance levels and policy domains. Such divergences can constrain institutional change when actors within different parts of the state hold competing interpretations of the transformative potential of emerging initiatives, as could be seen at the example of energy communities. At the same time, state actors contribute both to institutional change through the articulation of new policy goals and instruments, and to institutional stability by defending existing regulatory arrangements.

The cross-sectoral and coevolutionary perspective contributes to an increased understanding of the importance of institutional change and manifold interactions between market and state sectors. The results show that a lack of institutional support and minimal interaction can hinder diffusion, such as in the case of energy communities. On the contrary, interactions and institutional change are a prerequisite for successful sociotechnical change, as in the case of solar PV development, which benefitted from institutional support at regulative, normative, and cultural-cognitive levels.

Key policy implications of this work include that stable and transparent policy direction is essential for reducing perceived risk and encouraging sustained engagement from market actors, especially for early-stage or relatively less profitable technologies; and that coordination should be treated as an ongoing governance task rather than a one-time design problem and capacity included for continuous coordination, revision, and adjustment in mission-oriented or transformative innovation policy. Effective policy design must therefore address the inherent tension between offering long-term stability, while retaining the capacity for continuous coordination and adjustment as system dynamics evolve.

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