# 8. Accelerating energy innovation through transition policy mixes

*Karoline S. Rogge*

## 1. INTRODUCTION

As the world faces increasingly urgent pressures to reduce greenhouse gas emissions, the need to accelerate sustainable energy transitions is paramount (Sovacool, 2016; Markard, 2018). However, such transitions to net-zero energy systems entail profound changes across multiple dimensions (see Chapter 4 in this volume), encompassing innovation in technology, infrastructure, organisational structures, cultural aspects, user practices, and policy and institutional arrangements (Grin et al., 2010; Geels and Turnheim, 2022). These required transformative changes are not only highly complex but also deeply contested (Roberts et al., 2018; Schmid et al., 2021), including trade-offs between speed and depth of transitions (Geels et al., 2023). Empirical research indicates considerable variation of acceleration across socio-technical systems in terms of speed, scope, and contestation. For example, some low-carbon technologies progress faster than others (Malhotra and Schmidt, 2020; Wilson et al., 2020). We also observe significant differences across geographical and institutional contexts, such as between countries (Finnegan, 2022) and cities (Ehnert et al., 2018). Yet, while policy and academic interest in acceleration is growing (Rosenbloom and Meadowcroft, 2022; Sovacool et al., 2025), more research is needed to consolidate and advance our insights into the role of policy as a mechanism for speeding up net-zero energy innovation and transitions that have entered the acceleration phase (Markard et al., 2020; Rogge and Goedeking, 2024).

Multiple policy rationales call for implementing policies promoting innovation for transitioning to net-zero energy systems. The first set of rationales revolves around *market failures*, with economists stressing negative externalities of greenhouse gas emissions and positive knowledge spillovers of innovation (Rennings, 2000; Jaffe et al., 2005). This double externality problem leads to – without policies internalising such externalities – a sub-optimally low level of net-zero energy innovation. In addition, further market failures can arise from the imperfection in risk assessment and lack of technical expertise in capital markets, limited coordination of multiple supporting networks and systems, lack of information on sustainable solutions such as awareness of technologies, actions, or support, and the consideration of co-benefits beyond market rewards (Stern, 2022). Yet, while market failures are an important justification for policy intervention, they are not the only one (Jacobsson et al., 2017).

Instead, innovation and transition scholarship has pointed out that decarbonisation also requires an awareness of two other sets of policy rationales: structural as well as transformational system failures connected with system innovation (Weber and Rohracher, 2012). *Structural system failures* are highlighted in innovation studies and, for example, include tensions in building up low-carbon infrastructure (e.g. aligning electricity grids and storage with the requirements of new low-carbon technology) and in adjusting existing institutions to climate-neutral solutions (e.g. reforming electricity market design). *Transformational system*



Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*failures* draw on transition studies and, among others, include the provision of a clear direction (e.g. through shared visions and unambiguous guidance towards net-zero innovation) and better coordination across policy fields to overcome policy silos (e.g. climate policy and industrial policy) and achieve synergies between different governance levels (e.g. national and regional levels). Addressing these multiple market, system and transformational failures calls for a key role of the state in accelerating net-zero energy innovation and transitions (Johnstone and Newell, 2018).

The three sets of policy rationales imply that there are no 'silver bullets' where one policy instrument on its own, such as carbon pricing, would be able to address all aspects of these failures, thereby justifying the implementation of broader policy mixes combining several policy instruments (Tvinnereim and Mehling, 2018; Rosenbloom et al., 2020). Based on these premises, this chapter provides an overview of the state of the art in research on policy mixes for accelerating energy innovation and transitions. First, it summarises conceptual developments, introducing key analytical frameworks and core terminology for anyone interested in policy mix research (Section 2). After laying these foundations, it then proceeds to discussing policy implications arising from the challenges associated with accelerating net-zero energy transitions (Section 3). The chapter concludes by offering some reflections on future interdisciplinary policy mix research avenues of relevance for accelerating energy innovation.

## 2. FOUNDATIONS: TRACING COMPLEMENTARY DEVELOPMENTS IN POLICY MIX RESEARCH

This section provides an overview of six complementary developments in policy mix research relevant for policy interventions aimed at accelerating energy innovation in net-zero transitions. While some of these developments have occurred sequentially, others have happened in parallel. Key disciplines active in policy mix research include economics (Bouma et al., 2019), policy science (Howlett and Rayner, 2022), and innovation studies (Flanagan et al., 2011). Additionally, efforts by transition scholars have aimed to bridge these fields and integrate them into interdisciplinary approaches for policy mix thinking (Rogge and Reichardt, 2016; Kern, Rogge and Howlett, 2019) – the focus of this chapter.

The six areas of development towards broader policy mix considerations presented here are distinct but partly overlapping research advances, and thus are best understood as offering complementary lenses for research and advice on accelerating energy innovation through transition policy mixes. Consequently, the most appropriate advances should be chosen and potentially based on research questions and policy needs. Ultimately, this section serves as a toolkit for anyone interested in better understanding and/or pursuing policy mix research with a focus on accelerating net-zero transitions.

### 2.1 Development 1: From Policy Instrument Type to Instrument Design

Policy instruments are the concrete tools that state authorities have at their disposal for reaching their objectives (Howlett, 2005). Such instruments are also called implementing measures, programs, policies, or policies and measures, and they come with different types and designs (Rogge and Reichardt, 2016). Regarding the *instrument type*, environmental economists have investigated, both theoretically and empirically, differences in the innovation impact related

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

to the *type* of an environmental policy instrument, indicating a preference for market-based (i.e. economic) over command-and-control (i.e. regulation) instruments (Jaffe et al., 2002). Subsequent research has added further nuance to the conditions under which this conclusion holds (Popp, 2019), suggesting, among others, conditions under which command-and-control policies may outperform or complement market-based ones, for example due to path dependencies (Lamperti et al., 2020) or distributional concerns (Stiglitz, 2019). Similarly, innovation economists have analysed differences between instruments aiming at technology push compared to those targeting demand pull, showing the importance of both mechanisms, their locus, and their combination with systemic instruments (Smits and Kuhlmann, 2004; Di Stefano et al., 2012; Peters et al., 2012). Both research traditions have followed a variety of instrument typologies (Borrás and Edquist, 2019; Peñasco et al., 2021). These were combined by Rogge and Reichardt (2016) in a type-purpose typology (see Figure 8.1), indicating how different instrument types – economic instruments, regulation, and information – can contribute to different purposes – technology push, demand pull, and systemic – which can be combined for promoting innovation in sustainability transitions.

However, while much research has focused on the instrument types, economists have also stressed that the innovation impact of policy instruments is not just driven by their type, but also by their *design features* (Kemp, 1997), such as stringency or predictability (see Table 8.1). These instrument design features have been identified as being even more influential for environmental innovation than their type (Kemp and Pontoglio, 2011). In particular, policy stringency stands out as a key design feature for promoting environmental innovation, with higher levels of stringency associated with a greater innovation impact (Ashford et al., 1985; Frondel et al., 2007; Ghisetti and Pontoni, 2015). For example, in the context of emissions trading, a market-based policy instrument, research has shown the positive innovation impact arising

| | | PRIMARY PURPOSE | | |
|---|---|---|---|---|
| | | **Technology push** | **Demand pull** | **Systemic** |
| **PRIMARY TYPE** | **Economic instruments** | RD&D* grants and loans, tax incentives, state equity assistance | Subsidies, feed-in tariffs, trading systems, taxes, levies, deposit-refund-systems, public procurement, export credit guarantees | Tax and subsidy reforms, infrastructure provision, cooperative RD&D grants |
| | **Regulation** | Patent law, intellectual property rights | Technology / performance standards, prohibition of products / practices, application constraints | Market design, grid access guarantee, priority feed-in, environmental liability law |
| | **Information** | Professional training and qualification, entrepreneurship training, scientific workshops | Training on new technologies, rating and labelling programs, public information campaigns | Education system, thematic meetings, public debates, cooperative RD&D* programs, clusters |

*Note:* * RD&D = Research, development, and demonstration.
*Source:* Rogge and Reichardt (2016).

*Figure 8.1 Type-purpose instrument typology (with instrument examples)*

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*Table 8.1 Overview of selected design features of policy instruments*

| Design feature | Definition |
|---|---|
| Stringency | Refers to 'the ambition level of an instrument' regarding its goal and its design |
| Level of support | Captures 'the magnitude of positive incentives provided by a policy instrument' |
| Predictability | Addresses 'the degree of certainty associated with a policy instrument and its future development', including its overall direction, detailed rules, and timing |
| Flexibility | Captures 'the extent to which innovators are allowed to freely choose their preferred way of achieving compliance' |
| Differentiation | Refers to specific instrument provisions regarding 'industrial sector, size of the plant, technology or geographical location', etc. |
| Depth | Addresses whether an instrument's innovation incentives 'extend all the way to potential solutions with zero emissions' |

*Source:* Synopsis based on Rogge and Reichardt (2016), p. 1624.

from a higher stringency of the trading scheme, measured by a higher carbon price and lower share of free emission allowances (Rogge et al., 2011; Schmidt et al., 2012; Lilliestam et al., 2021). Design features other than stringency also matter for environmental innovation, such as the level of support or the predictability of an instrument (Hoffmann et al., 2008; Reichardt and Rogge, 2016). Ultimately, the innovation impact of policy instruments may depend on the combination of design features, such as an increase of the stringency of an instrument occurring in a predictable manner, while at the same time providing enough flexibility to allow for the exploration of novel solutions (Kivimaa, 2007).

The key takeaway from development 1 is not to get distracted by discussions around the best instrument type while forgetting instrument design. Put differently, when interested in accelerating energy innovation, it is first and foremost important to get the instrument design right, particularly in terms of stringency, predictability, flexibility, and level of support, while the type of instrument can rather be seen as a secondary concern.

### 2.2 Development 2: From Instrument Mixes to Policy Mixes

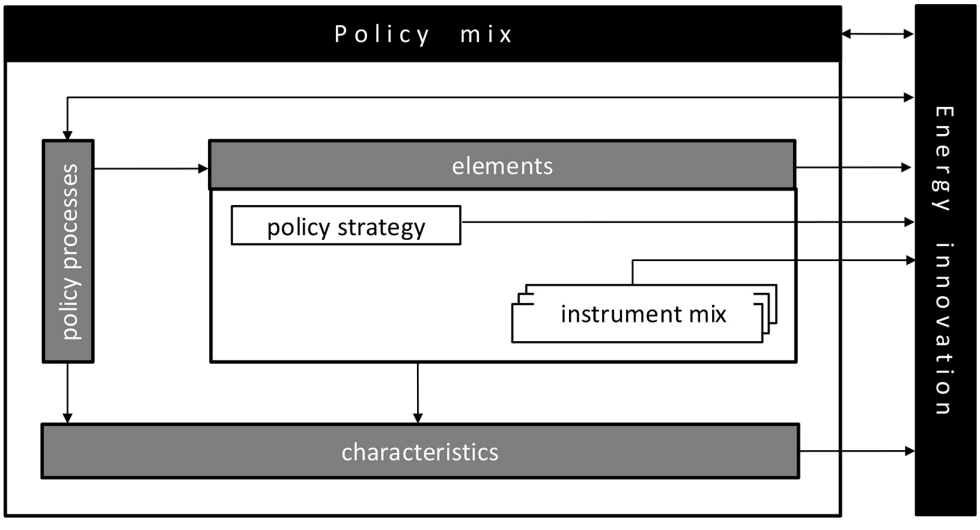
To address the various market and system failures in the context of energy innovation for net-zero transitions, several instruments are typically combined into instrument mixes that incrementally develop over time, as demonstrated by the journey of European Union (EU) climate policy from emissions trading to the European Green Deal (Oberthür and von Homeyer, 2023). Such instrument mixes have also been referred to as policy packages, policy portfolios, or policy mixes; however, here I follow Rogge and Reichardt (2016) in their distinction between instrument mixes and policy mixes, with the former focusing on the combination of policy instruments and the latter taking a broader approach.

Regarding the former, research has investigated how to optimally combine different instruments in instrument mixes (Braathen, 2007), and different approaches have been developed for the mapping and analysis of energy and climate policy instruments and their interactions (Spyridaki and Flamos, 2014; Vollebergh et al., 2023). Such interaction analysis has its origins in the seminal work on smart regulation by Gunningham and colleagues (1998),

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

who differentiated between complementary, incompatible, complementary if sequenced, and context-specific interaction outcomes. Interaction analysis has expanded significantly with the introduction of the EU emissions trading system (Del Río González, 2007). In this line of research, Sorrell and Sijm (2003) differentiate between beneficial, neutral, or counterproductive instrument interactions, indicating how the influence of one instrument is modified by the coexistence of others – either directly or indirectly. Innovation scholars have also addressed interactions of policy instruments aiming at supporting research and development (R&D) (Nauwelaers et al., 2009). For example, Flanagan and colleagues (2011) differentiate between four types of interaction: those between different instruments targeting the same actors; those between different instruments targeting different actors involved in the same process; those between different instruments targeting different processes in a broader system; and those where the same instruments interact across different policy, governance, geographical, or time dimensions. Finally, policy studies scholars have also investigated instrument interactions, leading them to suggest the design of more consistent bundles of instruments which reinforce rather than undermine each other (Howlett and Rayner, 2013). These conceptual considerations have been taken up in interdisciplinary research, such as modelling studies investigating the impact of different instrument combinations for the achievement of multiple policy objectives going beyond decarbonisation (Nuñez-Jimenez et al., 2022).

Research following the latter and thus broader policy mix approach acknowledges the complexity of real-world policy mixes and their relevance for innovation (Rogge and Reichardt, 2016; see Figure 8.2), whether in energy (Rogge et al., 2017), transport (Givoni et al., 2013), or industry (Scordato et al., 2018). Table 8.2 provides an overview of the three building blocks




*Source:* Slightly modified from Rogge and Reichardt (2016).

*Figure 8.2 Framework for analysing the links between the policy mix (with its building blocks of elements, processes, and characteristics) and energy innovation*

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*Table 8.2 Overview of the building blocks of a broad policy mix concept*

| Building blocks | Definition |
|---|---|
| **Elements** | '*Elements* comprise the (i) policy strategy with its objectives and principal plans for achieving them and (ii) the instrument mix with its interacting policy instruments. The content of these elements is an outcome of *policy processes*.' (p.1622) |
| Policy strategy | 'a combination of policy objectives and the principal plans for achieving them.' (p. 1623) |
| Instrument mix | 'only a part of the overarching policy mix. ... Regarding the instruments in this mix it may be useful to distinguish between core (or cornerstone) instruments and complementary (or supplementary) instruments of an instrument mix. ... At the heart of the concept of instrument mixes are interactions between the instruments.' (p. 1625) |
| **Processes** | 'political problem-solving process among constrained social actors in the search for solutions to societal problems – with the government as primary agent taking conscious, deliberate, authoritative and often interrelated decisions. As such, these interactive and continuous reconciliation processes with various feedback loops involve power, agency and politics.' (p. 1625) |
| **Characteristics** | 'both elements and processes can be described by their *characteristics*, including the consistency of elements, the coherence of processes, as well as the credibility and comprehensiveness of a policy mix.' (p.1622) |
| Consistency | 'captures how well the elements of the policy mix are aligned with each other, thereby contributing to the achievement of policy objectives. It may range from the absence of contradictions [weak consistency] to the existence of synergies [strong consistency] within and between the elements of the policy mix.' (p. 1626) |
| Credibility | 'the extent to which the policy mix is believable and reliable ... both overall and regarding its elements and processes.' (p. 1627) |
| Comprehensiveness | 'captures how extensive and exhaustive [the elements of the policy mix are] and the degree to which its processes are based on extensive decision-making. (p. 1627) |
| Coherence | 'referring to synergistic and systematic policymaking and implementation processes contributing – either directly or indirectly – towards the achievement of policy objectives.' (p. 1626) |
| Others | the '4Cs' are not intended to be a comprehensive list of policy mix characteristics but can be expanded upon (e.g. balance). |

*Source:* Synopsis based on Rogge and Reichardt (2016).

of elements, processes, and characteristics – shown in light grey in Figure 8.2 – together with their definitions. The concept recognises the importance of policy strategies (such as the Paris Agreement) alongside instrument mixes as key *elements* of policy mixes (Quitzow, 2015a), pays attention to the associated policymaking and implementation *processes* such as political lobbying or policy coordination (Kern and Rogge, 2018), and also includes overarching

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*characteristics* to describe the nature of policy mixes such as consistency or credibility (Rogge and Schleich, 2018; Bach and Hansen, 2023), while acknowledging the relevance of different dimensions (such as multiple policy fields and governance levels or time). These three building blocks draw on the combination of insights from different disciplines (Kern et al., 2019), with a focus on innovation studies (Flanagan et al., 2011) and policy studies (Howlett et al., 2015). Inspired by this line of research, I define policy mixes *relevant* for accelerating energy innovation in net-zero transitions as encompassing policy strategies and instrument mixes at different policy fields and governance levels which are enabling or impeding the acceleration of net-zero energy innovation and have evolved incrementally over many years (Kern and Howlett, 2009; Rogge and Reichardt, 2016; Rogge and Stadler, 2023).

Empirical studies following such a broad policy mix approach have yielded novel insights into the way policies influence energy innovation (Rogge, 2019). For example, long-term targets included in policy strategies have been shown beneficial in providing guidance to strategic investments and innovation (Schmidt et al., 2012). When backed up by stringent and consistent policy instruments, they become credible and thus more effective in promoting energy innovation, whereas inconsistencies lead to investment uncertainty hindering low-carbon solutions (Reichardt and Rogge, 2016; Uyarra et al., 2016). Credibility, in particular, has been shown to be key for low-carbon investments (Nemet et al., 2017). In this regard, companies' perceptions of policy mix credibility are influenced by the coherence of climate policymaking processes and the existence of ambitious phase-out policies for societally undesirable energy technologies (Rogge and Dütschke, 2018). It has also been shown that a comprehensive instrument mix which balances technology push instruments (e.g. public R&D support) and demand pull instruments (e.g. energy taxation) is beneficial for innovation in energy efficiency (Costantini et al., 2017; Nuñez-Jimenez et al., 2022). More generally, measuring the balance of instrument types can provide important insights into the temporal dynamics of instrument mixes and their importance for energy innovation (Schmidt and Sewerin, 2019).

The key takeaway from development 2 is that solely focusing on identifying the optimal combination of instruments is inadequate. Instead, adopting consistent and comprehensive instrument mixes in a coherent manner is crucial to facilitate the attainment of multiple objectives and targets outlined in policy strategies. Such a well-designed approach signals policy mix credibility, which is pivotal for energy innovation.

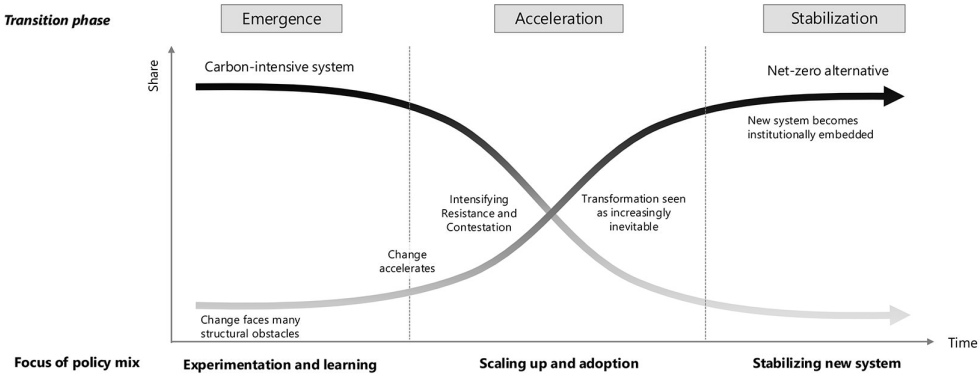
### 2.3 Development 3: From Policy Mixes Supporting Technological Innovation to Socio-Technical System Change

Research on the influence of policy mixes on energy innovation has primarily focused on technological change, such as in wind energy (Nemet, 2009). While one set of studies takes firms as the unit of analysis (Hoppmann et al., 2013, see the chapter on firms), another set investigates technologies within an industry, sector, or system context (Binz et al., 2017, see the chapter on system innovation). For example, the technological innovation system approach has been utilised as an analytical framework to investigate the role of policy mixes on solar water heating in China (Huang, 2019) or offshore wind in Germany (Reichardt et al., 2016), identifying the interplay between policy mixes and technological innovation systems. Another example is the combination of modelling and foresight techniques to co-create socio-technical scenarios for net-zero emission pathways for energy and industry sectors, providing nuanced insights into their feasibility (Wachsmuth et al., 2023). Similarly, the multi-level perspective

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

has been employed to investigate the role of policy mixes in the diffusion of novel low-carbon energy technologies in the future energy mix, such as for technology substitution versus broader system change pathways for the German electricity system (Rogge et al., 2020). While these system approaches have typically focused on technological innovations as the starting point, various other system dimensions have also been considered, including user demand, cultural aspects, and institutional arrangements. Nonetheless, even in such socio-technical system analyses, the role of social innovation has often been neglected, despite its relevance for accelerating sustainability transitions (Jacob and Ekins, 2020; Wittmayer et al., 2024), particularly in the acceleration phase.

While the previous emphasis on technological innovation has provided significant insights into the link between policy mixes and sustainable energy transitions (Rogge et al., 2017), we have comparatively less understanding of how they influence social innovation. In the context of net-zero energy transitions, social innovation is understood here as the '(combination of) ideas, objects, and/or activities that change social relations, involving new ways of doing, thinking and/or organising energy' (Wittmayer et al., 2022, p. 2). This broad understanding of social innovation in energy encompasses various types, such as energy cooperatives, prosuming, local peer-to-peer electricity exchange, participatory energy dialogues, campaigns against unsustainable energy pathways, energy gamification and nudging, and novel investment and finance mechanisms, among others (Wittmayer et al., 2020). While substantial




*Source:* Own combination and extension of policy mix considerations for transition phases (Meadowcroft and Rosenbloom, 2023) and primary innovation type (Rogge and Stadler, 2023).

*Figure 8.3 Tailoring policy mixes for net-zero energy innovation to transition phases and innovation type*

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

empirical research is emerging on each of these types (Hewitt et al., 2019; Wittmayer et al., 2021), dedicated attention to policy mixes for such social innovations has been lacking. In their exploration on participatory experimentation and incubation in Germany, Rogge and Stadler (2023) find that the policy mix mapping approaches developed by Ossenbrink et al. (2019) for the case of energy storage in California can also be applied to social innovation; however, they also conclude that existing instrument typologies should be adjusted to better cover both technological and social innovation, and that policy mixes should aim at socio-technical system change with varying foci across transition phases (see Figure 8.3). In each of the three phases – emergence, acceleration, and stabilisation – greater attention to policy mixes is necessary to enhance our understanding of their influence on social innovation in net-zero energy transitions, both by researchers (Wittmayer et al., 2024) and by energy policymakers (Rogge et al., 2023).

The key takeaway from development 3 is that transition policy mixes aimed at accelerating net-zero energy innovation should not only provide policy support for technological innovation. In other words, to accelerate net-zero transitions through energy innovation, the policy mix must extend beyond promoting technological innovation and also encompass support for social innovation, ideally in an integrated socio-technical manner that considers specific policy needs associated with the emergence, acceleration, and stabilisation phase of net-zero transitions.

### 2.4 Development 4: From Creation to Destruction in Policy Mixes

Initially, the focus of policy interventions for sustainability transitions has been on supporting the creation and development of niche innovations, such as net-zero energy innovations. Two key analytical approaches to understand such niche creation processes are the technological innovation system (TIS) framework (Hekkert et al., 2007; Markard et al., 2015) and the strategic niche management approach (Kemp et al., 1998; Schot and Geels, 2008; see Chapter 4 in this volume). Drawing on these, Kivimaa and Kern (2016) have synthesised existing lists of functions of innovation systems – typically seven, ranging from 'knowledge creation, development and diffusion' to 'influence on the direction of search' – and policies supporting these (see C1–C7 in Table 8.3). Importantly, one policy can support more than one function. Ultimately, what matters is how well the elements of the policy mix – but also the policy processes – ensure the TIS performance along all seven functions, as only together this smooth functioning of a TIS creates ideal conditions for the emergence and development of niche innovations (Suurs and Hekkert, 2009). For example, the case of offshore wind shows that clear guidance for the direction of search can be provided by an unambiguous policy strategy with ambitious targets, by policymakers actually implementing policy instruments that enable the achievement of the targets but also by the way problems are tackled as they arise (Reichardt et al., 2016; Reichardt et al., 2017). Bergek et al. (2008) emphasise that the functionality of a technological innovation system can be improved by addressing identified inducement and blocking mechanisms through policy interventions, which can help identify systemic instruments for systemic innovation problems, i.e. suggested changes to the policy mix relevant for the functioning of the innovation system (Wieczorek and Hekkert, 2012).

However, while the support for creating niche innovations continues to be important for accelerating net-zero energy innovation, a second key process for such acceleration concerns the destruction of incumbent regimes. Inspired by Schumpeter (1942), Kivimaa and Kern

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*Table 8.3 Policies promoting net-zero energy innovations by targeting technological innovation system creation functions*

| Creation processes (niche support) | Policy interventions (examples) |
|---|---|
| C1. Knowledge creation, development and diffusion | R&D funding schemes, innovation platforms, and other policies aiming to increase knowledge creation and diffusion through networks; subsidies for demonstrations; educational policies, training schemes, coordination of intellectual property rights, reference guidelines for best available technology. |
| C2. Establishing market niches / market formation | Regulation, tax exemptions, market-based policy instruments such as certificate trading, feed-in tariffs, public procurement, deployment subsidies, labelling. |
| C3. Price-performance improvements | Deployment and demonstration subsidies enabling learning-by-doing; R&D support (cost reductions through learning) |
| C4. Entrepreneurial experimentation | Policies stimulating entrepreneurship and diversification of existing firms, advice systems for small and medium enterprises, incubators, low-interest company loans, venture capital; relaxed regulatory conditions for experimenting |
| C5. Resource mobilisation | Financial: R&D funding, deployment subsidies, low-interest loans, venture capital<br>Human: educational policies, labour-market policies, secondment of expertise<br>Material: circular economy policies, environmental and security standards, trade agreements, joint purchasing clubs<br>Complementary assets: policies supporting infrastructure provision |
| C6. Support from powerful groups / legitimation | Innovation platforms, foresight exercises, public procurement, and labelling to create legitimacy for new technologies, practices, and visions |
| C7. Influence on the direction of search | Goal setting and framing in strategies, targeted R&D funding schemes, regulations, tax incentives, foresight exercises, voluntary agreements |

*Source:* Based on Kivimaa and Kern (2016), with minor policy modifications.

(2016) have derived four destruction functions to be tackled by policies destabilising unsustainable regimes (see D1–D4 in Table 8.4): first, control policies (e.g. stringent carbon pricing); second, significant changes in regime rules (e.g. electricity market reform); third, reduced support for dominant regime technologies (e.g. removing tax benefits for petrol); and fourth, changes in social networks and replacement of actors (e.g. more balanced representation of net-zero entrepreneurs in policy advisory councils). Later, Kivimaa and colleagues (2017) identified as a fifth function (C5) changes in organisational and institutional practices (e.g. administrative changes enabling coherent policy implementation). The initial scheme has been applied, for example, to the analysis of the creative and disruptive elements in Norway's policy mix in the transport and energy sector, showing sectoral and fuel differences in the use of disruptive policies (Cetkovic and Skjaerseth, 2019). As a consequence, the past years have seen increased attention to the 'phase-out' and deliberate decline in research on sustainability

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*Table 8.4 Policies promoting net-zero energy innovations by targeting technological innovation system destruction functions*

| Destruction processes (regime destabilisation) | Policy interventions (examples) |
|---|---|
| D1. Control policies | Carbon trading, taxes on greenhouse gas emissions, road pricing, import restrictions or carbon border adjustments, or a malus on carbon-intensive alternatives to put economic pressure on current unsustainable regimes. Banning certain fuels or technologies is the strongest form of regulatory pressure (e.g. phase-out of coal or cars with internal combustion engines) but is weakened by loopholes (e.g. exemptions for e-fuels). |
| D2. Significant changes in regime rules | Major rule changes changing the selection environment through structural reforms in legislation or significant new overarching laws (e.g. privatisation and liberalisation of electricity markets, new regulation on data access and sharing). |
| D3. Reduced support for dominant regime technologies | Withdrawing support for selected carbon-intensive fuels, technologies, and practices (e.g. cutting R&D funding for carbon-intensive technologies, removing subsidies for fossil fuel production, removing tax deductions for private motor transport). |
| D4. Changes in social networks, replacement of key actors | Balancing involvement of incumbents in policy advisory councils with net-zero energy niche actors; formation of new organisations or networks to take on tasks linked to net-zero system change. |
| D5. Changes in organisational and institutional practices | Procedural policies stimulating changes in existing organisational practices in public administrations and implementing agencies (e.g. agile enforcement teams), political leadership supporting the reorientation of incumbent policy actors towards more effective implementation of destabilisation policies (e.g. by changing administrative cultures and building transformative capacities of civil servants). |

*Source:* Based on Kivimaa and Kern (2016) and Kivimaa et al. (2017), with minor policy modifications.

transitions (Rosenbloom and Rinscheid, 2020; Rinscheid et al., 2021; Trencher et al., 2023). First empirical findings suggest that transition policy mixes which contain both elements of creation and destruction – and thus do not only aim for the support of innovation but also its flipside – stand a greater chance of accelerating net-zero energy transitions by providing clear transformative guidance for future markets (Rogge and Johnstone, 2017; Axsen and Wolinetz, 2023). However, the design and timing of such phase-out policies is critical for the innovation strategies of incumbents regarding alternative technologies (Scherrer and Rogge, 2025).

The key takeaway from development 4 is that the reluctance to implement phase-out policies for carbon-intensive fuels, technologies, and practices slows down net-zero energy transitions. In other words, the wide diffusion of net-zero energy innovations can be accelerated by a combination of policies targeting both creation and destruction processes in net-zero energy transitions.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

## 2.5 Development 5: From Innovation Policy Mixes for Creative Destruction to Policy Intervention Points

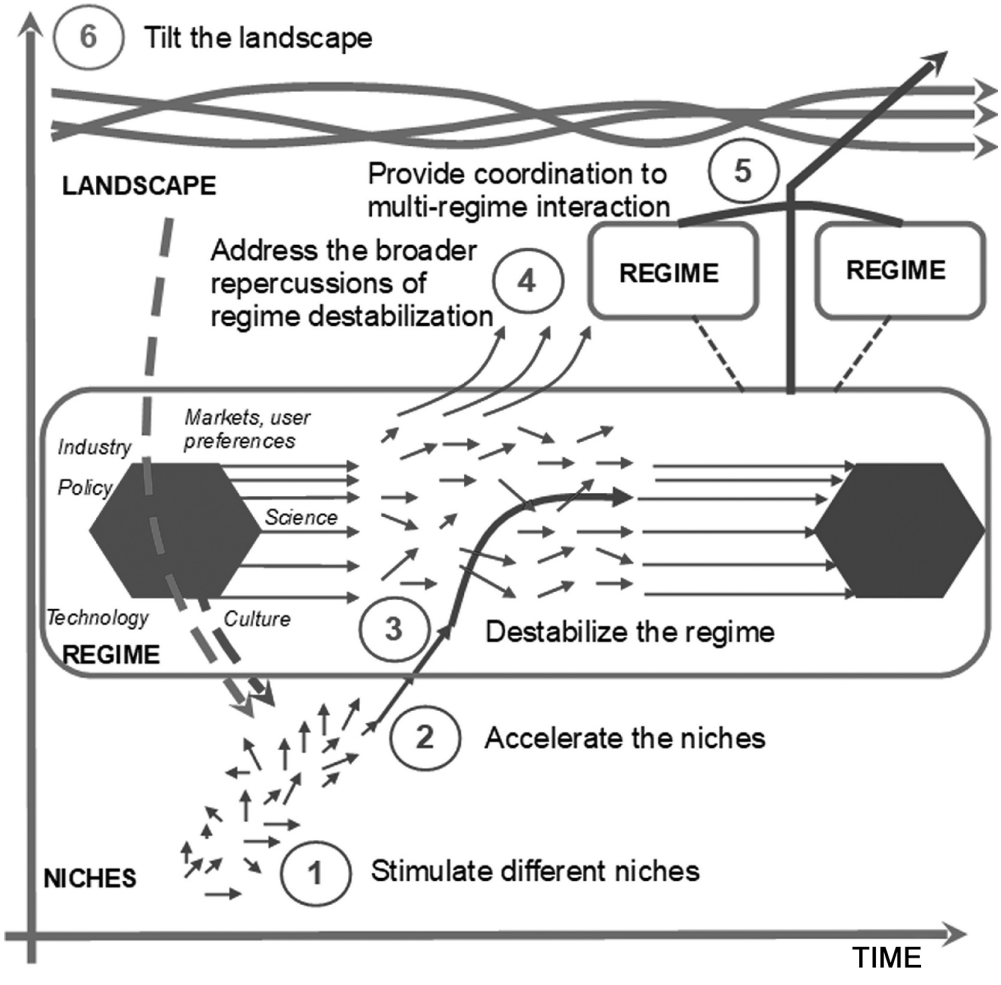
Acknowledging the dual nature that innovation policy mixes require to accelerate energy innovation is a crucial development in policy mix research (Kivimaa and Kern, 2016). The consideration of 'creative destruction' means that policymakers should design policy mixes that are, on the one hand, directly promoting the creation of net-zero energy innovations and, on the other hand, are indirectly supporting such innovations by also including policies aimed at the destruction of the existing unsustainable energy system (Geels, 2018). This insight has stimulated empirical studies investigating such phenomena (Rosenbloom and Rinscheid, 2020; Rinscheid et al., 2021) but has also led to attempts to broaden the concept of policy mixes for creative destruction. For example, David (2017) introduces the term 'exnovation' to describe the deliberate termination of fossil fuel-based technological trajectories, arguing that this terminology helps to go beyond the heuristic of creative destruction. Going significantly further, Kanger and colleagues (2020) identify six policy intervention points (IPs, see Table 8.5 and Figure 8.4) based on the multi-level perspective and its differentiation between niche, regime, and landscape levels (Geels, 2004, 2005). They define these policy IPs as 'particular areas in the socio-technical system or its environment where the application of appropriate policy instruments would likely facilitate transformative change in the system's directionality' (Kanger et al., 2020, p. 3). These IPs are closely connected to the idea of 'transformative outcomes' to be achieved by transformative innovation policy (Ghosh et al., 2021). Similarly to Kivimaa and Kern (2016), Kanger and colleagues (2020) distinguish between supporting the creation of niches – which they differentiate into stimulating versus accelerating niches – and

*Table 8.5 Overview of policy mix intervention points and examples of policy interventions*

| Intervention point | Policy interventions (examples) |
|---|---|
| 1. Stimulate different niches | Subsidies and regulatory shielding for niches in various systems, e.g. Chinese New Energy Vehicle policy |
| 2. Accelerate niches | Providing support for entering the markets and/or creating links between various niches, e.g. Danish wind energy policy |
| 3. Destabilise the regimes | Removal of various forms of regulatory and financial protection favouring incumbents, e.g. fossil fuel subsidy reform and phase-outs |
| 4. Address the broader repercussions of regime destabilisation | Provision of financial and educational support for structural unemployment and skill mismatch, e.g. German restructuring of the Ruhr valley |
| 5. Provide coordination to multi-regime interaction | Devising mutually supporting interventions in multiple systems, e.g. support for novel integrated solutions for electric mobility and heating at home combining solar photovoltaic, wall box, heat pump and electric vehicles |
| 6. Tilt the landscape | Participation in international negotiations to arrive at collectively binding agreements, e.g. the ban on chlorofluorocarbons |

*Source:* Kanger et al. (2020), with slight modifications.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/




*Source:* Kanger et al. (2020).

*Figure 8.4 Policy mix intervention points for system change*

the destabilisation of regimes. They argue that the destruction side is particularly important to tackle after the emergence phase of transitions (see Figures 8.3 and 8.4). While the *stimulation* of different niches (IP 1) is aimed at guaranteeing variety, i.e. the presence of various alternatives for systems change, the *acceleration* of selected niches (IP 2) is about them being scaled up and aligned with each other. In parallel, transition policy mixes should weaken the position of incumbent regime actors attempting to hinder net-zero transitions by destabilising the existing regime (IP 3). For example, phase-out policies for nuclear energy have been shown to be important drivers of innovation in renewable energies (Rogge and Johnstone, 2017). Lessons can also be drawn from the deliberate destabilisation of other established industries, such as coal and tobacco (Normann, 2019).

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

The main advancement of Kanger and colleagues (2020), however, lies in complementing the perspective of policy mixes for creative destruction with three further policy IPs to be tackled for accelerating sustainability transitions, which directly speak to net-zero energy transition policy mixes. These include addressing the broader repercussions of regime destabilisation (IP 4) in order to anticipate and manage the broader societal impacts resulting from systems change, such as reducing socio-economic impact and improving social deliberations associated with transitioning to a circular economy (Lazarevic et al., 2022) or those resulting from phasing out fossil fuels (Bang et al., 2022). It also includes the provision of coordination to multi-regime interaction (IP 5), thereby picking up an emerging line of transitions research on multi-system interactions (Andersen et al., 2020; Rosenbloom, 2020; Kanger et al., 2021), such as those arising from the electrification of transport (Canzler et al., 2017). This fifth policy IP aims at ensuring that the interactions between multiple systems would be complementary and not negative, for example in order to avoid that sustainability problems are only shifted from one system to the other (Papachristos et al., 2013). Finally, Kanger and colleagues (2020) also tackle the landscape level by suggesting that international policies could tilt the landscape (IP 6) by altering the broader framework conditions, for example in the form of ambitious, binding, and enforced international agreements, which in turn would enable change in the directionality of locally bounded socio-technical systems towards net zero. The first empirical policy mix studies applying this framework have emerged, ranging from a Delphi study on IPs in Estonia's energy transition (Pahker et al., 2024) to analyses of the EU food system (EEA, 2022) and Covid-19 recovery packages (Kivimaa et al., 2023).

The key takeaway from development 5 is that transition policy mixes aiming to accelerate energy innovation should not take a narrow approach that overlooks the complexity of energy system change, including the societal impact of net-zero energy innovations or system interactions resulting from the wider diffusion of such innovations. Put differently, the more advanced a net-zero energy transition is, the more policy intervention points should be considered in research and policymaking.

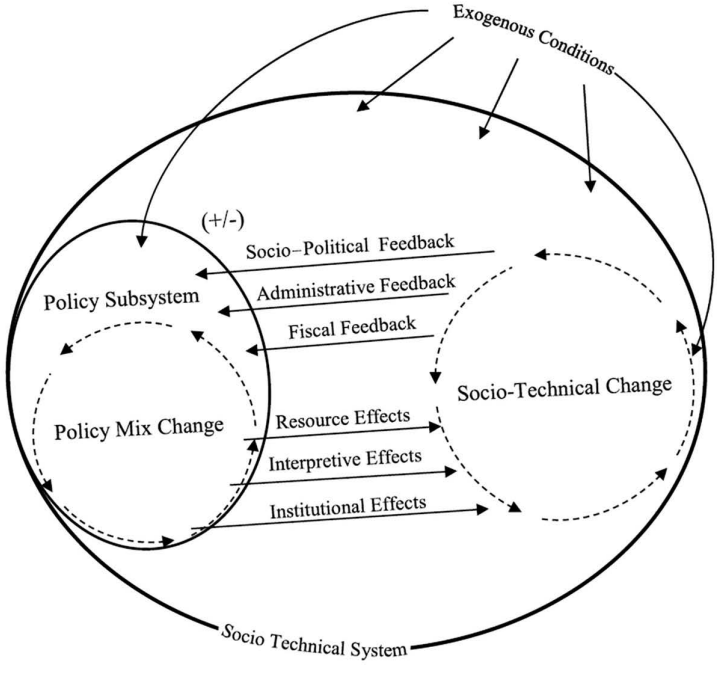
### 2.6 Development 6: From Navigating Resistance to Policy Mix Feedbacks

Transition policy mixes create not only winners, such as net-zero entrepreneurs, but also losers, such as fossil fuel incumbents with vested interests (Geels, 2014; Rosenbloom, 2018). A broader understanding of transition policy mixes thus takes into consideration that net-zero energy transitions are not only complex and uncertain but also contested and deeply political processes (Kern and Rogge, 2016; Roberts et al., 2018). Such resistance has been argued to justify supplementing carbon pricing with other policies designed to limit the impact on incumbents while supporting new entrants (Passey et al., 2012). In addition, the design of short-term policies has been suggested to be done in a way that helps provide later entry points for more ambitious climate policy (Kriegler et al., 2018), thereby accelerating energy innovation later on. More specifically, the sequencing of policies has been proposed as a way to build coalitions for net-zero transitions (Meckling et al., 2017). The idea here is to start with green industrial policy and introduce carbon pricing (or make it more stringent) once supportive coalitions of ambitious climate policy have been formed, with the United States Inflation Reduction Act being a case in point. Similarly, sequencing can also occur within climate and energy policy itself, where the creation of pro-change constituencies and learning can enable ratcheting up over time (Leipprand et al., 2020; Schmid and Lumsden, 2023). In particular,

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

net-zero innovation has been identified as an enabler of ratcheting up climate policy over time, for example through cost reductions and job creation (Schmidt and Sewerin, 2017). That is, building supportive coalitions, strengthening net-zero technologies, and empowering actors most likely to destabilise unsustainable regimes through creation policies can help prepare the ground for the later adoption of destruction policies, such as fossil fuel subsidy reform (Schmidt et al., 2017), which in turn can accelerate net-zero transitions.

Yet, while policymakers are advised to design policy mixes with such positive policy feedbacks in mind (e.g. through the creation of resources, provision of clear information, and establishment of credibility), more often than not, we observe cases of negative policy feedback, leading to a loss of political support for maintaining or strengthening specific policy mix elements such as strategies and instruments. A case in point is the United Kingdom zero-carbon homes target introduced in 2006, where initial policy mix changes stimulated socio-technical change in the low-carbon house-building sector, resulting in early positive feedbacks (Edmondson et al., 2020). However, over time, the policy mix started to produce negative feedbacks – arising from ineffective initial policy design and thus a lack of credibility, leading to uncertainty and inertia. This resulted in insufficient political support to withstand the negative turns in the economic and political context, ultimately leading to the target's abandonment in 2016. Therefore, the influence of such policy feedback calls for dedicated attention to the co-evolution of policy mixes and socio-technical systems (Edmondson et al., 2019). As illustrated in Figure 8.5, these policy mix feedbacks materialise through resource,




*Source:* Edmondson et al. (2019).

*Figure 8.5 Policy mix feedbacks*

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

interpretative, and institutional effects that an existing policy mix has on the energy system, such as through subsidies for net-zero energy innovation, information provision at net-zero energy conferences, or the expansion of state capacities for policy enforcement. The resulting changes in the energy system, in turn, can lead to socio-political, administrative, and fiscal feedback, such as the mobilisation of supporters versus opponents, the avoidance or creation of budgetary strains, or the strengthening versus weakening of the reputation of implementing agencies. This, in turn, influences the policy mix changes adopted and implemented in the future, which then again can influence the further development of the energy system and its transition to net zero. Research has also investigated such feedbacks by paying particular attention to the role of advocacy coalitions and cascading coalitions to help explain policy change in net-zero energy transitions (Schmid et al., 2020; Meckling and Goedeking, 2023).

## 3. TRANSITION POLICY MIX IMPLICATIONS: ENERGY INNOVATION IN THE ACCELERATION PHASE OF NET-ZERO TRANSITIONS

Past research on energy innovation has taken place when the transition of energy systems to net zero was still in the emergence phase (see Figure 8.3). However, now that we have entered the next phase of the net-zero energy transition (Markard, 2018), additional challenges emerge that are typical for the acceleration phase of transitions (Markard et al., 2020; Rogge and Goedeking, 2024), providing further rationales for policy intervention (for an overview, see Table 8.6). These challenges include the need for complementary technologies and infrastructures (Markard and Hoffmann, 2016; Andersen, Markard et al., 2023) and greater coordination requirements across multiple systems (Andersen et al., 2020; Andersen and Geels, 2023) and governance levels (Wittmann et al., 2021; Meadowcroft and Rosenbloom, 2023). Perhaps most visible to a broader public is the challenge of how to deal with the increasing resistance associated with decline (Meckling and Nahm, 2018b; Koretsky et al., 2022). In addition, contestations around the new rules of the game increase in relevance (Roberts and Geels, 2019; Rogge and Goedeking, 2024). Furthermore, as the transition enters mass markets, the need to change demand and user practices beyond early adopters constitutes another challenge (Schot et al., 2016; Sopjani et al., 2019; Whittle et al., 2019). In addition, justice considerations associated with acceleration grow in importance (Skjølsvold and Coenen, 2021; van Bommel and Höffken, 2023), as do international dynamics arising from global competition as well as complementarities (Quitzow, 2015b; Kern and Rogge, 2016). All of this implies greater demands on those governing net-zero transitions and coordinating policy mixes (Song et al., 2023), with greater needs of regulatory state capacity (Käsbohrer et al., 2025). Therefore, in this section, these additional acceleration challenges will be briefly introduced and their policy implications for supporting energy innovation summarised (Markard et al., 2020; Rogge and Goedeking, 2024).

### 3.1 Whole Systems Change

In the acceleration phase, net-zero energy transitions require major changes in the architecture of the energy system, which demands complementarity between multiple energy innovations (Markard and Hoffmann, 2016; McMeekin et al., 2019; Markard et al., 2020). For example,

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

*Table 8.6 Overview of challenges in the acceleration phase of net-zero transitions*

| No. | Challenge type | Description | Examples | Policy implications |
|---|---|---|---|---|
| 1 – WHO | Whole systems change | Major changes in system: complementary interactions between multiple innovations, fundamental changes in system architecture | Decentralisation and intermittency of electricity supply (e.g. photovoltaic) requiring enabling technologies (e.g. storage, grids) | Focus on entire systems instead of singular innovations, support experimentation with socio-technical system change instead of sole focus on technological change |
| 2 – MSI | Multi-system interactions | Increasing changes in the interaction of multiple systems, with a focus on tensions in multi-system interactions | Electrification of transport, heating, industry; digitalisation of vehicles and grids; mining impact of shift to electric vehicles | Overarching, cross-cutting missions; non-compartmentalised, more integral policymaking; multi-system task forces |
| 3 – DEC | Decline and resistance | Decline of existing industries and businesses, and multi-actor resistance to such decline | Petroleum industry, traditional combustion engine supply chain, and impacted shareholders, regions, unions, and politicians | Support structural change and reskilling of work force, create social acceptance, forge winning coalitions, compensate losers |
| 4 – EXP | Expansion and contestation | Contestation around the expanding trajectory, including framework conditions for new mass markets, securing future market shares and gains | Debates around ownership of charging stations and battery data, friction around manufacturers' focus on large electric vehicles | Update electricity market designs, regulate data access, set product and green finance standards, incentivise faster portfolio shifts to clean tech |
| 5 – CON | Consumers and social practices | Major changes in consumer practices and demand patterns | Home charging instead of refuelling at petrol stations, car sharing, shifting from car-only towards multi-modal transport | Stimulate technology adoption, behavioural change, and learning-by-using processes; enable new business models; adjust planning |
| 6 – JUS | Justice | Multi-dimensional justice implications of system changes and affordability of new technologies for low-income households | Access to affordable charging for multi-unit housing, availability of affordable electric vehicles (e.g. used car market) | Include a broad justice approach in policy design and evaluation, tailor policies to low-income households |

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

| No. | Challenge type | Description | Examples | Policy implications |
|---|---|---|---|---|
| 7 – INT | International dynamics | Global interplay driven by international competition, pioneering countries, geopolitical risks, and changes in global value chains | Inflation Reduction Act incentivising United States battery production, Chinese original equipment manufacturers entering foreign electric vehicle markets, securing critical raw materials | Renewed focus on green industrial policy, strategic resource partnerships, free trade clubs among like-minded partners |
| 8 – GOV | Governance | Increasing complexity of governance, policy paradigm change towards greater policy intervention | Multi-level collaboration in charging infrastructure roll-out; new e-mobility tasks for electricity market and grid regulators | Stronger vertical and horizontal policy coordination, governance reform, designing policy mixes for creative destruction, policy sequencing |

*Source:* Rogge and Goedeking (2024), building on Markard et al. (2020).

transitioning towards more decentralised forms of largely intermittent electricity supply, such as through solar photovoltaics, necessitates enabling technologies to balance supply and demand, such as new storage solutions or the upgrading and extension of electricity grids (Andersen, 2014; Mäkitie et al., 2022).

For policymaking, this calls for a shift in the focus of policy interventions from singular energy innovations towards the holistic monitoring of the entire energy system, providing information on simultaneously needed changes across multiple innovations and system dimensions. Consequentially, experimentation with socio-technical system change and the removal of barriers to it (e.g. infrastructure bottlenecks) should play a greater role in transition policy mixes aimed at accelerating energy innovation. A case in point is the updating of outdated or addition of missing regulation to help make energy systems more flexible, such as through designing energy storage provisions supporting whole system change (Käsbohrer et al., 2025).

### 3.2 Multi-System Interactions

As transitions towards net zero accelerate, there will be increasing interactions among multiple systems, and tensions arising from such multi-system interactions will need to be overcome (Markard et al., 2020; Andersen, Geels, et al., 2023). For example, the electrification of transport, heating, and industry illustrates the potential competition between different systems with their increasing electricity demands (Nykamp et al., 2023). Another example of such growing interactions among multiple systems involves tensions and opportunities arising from the digitalisation of vehicles and grids (Erlinghagen and Markard, 2012; Wentland, 2016; Gschwendtner and Krauss, 2022). The mining impact resulting from a shift to electric vehicles provides yet another example, highlighting broader sustainability impacts that can arise from multi-system interactions (Lee et al., 2020).

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

For policymaking, this underscores the need for overarching, cross-cutting missions that consider the complexity arising from multiple systems undergoing net-zero transitions. Rather than relying solely on traditional, compartmentalised policymaking, a move towards more integrated processes and the establishment of multi-system task forces could help address these challenges.

### 3.3 Decline and Resistance

As the diffusion of radical net-zero energy innovation grows, existing fossil fuel businesses and their stakeholders are likely to increase their resistance to such decline (Geels, 2014; Markard et al., 2020). A case in point is the coal and oil industry, including any impacted shareholders, regions, unions, employees, and politicians, attempting to at least slow down net-zero transitions (Leipprand and Flachsland, 2018; Rosenbloom, 2018). Another example arising from the transition towards electric vehicles is companies in the traditional combustion engine supply chain reluctant to adjust their product portfolio (Wells and Nieuwenhuis, 2012; Sick et al., 2016; Schwabe, 2020) and being less perceptible to demand pull policy mixes supporting electrification (Luetkehaus, 2025). However, incumbents can play diverging roles in net-zero transitions (Hockerts and Wüstenhagen, 2010; van Mossel et al., 2018): rather than only focusing on efforts to slow down transitions, they can also diversify and reorient, thereby contributing to accelerating net-zero changes (Smink et al., 2015; Steen and Weaver, 2017; Lockwood et al., 2019) – and transition policy mix design will play a key role for the speed and direction of such reorientation (Goedeking and Rogge, 2025; see also Chapter 7 in this volume).

For policymaking, this implies that to overcome such resistance and be able to adopt policies accelerating net-zero energy innovation, dedicated attention needs to be given to this challenge (Andersen and Gulbrandsen, 2020; Pichler et al., 2021). Policy options include the support of structural change processes and the reskilling of the work force; the creation of social acceptance; the forging of winning coalitions benefiting from accelerating net-zero energy innovation; and the compensation of losers that may struggle to transform without policy support.

### 3.4 Expansion and Contestation

As net-zero energy transitions enter the acceleration phase, contestation around defining the institutional framework conditions influencing the expanding trajectory of net-zero energy innovations (e.g. market design, regulation, standards) will increase in importance (Rogge and Goedeking, 2024). Rather than simply layering new policies and institutions on top of existing ones, as may have been the case in the early phase of transitions to net-zero energy systems (Lockwood, 2016), the acceleration of net-zero energy innovation implies radically changing or replacing old framework conditions with new ones. This may not be as visible as one distinct policy or institutional reform but may happen sequentially in several iterations (Kivimaa and Rogge, 2022), with actors from multiple systems performing institutional work (Käsbohrer et al., 2024). The resulting new rules of the game are key for accelerating net-zero energy innovation, for example through their impact on the development and success of new business models and services around net-zero energy innovation but also for the expansion of production capacities (Bolton and Hannon, 2016; Bidmon and Knab, 2018; Donner and

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

de Vries, 2021). Examples include debates around the ownership of charging stations, which tend to be closely connected to the degree of liberalisation of electricity systems (Zink et al., 2020; Meckling and Goedeking, 2023). Another example concerns frictions around the focus of automotive manufacturers on large electric vehicles rather than smaller, cheaper, and more efficient ones (IEA, 2023).

As the new framework conditions will determine the distribution of future gains among stakeholders, policymakers need to be aware that they are likely to be heavily contested among actors, with incumbents and new entrants competing for future market shares in the emerging mass markets associated with net-zero energy innovation. These corporate interests are not automatically aligned with societal ones (Johnstone et al., 2017; Lockwood et al., 2020). As a consequence, competing private and societal interests as well as their impact on future net-zero trajectories should be kept in mind in future policy and institutional changes, for example when updating electricity market designs, regulating data access, setting product standards, or incentivising faster portfolio shifts to net-zero energy innovations. Arguably, these policy interventions represent an additional policy mix IP to the ones mentioned in the framework by Kanger and colleagues (2020), which Rogge and Goedeking (2024) call 'building the new regime'.

### 3.5 Consumers and Social Practices

Entering the acceleration phase of net-zero transitions requires not only attracting early adopters but also reaching mass markets, where consumers may be more hesitant to adopt radical energy innovations if they entail major changes in consumer practices (Markard et al., 2020). For example, switching to an electric vehicle requires users to adjust their habit of refuelling at petrol stations to charging at home or work (Whittle et al., 2019; Wolbertus et al., 2020). Similarly, social innovations like car sharing and shifting from car only to multi-modal transport highlight the importance of consumers being open to learning new practices. Reluctance to such changes acts as a barrier to accelerated net-zero energy innovation (Schlüter and Weyer, 2019; Sopjani et al., 2019; Svennevik, 2019). Furthermore, transitions toward net-zero energy systems would benefit from a decrease in energy demand, which many consumers may be unwilling to pursue beyond incremental changes (Dubois et al., 2019; Dütschke et al., 2022).

For policymaking, this implies that the adoption of net-zero energy innovation would benefit from supporting programs that encourage behavioural change and learning by using (Gazheli et al., 2015; Huttunen et al., 2021). Additionally, policies aiming to change practices should address all policy IPs (Keller et al., 2022) and help facilitate the creation of new business models tackling changes in consumer practices and demand reductions (Petzer et al., 2020; Ruggiero et al., 2021; Sarasini and Langeland, 2021). Policy mixes should also support more holistic solutions, such as through adjustments in urban or regional planning, for example, to provide attractive charging solutions for multi-unit dwellings.

### 3.6 Justice

As net-zero energy transitions enter the acceleration phase, the multi-dimensional implications of 'justice' in net-zero energy transitions and the affordability of net-zero energy innovations for low-income households are expected to gain political salience (Rogge and Goedeking, 2024). These justice considerations encompass more than compensating losers

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

in the declining trajectory (e.g. employees in the fossil fuel industry), but call for a holistic approach to just transitions that integrates procedural, distributive, recognition, and restorative justice (Heffron and McCauley, 2018; Abram et al., 2022). One crucial issue revolves around ensuring the affordability of net-zero energy innovations for low-income and disadvantaged households (Sovacool et al., 2019; Wyse et al., 2021). For example, there is currently a shortage of affordable battery electric vehicles, including in the used car market, and low-income households may not have access to inexpensive home charging solutions, necessitating affordable charging alternatives. Failure to address justice challenges can result in negative policy mix feedback in the form of backlash (Huber and Wicki, 2021), which may ultimately weaken the ambition level of transition policy mixes, thereby slowing down progress towards net-zero energy transitions. As such, this challenge type is highly political and closely intertwined with both decline and expansion.

For policymaking, this implies including a broad justice approach in policy design, monitoring, and evaluation, such as through co-designing offsetting schemes (Tomás et al., 2023) or developing transition contracts. It also means paying greater attention to designing policy instruments and mixes tailored to low-income households, for example, by providing income-dependent purchase subsidies for net-zero energy technologies or by recycling revenues from carbon pricing to reduce the burden on low-income households (Muth, 2023).

### 3.7 International Dynamics

As net-zero energy transitions accelerate, challenges associated with the global interplay of energy systems and their decarbonisation gain in importance (Rogge and Goedeking, 2024). This includes changes to global value chains, the diminishing international market shares of incumbents, and international competitors entering the domestic market with their net-zero energy innovations (Binz et al., 2017). Such 'international dynamics' occurring in global innovation systems (Binz and Truffer, 2017) have been recognised as potential drivers for accelerating transitions (Kern and Rogge, 2016), but they can also impede acceleration, for example, through material constraints (IRENA, 2023; Gong and Andersen, 2024), industrial protectionism (Meckling et al., 2015; Hughes and Meckling, 2018; Meckling and Nahm, 2019), trade disputes (Hughes and Meckling, 2017), and heightened geopolitical risks (Gosens et al., 2020). Examples of global interplay include the Inflation Reduction Act incentivising United States battery production, Chinese original equipment manufacturers entering foreign markets with electric vehicles, and the dependence on critical raw materials from only a few source countries with high geopolitical risks.

For policymaking, this implies a renewed focus on green industrial policy as an important part of the overarching policy mix, the establishment of strategic resource partnerships, or free trade clubs among like-minded partner countries. Additionally, international dynamics should be linked with justice considerations, which may require policy coordination for establishing sustainable and just global value chains, for example, for critical minerals (Sovacool et al., 2020).

### 3.8 Governance

Governing net-zero energy transitions becomes increasingly contested and complex, facing multiple acceleration challenges simultaneously (Markard et al., 2020). While transition

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

policy mixes are arguably more effective when they simultaneously support the creation of energy innovation and promote their wider diffusion by phasing out support for greenhouse gas-emitting technologies and practices (Kivimaa and Kern, 2016), such policy mixes for creative destruction face political resistance from incumbents (see Section 3.3). They also require balancing competing interests in the expanding trajectory (see Section 3.4). Additionally, governments are not only challenged by the dual politics around transition policy mixes but also by the increasing complexity of net-zero transitions, for example concerning whole systems change (Section 3.1), multi-system interactions (Section 3.2), or justice considerations and resulting lack of public acceptance (Section 3.6), among others, all requiring effective governance for coordinating the net-zero energy transition (Goedeking and Meckling, 2024). This increasing complexity necessitates intensified horizontal and vertical coordination across multiple governing entities (Song et al., 2023) as well as inclusive policymaking processes that seek to bridge perspectives of multiple sectors and actors (Ateş et al., 2024). However, coordination may face limitations due to differences in political will across governance levels (Zepa and Hoffmann, 2023) and current administrative practices (Braams et al., 2022).

Ultimately, governing the acceleration of net-zero transitions demands a policy paradigm shift towards greater policy intervention. This entails rethinking fundamental beliefs about the role of government (Braams et al., 2021), finding new governance and institutional arrangements (Haley, 2016; Finnegan, 2022) and enhancing regulatory state capacity (Käsbohrer et al., 2025). Examples of how governments are addressing such increasing complexity include creating new e-mobility task forces, bringing together experts from several sectors (e.g. electricity market and transport system regulators) and harnessing cross-cutting policy functions (e.g. fiscal policy for reforming the tax system). Another example is the collaborative effort of actors from multiple governance levels in the roll-out of the charging infrastructure, as seen, for example, in California, with oversight from a steering group tasked with achieving climate neutrality. For policymakers, this implies a greater need for vertical and horizontal policy coordination, necessitating overarching capacities for policy mix mapping that transcends narrow policy silos and takes system actors as a starting point (Ossenbrink et al., 2019). Handling the greater complexity of net-zero transitions also calls for institutional and governance reforms to enable the design and implementation of policy mixes for creative destruction (Goedeking and Rogge, 2025). It encompasses the task of generating policy support through positive policy mix feedbacks (Rosenbloom et al., 2019; Sewerin et al., 2020; Lockwood, 2022).

## 4. CONCLUSION

This chapter has outlined six conceptual developments and key terminologies in policy mix research, providing insights into the role of transition policy mixes in accelerating net-zero energy innovation. In conclusion, I highlight three key insights emerging from this research. First, the *stringency* of policy instruments is a crucial design feature for accelerating net-zero energy innovation. Therefore, policymakers must ensure that policies are sufficiently stringent to drive the desired changes effectively. Second, *phase-out policies* represent a fundamental yet often underutilised driver in accelerating net-zero transitions. Governments should pay greater attention to creating attractive markets for net-zero energy innovation by adjusting the rules of the game so that they no longer benefit fossil fuel-based energy solutions. Third,

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

overcoming resistance to implementing transition policy mixes targeting creation and destruction requires dynamic thinking to harness the effects of positive *policy mix feedbacks* while avoiding negative ones. This necessitates considering longer time frames beyond short electoral cycles and may entail institutional changes to facilitate this approach. By embracing these insights, policymakers can support the acceleration of net-zero energy transitions and drive meaningful change towards a more sustainable future.

While this chapter did not delve into the systematic evaluation of the impact of transition policy mixes for net-zero energy innovation, such research is clearly needed. The shortage of systematic evaluation studies applying broader transition policy mix thinking indicates a gap in the literature that warrants further exploration. Future research should build on systematically mapping out the policy mix of relevance for a particular net-zero energy innovation or broader transitions to net-zero energy systems. This important precondition for policy mix evaluation and design involves identifying policy strategies and instruments across all relevant governing levels and policy fields, considering both intentional and unintentional policy mix effects for the selected impact domain (Ossenbrink et al., 2019). Additionally, there needs to be increased attention to the politics surrounding transition policy mixes and strategies for overcoming resistance. This might involve, for example, coalition building through green industrial policy and generating public support through creating beneficiaries of such policy changes (Meckling et al., 2015). Furthermore, more research is needed to understand the state capacities required to effectively govern transition policy mixes for accelerating net-zero energy transitions (Meckling and Nahm, 2018a; Goedeking and Rogge, 2024). Such future research would help inform policy mix design and implementation to drive energy innovation and accelerate net-zero energy transitions.

## ACKNOWLEDGEMENTS

I gratefully acknowledge funding received from the European Research Council under the European Union's Horizon 2020 research and innovation programme (grant agreement no. 852730). ChatGPT was utilised to assist with proofreading the manuscript.

## REFERENCES

Abram, S. et al. (2022) 'Just transition: A whole-systems approach to decarbonisation', *Climate Policy*, 22(8), pp. 1033–1049. Available at: https://doi.org/10.1080/14693062.2022.2108365.

Andersen, A.D. (2014) 'No transition without transmission: HVDC electricity infrastructure as an enabler for renewable energy?', *Environmental Innovation and Societal Transitions*, 13, pp. 75–95. Available at: https://doi.org/10.1016/j.eist.2014.09.004.

Andersen, A.D. et al. (2020) 'The role of inter-sectoral dynamics in sustainability transitions: A comment on the transitions research agenda', *Environmental Innovation and Societal Transitions*, 34, pp. 348–351. Available at: https://doi.org/10.1016/j.eist.2019.11.009.

Andersen, A.D. and Geels, F.W. (2023) 'Multi-system dynamics and the speed of net-zero transitions: Identifying causal processes related to technologies, actors, and institutions', *Energy Research and Social Science*, 102(February), p. 103178. Available at: https://doi.org/10.1016/j.erss.2023.103178.

Andersen, A.D., Geels, F.W. et al. (2023) 'Building multi-system nexuses in low-carbon transitions: Conflicts and asymmetric adjustments in Norwegian ferry electrification', *Proceedings of the National Academy of Sciences*, 120(47), p. 2017. Available at: https://doi.org/10.1073/pnas.2207746120.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Andersen, A.D. and Gulbrandsen, M. (2020) 'The innovation and industry dynamics of technology phase-out in sustainability transitions: Insights from diversifying petroleum technology suppliers in Norway', *Energy Research and Social Science*, 64. Available at: https://doi.org/10.1016/j.erss.2020.101447.

Andersen, A.D., Markard, J. et al. (2023) 'Architectural change in accelerating transitions: Actor preferences, system architectures, and flexibility technologies in the German energy transition', *Energy Research and Social Science*, 97(January), p. 102945. Available at: https://doi.org/10.1016/j.erss.2023.102945.

Ashford, N., Ayers, C., and Stone, R.F. (1985) 'Using regulation to change the market for innovation', *Harvard Environmental Law Review*, 9(2), pp. 419–466.

Ateş, A., Rogge, K.S., and Lovell, K. (2024) 'Governance in multi-system transitions: A new methodological approach for actor involvement in policy making processes', *Energy Policy*, 195, 114313. Available at: https://doi.org/10.1016/j.enpol.2024.114313.

Axsen, J. and Wolinetz, M. (2023) 'What does a low-carbon fuel standard contribute to a policy mix? An interdisciplinary review of evidence and research gaps', *Transport Policy*, 133, pp. 54–63. Available at: https://doi.org/10.1016/j.tranpol.2023.01.008.

Bach, H. and Hansen, T. (2023) 'Flickering guiding light from the International Maritime Organisation's policy mix', *Environmental Innovation and Societal Transitions*, 47, p. 100720. Available at: https://doi.org/10.1016/j.eist.2023.100720.

Bang, G., Rosendahl, K.E. and Böhringer, C. (2022) 'Balancing cost and justice concerns in the energy transition: Comparing coal phase-out policies in Germany and the UK', *Climate Policy*, 22(8), pp. 1000–1015. Available at: https://doi.org/10.1080/14693062.2022.2052788.

Bergek, A. et al. (2008) 'Analyzing the functional dynamics of technological innovation systems: A scheme of analysis', *Research Policy*, 37(3), pp. 407–429. Available at: https://doi.org/10.1016/j.respol.2007.12.003.

Bidmon, C.M. and Knab, S.F. (2018) 'The three roles of business models in societal transitions: New linkages between business model and transition research', *Journal of Cleaner Production*, 178. Available at: https://doi.org/10.1016/j.jclepro.2017.12.198.

Binz, C., Tang, T., and Huenteler, J. (2017) 'Spatial lifecycles of cleantech industries: The global development history of solar photovoltaics', *Energy Policy*, 101(November), pp. 386–402. Available at: https://doi.org/10.1016/j.enpol.2016.10.034.

Binz, C. and Truffer, B. (2017) 'Global innovation systems: A conceptual framework for innovation dynamics in transnational contexts', *Research Policy*, 46(7), pp. 1284–1298. Available at: https://doi.org/10.1016/j.respol.2017.05.012.

Bolton, R. and Hannon, M. (2016) 'Governing sustainability transitions through business model innovation: Towards a systems understanding', *Research Policy*, 45(9), pp. 1731–1742. Available at: https://doi.org/10.1016/j.respol.2016.05.003.

Borrás, S. and Edquist, C. (2019) *Holistic Innovation Policy: Theoretical Foundations, Policy Problems, and Instrument Choices*. Oxford University Press. Available at: https://doi.org/10.1093/oso/9780198809807.001.0001.

Bouma, J.A. et al. (2019) 'Policy mix: Mess or merit?', *Journal of Environmental Economics and Policy*, 8(1), pp. 32–47. Available at: https://doi.org/10.1080/21606544.2018.1494636.

Braams, R.B. et al. (2021) 'Legitimizing transformative government: Aligning essential government tasks from transition literature with normative arguments about legitimacy from public administration traditions', *Environmental Innovation and Societal Transitions*, 39(March), pp. 191–205. Available at: https://doi.org/10.1016/j.eist.2021.04.004.

Braams, R.B. et al. (2022) 'Understanding why civil servants are reluctant to carry out transition tasks', *Science and Public Policy*, 49(6), pp. 905–914. Available at: https://doi.org/10.1093/scipol/scac037.

Braathen, N.A. (2007) 'Instrument mixes for environmental policy: How many stones should be used to kill a bird?', *International Review of Environmental and Resource Economics*, 1(2), pp. 185–235. Available at: https://doi.org/10.1561/101.00000005.

Canzler, W. et al. (2017) 'From "living lab" to strategic action field: Bringing together energy, mobility, and ICT in Germany', *Energy Research and Social Science*, 27, pp. 25–35. Available at: https://doi.org/10.1016/j.erss.2017.02.003.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Cetkovic, S. and Skjaerseth, J.B. (2019) 'Creative and disruptive elements in Norway's climate policy mix: The small-state perspective', *Environmental Politics*, 28(6, SI), pp. 1039–1060. Available at: https://doi.org/10.1080/09644016.2019.1625145.

Costantini, V., Crespi, F., and Palma, A. (2017) 'Characterizing the policy mix and its impact on eco-innovation: A patent analysis of energy-efficient technologies', *Research Policy*, 46(4), pp. 799–819. Available at: https://doi.org/10.1016/j.respol.2017.02.004.

David, M. (2017) 'Moving beyond the heuristic of creative destruction: Targeting exnovation with policy mixes for energy transitions', *Energy Research & Social Science*, 33, pp. 138–146. Available at: https://doi.org/10.1016/j.erss.2017.09.023.

Del Río González, P. (2007) 'The interaction between emissions trading and renewable electricity support schemes. An overview of the literature', *Mitigation and Adaptation Strategies for Global Change*, 12(8), pp. 1363–1390. Available at: https://doi.org/10.1007/s11027-006-9069-y.

Di Stefano, G., Gambardella, A., and Verona, G. (2012) 'Technology push and demand pull perspectives in innovation studies: Current findings and future research directions', *Research Policy*, 41(8), pp. 1283–1295. Available at: https://doi.org/10.1016/j.respol.2012.03.021.

Donner, M. and de Vries, H. (2021) 'How to innovate business models for a circular bio-economy?', *Business Strategy and the Environment*, 30(4), pp. 1932–1947. Available at: https://doi.org/10.1002/bse.2725.

Dubois, G. et al. (2019) 'It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures', *Energy Research and Social Science*, 52(March), pp. 144–158. Available at: https://doi.org/10.1016/j.erss.2019.02.001.

Dütschke, E. et al. (2022) 'Car driving, air travel or more sustainable transport? Socio-psychological factors in everyday mobility and long-distance leisure travel', *Travel Behaviour and Society*, 28(March), pp. 115–127. Available at: https://doi.org/10.1016/j.tbs.2022.03.002.

Edmondson, D.L., Kern, F., and Rogge, K.S. (2019) 'The co-evolution of policy mixes and socio-technical systems: Towards a conceptual framework of policy mix feedback in sustainability transitions', *Research Policy*, 48(10), p. 103555. Available at: https://doi.org/10.1016/j.respol.2018.03.010.

Edmondson, D.L., Rogge, K.S., and Kern, F. (2020) 'Zero carbon homes in the UK? Analysing the co-evolution of policy mix and socio-technical system', *Environmental Innovation and Societal Transitions*, 35, pp. 135–161. Available at: https://doi.org/10.1016/j.eist.2020.02.005.

EEA (2022) *Transforming Europe's food system: Assessing the EU policy mix*. Available at: https://www.eea.europa.eu/en/newsroom/news/transforming-europes-food-system.

Ehnert, F. et al. (2018) 'The acceleration of urban sustainability transitions: A comparison of Brighton, Budapest, Dresden, Genk, and Stockholm', *Sustainability*, 10(3). Available at: https://doi.org/10.3390/su10030612.

Erlinghagen, S. and Markard, J. (2012) 'Smart grids and the transformation of the electricity sector: ICT firms as potential catalysts for sectoral change', *Energy Policy*, 51, pp. 895–906. Available at: https://doi.org/10.1016/j.enpol.2012.09.045.

Finnegan, J.J. (2022) 'Institutions, climate change, and the foundations of long-term policymaking', *Comparative Political Studies*, 55(7), pp. 1198–1235. Available at: https://doi.org/10.1177/00104140211047416.

Flanagan, K., Uyarra, E., and Laranja, M. (2011) 'Reconceptualising the "policy mix" for innovation', *Research Policy*, 40(5), pp. 702–713. Available at: https://doi.org/10.1016/j.respol.2011.02.005.

Frondel, M., Horbach, J., and Rennings, K. (2007) 'End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries', *Business Strategy and the Environment*, 16(8), pp. 571–584. Available at: https://doi.org/10.1002/bse.496.

Gazheli, A., Antal, M., and van den Bergh, J. (2015) 'The behavioral basis of policies fostering long-run transitions: Stakeholders, limited rationality and social context', *Futures*, 69, pp. 14–30. Available at: https://doi.org/10.1016/j.futures.2015.03.008.

Geels, F.W. (2004) 'From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory', *Research Policy*, 33(6–7), pp. 897–920. Available at: https://doi.org/10.1016/j.respol.2004.01.015.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Geels, F.W. (2005) 'Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective', *Technological Forecasting and Social Change*, 72(6), pp. 681–696. Available at: https://doi.org/10.1016/j.techfore.2004.08.014.

Geels, F.W. (2014) 'Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective', *Theory, Culture & Society*, 31(5), pp. 21–40. Available at: https://doi.org/10.1177/0263276414531627.

Geels, F.W. (2018) 'Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the multi-level perspective', *Energy Research and Social Science*, 37, pp. 224–231. Available at: https://doi.org/10.1016/j.erss.2017.10.010.

Geels, F.W., Kern, F., and Clark, W.C. (2023) 'Sustainability transitions in consumption-production systems', *Proceedings of the National Academy of Sciences*, 120(47), pp. 1–10. Available at: https://doi.org/10.1073/pnas.2310070120.

Geels, F.W. and Turnheim, B. (2022) *The Great Reconfiguration*. Cambridge University Press. Available at: https://doi.org/10.1017/9781009198233.

Ghisetti, C. and Pontoni, F. (2015) 'Investigating policy and R&D effects on environmental innovation: A meta-analysis', *Ecological Economics*, 118, pp. 57–66. Available at: https://doi.org/10.1016/j.ecolecon.2015.07.009.

Ghosh, B. et al. (2021) 'Transformative outcomes: Assessing and reorienting experimentation with transformative innovation policy', *Science and Public Policy*, 48(5), pp. 739–756. Available at: https://doi.org/10.1093/scipol/scab045.

Givoni, M. et al. (2013) 'From policy measures to policy packages', *Transport Reviews*, 33(1), pp. 1–20. Available at: https://doi.org/10.1080/01441647.2012.744779.

Goedeking, N. and Meckling, J. (2024) 'Coordinating the energy transition: Electrifying transportation in California and Germany', *Energy Policy*, 195, 114321. Available at: https://doi.org/10.1016/j.enpol.2024.114321.

Goedeking, N. and Rogge, K.S. (2025) 'Systemic acceleration capacity in net-zero transitions: Electrifying transportation in California', *Environmental Politics*, 19(4).

Gong, H. and Andersen, A.D. (2024) 'The role of material resources for rapid technology diffusion in net-zero transitions: Insights from EV lithium-ion battery technological innovation system in China', *Technological Forecasting and Social Change*, 200(July), p. 123141. Available at: https://doi.org/10.1016/j.techfore.2023.123141.

Gosens, J., Binz, C., and Lema, R. (2020) 'China's role in the next phase of the energy transition: Contributions to global niche formation in the concentrated solar power sector', *Environmental Innovation and Societal Transitions*, 34, pp. 61–75. Available at: https://doi.org/10.1016/j.eist.2019.12.004.

Grin, J., Rotmans, J., and Schot, J. (2010) *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*, Routledge. Available at: https://doi.org/10.4324/9780203856598.

Gschwendtner, C. and Krauss, K. (2022) 'Coupling transport and electricity: How can vehicle-to-grid boost the attractiveness of carsharing?', *Transportation Research Part D: Transport and Environment*, 106, p. 103261. Available at: https://doi.org/10.1016/j.trd.2022.103261.

Gunningham, N., Grabosky, P., and Sinclair, D. (1998) *Smart Regulation*. Oxford University Press. Available at: https://doi.org/10.1093/oso/9780198268574.001.0001.

Haley, B. (2016) 'Getting the institutions right: Designing the public sector to promote clean innovation', *Canadian Public Policy*, 42(1), pp. S54–S66. Available at: https://doi.org/10.3138/cpp.2016-051.

Heffron, R.J. and McCauley, D. (2018) 'What is the "just transition"?', *Geoforum*, 88(December), pp. 74–77. Available at: https://doi.org/10.1016/j.geoforum.2017.11.016.

Hekkert, M.P. et al. (2007) 'Functions of innovation systems: A new approach for analysing technological change', *Technological Forecasting and Social Change*, 74(4), pp. 413–432. Available at: https://doi.org/10.1016/j.techfore.2006.03.002.

Hewitt, R.J. et al. (2019) 'Social innovation in community energy in Europe: A review of the evidence', *Frontiers in Energy Research*, 7(APR). Available at: https://doi.org/10.3389/fenrg.2019.00031.

Hockerts, K. and Wüstenhagen, R. (2010) 'Greening Goliaths versus emerging Davids: Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship', *Journal of Business Venturing*, 25(5), pp. 481–492. Available at: https://doi.org/10.1016/j.jbusvent.2009.07.005.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Hoffmann, V.H., Trautmann, T., and Schneider, M. (2008) 'A taxonomy for regulatory uncertainty-application to the European Emission Trading Scheme', *Environmental Science and Policy*, 11(8), pp. 712–722. Available at: https://doi.org/10.1016/j.envsci.2008.07.001.

Hoppmann, J. et al. (2013) 'The two faces of market support: How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry', *Research Policy*, 42(4), pp. 989–1003. Available at: https://doi.org/10.1016/j.respol.2013.01.002.

Howlett, M. (2005) 'What is a policy instrument? Tools, mixes, and implementation styles', in *Designing Government*. McGill-Queen's University Press, pp. 31–50. Available at: https://doi.org/10.1515/9780773581708-004.

Howlett, M., Mukherjee, I., and Woo, J.J. (2015) 'From tools to toolkits in policy design studies: The new design orientation towards policy formulation research', *Policy & Politics*, 43(2), pp. 291–311. Available at: https://doi.org/10.1332/147084414X13992869118596.

Howlett, M. and Rayner, J. (2013) 'Patching vs packaging in policy formulation: Assessing policy portfolio design', *Politics and Governance*, 1(2), pp. 170–182. Available at: https://doi.org/10.12924/pag2013.01020170.

Howlett, M. and Rayner, J. (2022) 'Policy tools and (new) governance arrangements', in *The Routledge Handbook of Policy Tools*. Routledge, pp. 441–452. Available at: https://doi.org/10.4324/9781003163954-42.

Huang, P. (2019) 'The verticality of policy mixes for sustainability transitions: A case study of solar water heating in China', *Research Policy*, 48(10). Available at: https://doi.org/10.1016/j.respol.2019.02.009.

Huber, R.A. and Wicki, M. (2021) 'What explains citizen support for transport policy? The roles of policy design, trust in government and proximity among Swiss citizens', *Energy Research and Social Science*, 75(January), p. 101973. Available at: https://doi.org/10.1016/j.erss.2021.101973.

Hughes, L. and Meckling, J. (2017) 'The politics of renewable energy trade: The US–China solar dispute', *Energy Policy*, 105, pp. 256–262. Available at: https://doi.org/10.1016/j.enpol.2017.02.044.

Hughes, L. and Meckling, J. (2018) 'Policy competition in clean technology: Scaling up or innovating up?', *Business and Politics*, 20(4), pp. 588–614. Available at: https://doi.org/10.1017/bap.2018.20.

Huttunen, S. et al. (2021) 'Pluralising agency to understand behaviour change in sustainability transitions', *Energy Research and Social Science*, 76. Available at: https://doi.org/10.1016/j.erss.2021.102067.

IEA (2023) *Global EV Outlook 2023: Catching Up with Climate Ambitions*. OECD. Available at: https://doi.org/10.1787/cbe724e8-en.

IRENA (2023) *Geopolitics of the energy transition: Critical materials*. Available at: https://doi.org/10.1007/s11442-023-2101-2.

Jacob, K. and Ekins, P. (2020) 'Environmental policy, innovation and transformation: Affirmative or disruptive?', *Journal of Environmental Policy and Planning*, pp. 1–15. Available at: https://doi.org/10.1080/1523908X.2020.1793745.

Jacobsson, S., Bergek, A., and Sandén, B. (2017) 'Improving the European Commission's analytical base for designing instrument mixes in the energy sector: Market failures versus system weaknesses', *Energy Research and Social Science*, 33(January), pp. 11–20. Available at: https://doi.org/10.1016/j.erss.2017.09.009.

Jaffe, A.B., Newell, R.G., and Stavins, R.N. (2002) 'Environmental policy and technological change', *Environmental and Resource Economics*, 22(1–2), pp. 41–70. Available at: https://doi.org/10.1023/A:1015519401088.

Jaffe, A.B., Newell, R.G., and Stavins, R.N. (2005) 'A tale of two market failures: Technology and environmental policy', *Ecological Economics*, 54(2–3), pp. 164–174. Available at: https://doi.org/10.1016/j.ecolecon.2004.12.027.

Johnstone, P. and Newell, P. (2018) 'Sustainability transitions and the state', *Environmental Innovation and Societal Transitions*, 27, pp. 72–82. Available at: https://doi.org/10.1016/j.eist.2017.10.006.

Johnstone, P., Stirling, A., and Sovacool, B. (2017) 'Policy mixes for incumbency: Exploring the destructive recreation of renewable energy, shale gas "fracking", and nuclear power in the United Kingdom', *Energy Research and Social Science*, 33, pp. 147–162. Available at: https://doi.org/10.1016/j.erss.2017.09.005.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Kanger, L. et al. (2021) 'Research frontiers for multi-system dynamics and deep transitions', *Environmental Innovation and Societal Transitions*, 41(October), pp. 52–56. Available at: https://doi.org/10.1016/j.eist.2021.10.025.

Kanger, L., Sovacool, B.K., and Noorkõiv, M. (2020) 'Six policy intervention points for sustainability transitions: A conceptual framework and a systematic literature review', *Research Policy*, 49(7), p. 104072. Available at: https://doi.org/10.1016/j.respol.2020.104072.

Käsbohrer, A., Hansen, T., and Zademach, H.-M. (2024) 'Multi-system interactions and institutional work: Actor interactions at the interface of residential storage systems and electric vehicles in Germany', *Environmental Innovation and Societal Transitions*, 51, p. 100844. Available at: https://doi.org/10.1016/j.eist.2024.100844.

Käsbohrer, A., Rogge, K.S., and Zademach, H.M. (2025) 'Regulatory state capacity for accelerating net-zero transitions: Lessons learned from governing electricity storage in Germany', *Energy Policy*, 205(May). Available at: https://doi.org/10.1016/j.enpol.2025.114659.

Keller, M., Noorkõiv, M., and Vihalemm, T. (2022) 'Systems and practices: Reviewing intervention points for transformative socio-technical change', *Energy Research and Social Science*, 88, p. 102608. Available at: https://doi.org/10.1016/j.erss.2022.102608.

Kemp, R. (1997) *Environmental Policy and Technical Change: A Comparison of the Technological Impact of Policy Instruments*. Edward Elgar Publishing. Available at: https://www.e-elgar.com/shop/gbp/environmental-policy-and-technical-change-9781858985060.html.

Kemp, R. and Pontoglio, S. (2011) 'The innovation effects of environmental policy instruments: A typical case of the blind men and the elephant?', *Ecological Economics*, 72, pp. 28–36. Available at: https://doi.org/10.1016/j.ecolecon.2011.09.014.

Kemp, R., Schot, J., and Hoogma, R. (1998) 'Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management', *Technology Analysis and Strategic Management*, 10(2), pp. 175–198. Available at: https://doi.org/10.1080/09537329808524310.

Kern, F. and Howlett, M. (2009) 'Implementing transition management as policy reforms: A case study of the Dutch energy sector', *Policy Sciences*, 42(4), pp. 391–408. Available at: https://doi.org/10.1007/s11077-009-9099-x.

Kern, F. and Rogge, K.S. (2016) 'The pace of governed energy transitions: Agency, international dynamics and the global Paris Agreement accelerating decarbonisation processes?', *Energy Research & Social Science*, 22, pp. 13–17. Available at: https://doi.org/10.1016/j.erss.2016.08.016.

Kern, F. and Rogge, K.S. (2018) 'Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey', *Environmental Innovation and Societal Transitions*, 27, pp. 102–117. Available at: https://doi.org/10.1016/j.eist.2017.11.001.

Kern, F., Rogge, K.S., and Howlett, M. (2019) 'Policy mixes for sustainability transitions: New approaches and insights through bridging innovation and policy studies', *Research Policy*, 48(10), p. 103832. Available at: https://doi.org/10.1016/j.respol.2019.103832.

Kivimaa, P. (2007) 'The determinants of environmental innovation: The impacts of environmental policies on the Nordic pulp, paper and packaging industries', *European Environment*, 17(2), pp. 92–105. Available at: https://doi.org/10.1002/eet.442.

Kivimaa, P., Kangas, H.L., and Lazarevic, D. (2017) 'Client-oriented evaluation of "creative destruction" in policy mixes: Finnish policies on building energy efficiency transition', *Energy Research and Social Science*, 33(August), pp. 115–127. Available at: https://doi.org/10.1016/j.erss.2017.09.002.

Kivimaa, P. and Kern, F. (2016) 'Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions', *Research Policy*, 45(1), pp. 205–217. Available at: https://doi.org/10.1016/j.respol.2015.09.008.

Kivimaa, P., Lukkarinen, J., and Lazarevic, D. (2023) 'Analysis of Covid-19 recovery and resilience policy in Finland: A transformative policy mix approach', *Science and Public Policy*, 50(4), pp. 681–694. Available at: https://doi.org/10.1093/scipol/scad016.

Kivimaa, P. and Rogge, K.S. (2022) 'Interplay of policy experimentation and institutional change in sustainability transitions: The case of mobility as a service in Finland', *Research Policy*, 51(1), p. 104412. Available at: https://doi.org/10.1016/j.respol.2021.104412.

Koretsky, Z. et al. (2022) *Technologies in Decline: Socio-Technical Approaches to Discontinuation and Destabilisation*. Routledge. Available at: https://doi.org/10.4324/9781003213642.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Kriegler, E. et al. (2018) 'Short term policies to keep the door open for Paris climate goals', *Environmental Research Letters*, 13(7). Available at: https://doi.org/10.1088/1748-9326/aac4f1.

Lamperti, F., Napoletano, M., and Roventini, A. (2020) 'Green transitions and the prevention of environmental disasters: Market-based vs. command-and-control policies', *Macroeconomic Dynamics*, 24(7), pp. 1861–1880. Available at: https://doi.org/10.1017/S1365100518001001.

Lazarevic, D., Salo, H., and Kautto, P. (2022) 'Circular economy policies and their transformative outcomes: The transformative intent of Finland's strategic policy programme', *Journal of Cleaner Production*, 379, p. 134892. Available at: https://doi.org/10.1016/j.jclepro.2022.134892.

Lee, J. et al. (2020) 'Responsible or reckless? A critical review of the environmental and climate assessments of mineral supply chains', *Environmental Research Letters*, 15(10). Available at: https://doi.org/10.1088/1748-9326/ab9f8c.

Leipprand, A. and Flachsland, C. (2018) 'Regime destabilization in energy transitions: The German debate on the future of coal', *Energy Research and Social Science*, 40(July), pp. 190–204. Available at: https://doi.org/10.1016/j.erss.2018.02.004.

Leipprand, A., Flachsland, C., and Pahle, M. (2020) 'Starting low, reaching high? Sequencing in EU climate and energy policies', *Environmental Innovation and Societal Transitions*, 37(April), pp. 140–155. Available at: https://doi.org/10.1016/j.eist.2020.08.006.

Lilliestam, J., Patt, A., and Bersalli, G. (2021) 'The effect of carbon pricing on technological change for full energy decarbonization: A review of empirical ex-post evidence', *Wiley Interdisciplinary Reviews: Climate Change*, 12(1). Available at: https://doi.org/10.1002/wcc.681.

Lockwood, M. (2016) 'Creating protective space for innovation in electricity distribution networks in Great Britain: The politics of institutional change', *Environmental Innovation and Societal Transitions*, 18, pp. 111–127. Available at: https://doi.org/10.1016/j.eist.2015.05.007.

Lockwood, M. (2022) 'Policy feedback and institutional context in energy transitions', *Policy Sciences*, 55(3), pp. 487–507. Available at: https://doi.org/10.1007/s11077-022-09467-1.

Lockwood, M., Mitchell, C., and Hoggett, R. (2019) 'Unpacking "regime resistance" in low-carbon transitions: The case of the British capacity market', *Energy Research and Social Science*, 58. Available at: https://doi.org/10.1016/j.erss.2019.101278.

Lockwood, M., Mitchell, C., and Hoggett, R. (2020) 'Incumbent lobbying as a barrier to forward-looking regulation: The case of demand-side response in the GB capacity market for electricity', *Energy Policy*, 140. Available at: https://doi.org/10.1016/j.enpol.2020.111426.

Luetkehaus, H. (2025) 'Looking under the hood: How incumbent characteristics reduce the innovation impact of trajectory-changing demand-pull policy mixes for battery electric vehicles', *Research Policy*, 54(5), 105212. https://doi.org/10.1016/j.respol.2025.105212.

Mäkitie, T. et al. (2022) 'Complementarity formation mechanisms in technology value chains', *Research Policy*, 51(7). Available at: https://doi.org/10.1016/j.respol.2022.104559.

Malhotra, A. and Schmidt, T.S. (2020) 'Accelerating low-carbon innovation', *Joule*, 4(11), pp. 2259–2267. Available at: https://doi.org/10.1016/j.joule.2020.09.004.

Markard, J. (2018) 'The next phase of the energy transition and its implications for research and policy', *Nature Energy*, 3(8), pp. 628–633. Available at: https://doi.org/10.1038/s41560-018-0171-7.

Markard, J., Geels, F.W., and Raven, R. (2020) 'Challenges in the acceleration of sustainability transitions', *Environmental Research Letters*, 15(8), p. 81001. Available at: https://doi.org/10.1088/1748-9326/ab9468.

Markard, J., Hekkert, M., and Jacobsson, S. (2015) 'The technological innovation systems framework: Response to six criticisms', *Environmental Innovation and Societal Transitions*, 16, pp. 76–86. Available at: https://doi.org/10.1016/j.eist.2015.07.006.

Markard, J. and Hoffmann, V.H. (2016) 'Analysis of complementarities: Framework and examples from the energy transition', *Technological Forecasting and Social Change*, 111, pp. 63–75. Available at: https://doi.org/10.1016/j.techfore.2016.06.008.

McMeekin, A., Geels, F.W., and Hodson, M. (2019) 'Mapping the winds of whole system reconfiguration: Analysing low-carbon transformations across production, distribution and consumption in the UK electricity system (1990–2016)', *Research Policy*, 48(5), pp. 1216–1231. Available at: https://doi.org/10.1016/j.respol.2018.12.007.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Meadowcroft, J. and Rosenbloom, D. (2023) 'Governing the net-zero transition: Strategy, policy, and politics', *Proceedings of the National Academy of Sciences of the United States of America*, 120(47), pp. 1–11. Available at: https://doi.org/10.1073/pnas.2207727120.

Meckling, J. et al. (2015) 'Winning coalitions for climate policy: Green industrial policy builds support for carbon regulation', *Science*, 349(6253), pp. 1170–1171. Available at: https://doi.org/10.1126/science.aab1336.

Meckling, J. and Goedeking, N. (2023) 'Coalition cascades: The politics of tipping points in clean energy transitions', *Policy Studies Journal*. Available at: https://doi.org/10.1111/psj.12507.

Meckling, J. and Nahm, J. (2018a) 'The power of process: State capacity and climate policy', *Governance*, 31(4), pp. 741–757. Available at: https://doi.org/10.1111/gove.12338.

Meckling, J. and Nahm, J. (2018b) 'When do states disrupt industries? Electric cars and the politics of innovation', *Review of International Political Economy*, 25(4), pp. 505–529. Available at: https://doi.org/10.1080/09692290.2018.1434810.

Meckling, J. and Nahm, J. (2019) 'The politics of technology bans: Industrial policy competition and green goals for the auto industry', *Energy Policy*, 126, pp. 470–479. Available at: https://doi.org/10.1016/j.enpol.2018.11.031.

Meckling, J., Sterner, T., and Wagner, G. (2017) 'Policy sequencing toward decarbonization', *Nature Energy*, 7, p. 313. Available at: https://doi.org/10.1038/s41560-017-0025-8.

Muth, D. (2023) 'Pathways to stringent carbon pricing: Configurations of political economy conditions and revenue recycling strategies. A comparison of thirty national level policies', *Ecological Economics*, 214(September), p. 107995. Available at: https://doi.org/10.1016/j.ecolecon.2023.107995.

Nauwelaers, C. et al. (2009) *Policy mixes for R&D in Europe*, *European Commission–Directorate-General for Research, Maastricht*. Available at: https://research.manchester.ac.uk/files/33081654/FULL_TEXT.PDF.

Nemet, G.F. (2009) 'Demand-pull, technology-push, and government-led incentives for non-incremental technical change', *Research Policy*, 38(5), pp. 700–709. Available at: https://doi.org/10.1016/j.respol.2009.01.004.

Nemet, G.F. et al. (2017) 'Addressing policy credibility problems for low-carbon investment', *Global Environmental Change*, 42, pp. 47–57. Available at: https://doi.org/10.1016/j.gloenvcha.2016.12.004.

Normann, H.E. (2019) 'Conditions for the deliberate destabilisation of established industries: Lessons from US tobacco control policy and the closure of Dutch coal mines', *Environmental Innovation and Societal Transitions*, 33, pp. 102–114. Available at: https://doi.org/10.1016/j.eist.2019.03.007.

Nuñez-Jimenez, A. et al. (2022) 'Beyond innovation and deployment: Modeling the impact of technology-push and demand-pull policies in Germany's solar policy mix', *Research Policy*, 51(10). Available at: https://doi.org/10.1016/j.respol.2022.104585.

Nykamp, H., Andersen, A.D., and Geels, F.W. (2023) 'Low-carbon electrification as a multi-system transition: a socio-technical analysis of Norwegian maritime transport, construction, and chemical sectors', *Environmental Research Letters*, 18(9). Available at: https://doi.org/10.1088/1748-9326/acf67a.

Oberthür, S. and von Homeyer, I. (2023) 'From emissions trading to the European Green Deal: The evolution of the climate policy mix and climate policy integration in the EU', *Journal of European Public Policy*, 30(3), pp. 445–468. Available at: https://doi.org/10.1080/13501763.2022.2120528.

Ossenbrink, J. et al. (2019) 'Delineating policy mixes: Contrasting top-down and bottom-up approaches to the case of energy-storage policy in California', *Research Policy*, 48(10), p. 103582. Available at: https://doi.org/10.1016/j.respol.2018.04.014.

Pahker, A.-K. et al. (2024) 'What's worse, communism or carbon? Using the Transitions Delphi approach to identify viable interventions for the Estonian energy transition', *Energy Research & Social Science*, 109(June 2023), p. 103421. Available at: https://doi.org/10.1016/j.erss.2024.103421.

Papachristos, G., Sofianos, A., and Adamides, E. (2013) 'System interactions in socio-technical transitions: Extending the multi-level perspective', *Environmental Innovation and Societal Transitions*, 7, pp. 53–69. Available at: https://doi.org/10.1016/j.eist.2013.03.002.

Passey, R. et al. (2012) 'The inevitability of "flotilla policies" as complements or alternatives to flagship emissions trading schemes', *Energy Policy*, 48, pp. 551–561. Available at: https://doi.org/10.1016/j.enpol.2012.05.059.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Peñasco, C., Anadon, L.D., and Verdolini, E. (2021) 'Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments', *Nature Climate Change*, 11, 257–265. Available at: https://doi.org/10.1038/s41558-020-00971-x.

Peters, M. et al. (2012) 'The impact of technology-push and demand-pull policies on technical change: Does the locus of policies matter?', *Research Policy*, 41(8), pp. 1296–1308. Available at: https://doi.org/10.1016/j.respol.2012.02.004.

Petzer, B.J.M., Wieczorek, A.J., and Verbong, G.P. (2020) 'Cycling as a service assessed from a combined business-model and transitions perspective', *Environmental Innovation and Societal Transitions*, 36, pp. 255–269. Available at: https://doi.org/10.1016/j.eist.2019.09.001.

Pichler, M. et al. (2021) 'EU industrial policy: Between modernization and transformation of the automotive industry', *Environmental Innovation and Societal Transitions*, 38, pp. 140–152. Available at: https://doi.org/10.1016/j.eist.2020.12.002.

Popp, D. (2019) 'Environmental policy and innovation: A decade of research', *International Review of Environmental and Resource Economics*, 13(3–4), pp. 265–337. Available at: https://doi.org/10.1561/101.00000111.

Quitzow, R. (2015a) 'Assessing policy strategies for the promotion of environmental technologies: A review of India's national solar mission', *Research Policy*, 44(1), pp. 233–243. Available at: https://doi.org/10.1016/j.respol.2014.09.003.

Quitzow, R. (2015b) 'Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany', *Environmental Innovation and Societal Transitions*, 17, pp. 126–148. Available at: https://doi.org/10.1016/j.eist.2014.12.002.

Reichardt, K. et al. (2016) 'Analyzing interdependencies between policy mixes and technological innovation systems: The case of offshore wind in Germany', *Technological Forecasting and Social Change*, 106, pp. 11–21. Available at: https://doi.org/10.1016/j.techfore.2016.01.029.

Reichardt, K. and Rogge, K. (2016) 'How the policy mix impacts innovation: Findings from company case studies on offshore wind in Germany', *Environmental Innovation and Societal Transitions*, 18, pp. 62–81. Available at: https://doi.org/10.1016/j.eist.2015.08.001.

Reichardt, K., Rogge, K.S., and Negro, S.O. (2017) 'Unpacking policy processes for addressing systemic problems in technological innovation systems: The case of offshore wind in Germany', *Renewable and Sustainable Energy Reviews*, 80, pp. 1217–1226. Available at: https://doi.org/10.1016/j.rser.2017.05.280.

Rennings, K. (2000) 'Redefining innovation: Eco-innovation research and the contribution from ecological economics', *Ecological Economics*, 32(2), pp. 319–332. Available at: https://doi.org/10.1016/S0921-8009(99)00112-3.

Rinscheid, A. et al. (2021) 'From terminating to transforming: The role of phase-out in sustainability transitions', *Environmental Innovation and Societal Transitions*, 41(October), pp. 27–31. Available at: https://doi.org/10.1016/j.eist.2021.10.019.

Roberts, C. et al. (2018) 'The politics of accelerating low-carbon transitions: Towards a new research agenda', *Energy Research and Social Science*, 44(June), pp. 304–311. Available at: https://doi.org/10.1016/j.erss.2018.06.001.

Roberts, C. and Geels, F.W. (2019) 'Conditions for politically accelerated transitions: Historical institutionalism, the multi-level perspective, and two historical case studies in transport and agriculture', *Technological Forecasting and Social Change*, 140, pp. 221–240. Available at: https://doi.org/10.1016/j.techfore.2018.11.019.

Rogge, K.S. (2019) 'Policy mixes for sustainable innovation: conceptual considerations and empirical insights', in *Handbook of Sustainable Innovation*. Cheltenham: Edward Elgar Publishing, pp. 165–185. Available at: https://doi.org/10.4337/9781788112574.00016.

Rogge, K.S. et al. (2023) 'Fit for social innovation? Policy reflections for EU energy and climate policy making', *Oxford Open Energy*, 2(November), pp. 1–9. Available at: https://doi.org/10.1093/ooenergy/oiac010.

Rogge, K.S. and Dütschke, E. (2018) 'What makes them believe in the low-carbon energy transition? Exploring corporate perceptions of the credibility of climate policy mixes', *Environmental Science and Policy*, 87, pp. 74–84. Available at: https://doi.org/10.1016/j.envsci.2018.05.009.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the individual product page at www.elgaronline.com under a Creative Commons AttributionNonCommercial-NoDerivatives 4.0 International (https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Rogge, K.S. and Goedeking, N. (2024) 'Challenges in accelerating net-zero transitions: Insights from transport electrification in Germany and California', *Environmental Research Letters*, 19(4), p. 44007. Available at: https://doi.org/10.1088/1748-9326/ad2d84.

Rogge, K.S. and Johnstone, P. (2017) 'Exploring the role of phase-out policies for low-carbon energy transitions: The case of the German Energiewende', *Energy Research and Social Science*, 33, pp. 128–137. Available at: https://doi.org/10.1016/j.erss.2017.10.004.

Rogge, K.S., Kern, F., and Howlett, M. (2017) 'Conceptual and empirical advances in analysing policy mixes for energy transitions', *Energy Research and Social Science*, 33(September), pp. 1–10. Available at: https://doi.org/10.1016/j.erss.2017.09.025.

Rogge, K.S., Pfluger, B., and Geels, F.W. (2020) 'Transformative policy mixes in socio-technical scenarios: The case of the low-carbon transition of the German electricity system (2010–2050)', *Technological Forecasting and Social Change*, 151, p. 119259. Available at: https://doi.org/10.1016/j.techfore.2018.04.002.

Rogge, K.S. and Reichardt, K. (2016) 'Policy mixes for sustainability transitions: An extended concept and framework for analysis', *Research Policy*, 45(8), pp. 1620–1635. Available at: https://doi.org/10.1016/j.respol.2016.04.004.

Rogge, K.S. and Schleich, J. (2018) 'Do policy mix characteristics matter for low-carbon innovation? A survey-based exploration of renewable power generation technologies in Germany', *Research Policy*, 47(9), pp. 1639–1654. Available at: https://doi.org/10.1016/j.respol.2018.05.011.

Rogge, K.S., Schneider, M., and Hoffmann, V.H. (2011) 'The innovation impact of the EU Emission Trading System: Findings of company case studies in the German power sector', *Ecological Economics*, 70(3), pp. 513–523. Available at: https://doi.org/10.1016/j.ecolecon.2010.09.032.

Rogge, K.S. and Stadler, M. (2023) 'Applying policy mix thinking to social innovation: From experimentation to socio-technical change', *Environmental Innovation and Societal Transitions*, 47(April), p. 100723. Available at: https://doi.org/10.1016/j.eist.2023.100723.

Rosenbloom, D. (2018) 'Framing low-carbon pathways: A discursive analysis of contending storylines surrounding the phase-out of coal-fired power in Ontario', *Environmental Innovation and Societal Transitions*, 27, pp. 129–145. Available at: https://doi.org/10.1016/j.eist.2017.11.003.

Rosenbloom, D. (2020) 'Engaging with multi-system interactions in sustainability transitions: A comment on the transitions research agenda', *Environmental Innovation and Societal Transitions*, 34, pp. 336–340. Available at: https://doi.org/10.1016/j.eist.2019.10.003.

Rosenbloom, D. et al. (2020) 'Why carbon pricing is not sufficient to mitigate climate change – and how "sustainability transition policy" can help', *Proceedings of the National Academy of Sciences of the United States of America*, 117(16), pp. 8664–8668. Available at: https://doi.org/10.1073/pnas.2004093117.

Rosenbloom, D. and Meadowcroft, J. (2022) 'Accelerating pathways to net zero: Governance strategies from transition studies and the transition accelerator', *Current Climate Change Reports*, 8(4), pp. 104–114. Available at: https://doi.org/10.1007/s40641-022-00185-7.

Rosenbloom, D., Meadowcroft, J., and Cashore, B. (2019) 'Stability and climate policy? Harnessing insights on path dependence, policy feedback, and transition pathways', *Energy Research and Social Science*, 50(March), pp. 168–178. Available at: https://doi.org/10.1016/j.erss.2018.12.009.

Rosenbloom, D. and Rinscheid, A. (2020) 'Deliberate decline: An emerging frontier for the study and practice of decarbonization', *Wiley Interdisciplinary Reviews: Climate Change*, 11(6), pp. 1–20. Available at: https://doi.org/10.1002/wcc.669.

Ruggiero, S. et al. (2021) 'Business model innovation in demand response firms: Beyond the niche-regime dichotomy', *Environmental Innovation and Societal Transitions*, 39, pp. 1–17. Available at: https://doi.org/10.1016/j.eist.2021.02.002.

Sarasini, S. and Langeland, O. (2021) 'Business model innovation as a process for transforming user mobility practices', *Environmental Innovation and Societal Transitions*, 39, pp. 229–248. Available at: https://doi.org/10.1016/j.eist.2021.04.005.

Scherrer, A. and Rogge, K.S. (2025) 'When do incumbents adopt radical net-zero technologies? Analysing differences in strategy trajectories of European truck manufacturers towards alternative vehicle technologies', *Technological Forecasting and Social Change*, 211, 123872. Available at: https://doi.org/10.1016/j.techfore.2024.123872.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Schlüter, J. and Weyer, J. (2019) 'Car sharing as a means to raise acceptance of electric vehicles: An empirical study on regime change in automobility', *Transportation Research Part F: Traffic Psychology and Behaviour*, 60, pp. 185–201. Available at: https://doi.org/10.1016/j.trf.2018.09.005.

Schmid, N. et al. (2021) 'Elite vs. mass politics of sustainability transitions', *Environmental Innovation and Societal Transitions*, 41(May), pp. 67–70. Available at: https://doi.org/10.1016/j.eist.2021.09.014.

Schmid, N. and Lumsden, C. (2023) 'Sowing the seeds of change: Policy feedback and ratcheting up in South African energy policy', *Energy Policy*, 178, p. 113597. Available at: https://doi.org/10.1016/j.enpol.2023.113597.

Schmid, N., Sewerin, S., and Schmidt, T.S. (2020) 'Explaining advocacy coalition change with policy feedback', *Policy Studies Journal*, 48(4), pp. 1109–1134. Available at: https://doi.org/10.1111/psj.12365.

Schmidt, T.S. et al. (2012) 'The effects of climate policy on the rate and direction of innovation: A survey of the EU ETS and the electricity sector', *Environmental Innovation and Societal Transitions*, 2, pp. 23–48. Available at: https://doi.org/10.1016/j.eist.2011.12.002.

Schmidt, T.S., Matsuo, T., and Michaelowa, A. (2017) 'Renewable energy policy as an enabler of fossil fuel subsidy reform? Applying a socio-technical perspective to the cases of South Africa and Tunisia', *Global Environmental Change*, 45, pp. 99–110. Available at: https://doi.org/10.1016/j.gloenvcha.2017.05.004.

Schmidt, T.S. and Sewerin, S. (2017) 'Technology as a driver of climate and energy politics', *Nature Energy*, 2(6), p. 17084. Available at: https://doi.org/10.1038/NENERGY.2017.84.

Schmidt, T.S. and Sewerin, S. (2019) 'Measuring the temporal dynamics of policy mixes: An empirical analysis of renewable energy policy mixes' balance and design features in nine countries', *Research Policy*, 48(10). Available at: https://doi.org/10.1016/j.respol.2018.03.012.

Schot, J. and Geels, F.W. (2008) 'Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy', *Technology Analysis & Strategic Management*, 20(5), pp. 537–554. Available at: https://doi.org/10.1080/09537320802292651.

Schot, J., Kanger, L., and Verbong, G. (2016) 'The roles of users in shaping transitions to new energy systems', *Nature Energy*, 1, p. 16054. Available at: https://doi.org/10.1038/nenergy.2016.54.

Schumpeter, J.A. (1942) *Capitalism, Socialism, and Democracy*. Harper & Brothers. Available at: https://search.worldcat.org/title/30488029.

Schwabe, J. (2020) 'Risk and counter-strategies: The impact of electric mobility on German automotive suppliers', *Geoforum*, 110(March), pp. 157–167. Available at: https://doi.org/10.1016/j.geoforum.2020.02.011.

Scordato, L. et al. (2018) 'Policy mixes for the sustainability transition of the pulp and paper industry in Sweden', *Journal of Cleaner Production*, 183, pp. 1216–1227. Available at: https://doi.org/10.1016/j.jclepro.2018.02.212.

Sewerin, S., Béland, D., and Cashore, B. (2020) 'Designing policy for the long term: Agency, policy feedback and policy change', *Policy Sciences*, 53(2), pp. 243–252. Available at: https://doi.org/10.1007/s11077-020-09391-2.

Sick, N. et al. (2016) 'The legend about sailing ship effects – is it true or false? The example of cleaner propulsion technologies diffusion in the automotive industry', *Journal of Cleaner Production*, 137, pp. 405–413. Available at: https://doi.org/10.1016/j.jclepro.2016.07.085.

Skjølsvold, T.M. and Coenen, L. (2021) 'Are rapid and inclusive energy and climate transitions oxymorons? Towards principles of responsible acceleration', *Energy Research and Social Science*, 79(January), p. 102164. Available at: https://doi.org/10.1016/j.erss.2021.102164.

Smink, M.M., Hekkert, M.P., and Negro, S.O. (2015) 'Keeping sustainable innovation on a leash? Exploring incumbents' institutional strategies', *Business Strategy and the Environment*, 24(2), pp. 86–101. Available at: https://doi.org/10.1002/bse.1808.

Smits, R. and Kuhlmann, S. (2004) 'The rise of systemic instruments in innovation policy', *International Journal of Foresight and Innovation Policy*, 1(1/2), p. 4. Available at: https://doi.org/10.1504/IJFIP.2004.004621.

Song, Q., Rogge, K., and Ely, A. (2023) 'Mapping the governing entities and their interactions in designing policy mixes for sustainability transitions: The case of electric vehicles in China', *Environmental Innovation and Societal Transitions*, 46, p. 100691. Available at: https://doi.org/10.1016/j.eist.2023.100691.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Sopjani, L. et al. (2019) 'Involving users and user roles in the transition to sustainable mobility systems: The case of light electric vehicle sharing in Sweden', *Transportation Research Part D: Transport and Environment*, 71(SI), pp. 207–221. Available at: https://doi.org/10.1016/j.trd.2018.12.011.

Sorrell, S. and Sijm, J. (2003) 'Carbon trading in the policy mix', *Oxford Review of Economic Policy*, 19(3), pp. 420–437. Available at: https://doi.org/10.1093/oxrep/19.3.420.

Sovacool, B.K. (2016) 'How long will it take? Conceptualizing the temporal dynamics of energy transitions', *Energy Research and Social Science*, 13, pp. 202–215. Available at: https://doi.org/10.1016/j.erss.2015.12.020.

Sovacool, B.K. et al. (2025) 'The acceleration of low-carbon transitions: Insights, concepts, challenges, and new directions for research', *Energy Research & Social Science*, 121, p. 103948. Available at: https://doi.org/10.1016/j.erss.2025.103948.

Sovacool, B.K. et al. (2020) 'Sustainable minerals and metals for a low-carbon future: Policy coordination is needed for global supply chains', *Science*, 367(6473), pp. 30–33. Available at: https://doi.org/10.1126/science.aaz6003.

Sovacool, B.K., Lipson, M.M., and Chard, R. (2019) 'Temporality, vulnerability, and energy justice in household low carbon innovations', *Energy Policy*, 128(January), pp. 495–504. Available at: https://doi.org/10.1016/j.enpol.2019.01.010.

Spyridaki, N.A. and Flamos, A. (2014) 'A paper trail of evaluation approaches to energy and climate policy interactions', *Renewable and Sustainable Energy Reviews*, 40, pp. 1090–1107. Available at: https://doi.org/10.1016/j.rser.2014.08.001.

Steen, M. and Weaver, T. (2017) 'Incumbents' diversification and cross-sectorial energy industry dynamics', *Research Policy*, 46(6), pp. 1071–1086. Available at: https://doi.org/10.1016/j.respol.2017.04.001.

Stern, N. (2022) 'A time for action on climate change and a time for change in economics', *The Economic Journal*, 132(644), pp. 1259–1289. Available at: https://doi.org/10.1093/ej/ueac005.

Stiglitz, J.E. (2019) 'Addressing climate change through price and non-price interventions', *European Economic Review*, 119, pp. 594–612. Available at: https://doi.org/10.1016/j.euroecorev.2019.05.007.

Suurs, R.A.A. and Hekkert, M.P. (2009) 'Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands', *Technological Forecasting and Social Change*, 76(8), pp. 1003–1020. Available at: https://doi.org/10.1016/j.techfore.2009.03.002.

Svennevik, E.M.C. (2019) 'The existing and the emerging: Car ownership and car sharing on the road towards sustainable mobility', *International Journal of Automotive Technology and Management*, 19(3–4), pp. 281–300. Available at: https://doi.org/10.1504/IJATM.2019.10021998.

Tomás, M. et al. (2023) 'Ensuring a just energy transition: A distributional analysis of diesel tax reform in Spain with stakeholder engagement', *Energy Policy*, 177(February), p. 113558. Available at: https://doi.org/10.1016/j.enpol.2023.113558.

Trencher, G. et al. (2023) 'The evolution of "phase-out" as a bridging concept for sustainability: From pollution to climate change', *One Earth*, 6(7), pp. 854–871. Available at: https://doi.org/10.1016/j.oneear.2023.06.003.

Tvinnereim, E. and Mehling, M. (2018) 'Carbon pricing and deep decarbonisation', *Energy Policy*, 121(November), pp. 185–189. Available at: https://doi.org/10.1016/j.enpol.2018.06.020.

Uyarra, E., Shapira, P., and Harding, A. (2016) 'Low carbon innovation and enterprise growth in the UK: Challenges of a place-blind policy mix', *Technological Forecasting and Social Change*, 103, pp. 264–272. Available at: https://doi.org/10.1016/j.techfore.2015.10.008.

van Bommel, N. and Höffken, J.I. (2023) 'The urgency of climate action and the aim for justice in energy transitions: Dynamics and complexity', *Environmental Innovation and Societal Transitions*, 48(November), p. 100763. Available at: https://doi.org/10.1016/j.eist.2023.100763.

van Mossel, A., van Rijnsoever, F.J., and Hekkert, M.P. (2018) 'Navigators through the storm: A review of organization theories and the behavior of incumbent firms during transitions', *Environmental Innovation and Societal Transitions*, 26, pp. 44–63. Available at: https://doi.org/10.1016/j.eist.2017.07.001.

Vollebergh, H., van der Werf, E., and Vogel, J. (2023) 'A descriptive framework to evaluate instrument packages for the low-carbon transition', *Ecological Economics*, 205(November), p. 107717. Available at: https://doi.org/10.1016/j.ecolecon.2022.107717.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/

Wachsmuth, J. et al. (2023) 'Co-creating socio-technical scenarios for net-zero emission pathways: Comparison of five national case studies', *Renewable and Sustainable Energy Transition*, 4(July), p. 100064. Available at: https://doi.org/10.1016/j.rset.2023.100064.

Weber, K.M. and Rohracher, H. (2012) 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework', *Research Policy*, 41(6), pp. 1037–1047. Available at: https://doi.org/10.1016/j.respol.2011.10.015.

Wells, P. and Nieuwenhuis, P. (2012) 'Transition failure: Understanding continuity in the automotive industry', *Technological Forecasting and Social Change*, 79(9), pp. 1681–1692. Available at: https://doi.org/10.1016/j.techfore.2012.06.008.

Wentland, A. (2016) 'Imagining and enacting the future of the German energy transition: Electric vehicles as grid infrastructure', *Innovation: The European Journal of Social Science Research*, 29(3), pp. 285–302. Available at: https://doi.org/10.1080/13511610.2016.1159946.

Whittle, C. et al. (2019) 'User decision-making in transitions to electrified, autonomous, shared or reduced mobility', *Transportation Research Part D: Transport and Environment*, 71, pp. 302–319. Available at: https://doi.org/10.1016/j.trd.2018.12.014.

Wieczorek, A.J. and Hekkert, M.P. (2012) 'Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars', *Science and Public Policy*, 39(1), pp. 74–87. Available at: https://doi.org/10.1093/scipol/scr008.

Wilson, C. et al. (2020) 'Granular technologies to accelerate decarbonization', *Science*, 368(6486), pp. 36–39. Available at: https://doi.org/10.1126/science.aaz8060.

Wittmann, F. et al. (2021) 'Governing varieties of mission-oriented innovation policies: A new typology', *Science and Public Policy*, 48(5), pp. 727–738. Available at: https://doi.org/10.1093/scipol/scab044.

Wittmayer, J.M. et al. (2020) 'Beyond instrumentalism: Broadening the understanding of social innovation in socio-technical energy systems', *Energy Research and Social Science*, 70. Available at: https://doi.org/10.1016/j.erss.2020.101689.

Wittmayer, J.M. et al. (2021) 'Contributing to sustainable and just energy systems? The mainstreaming of renewable energy prosumerism within and across institutional logics', *Energy Policy*, 149. Available at: https://doi.org/10.1016/j.enpol.2020.112053.

Wittmayer, J.M. et al. (2022) 'A typology for unpacking the diversity of social innovation in energy transitions', *Energy Research & Social Science*, 88, p. 102513. Available at: https://doi.org/10.1016/j.erss.2022.102513.

Wittmayer, J.M. et al. (2024) 'Advancing the understanding of social innovation in sustainability transitions: Exploring processes, politics, and policies for accelerating transitions', *Environmental Innovation and Societal Transitions*, 50(December), p. 100805. Available at: https://doi.org/10.1016/j.eist.2023.100805.

Wolbertus, R., Jansen, S., and Kroesen, M. (2020) 'Stakeholders' perspectives on future electric vehicle charging infrastructure developments', *Futures*, 123, p. 102610. Available at: https://doi.org/10.1016/j.futures.2020.102610.

Wyse, S.M. et al. (2021) 'Investigating energy justice in demand-side low-carbon innovations in Ontario', *Frontiers in Sustainable Cities*, 3(August), pp. 1–19. Available at: https://doi.org/10.3389/frsc.2021.633122.

Zepa, I. and Hoffmann, V.H. (2023) 'Policy mixes across vertical levels of governance in the EU: The case of the sustainable energy transition in Latvia', *Environmental Innovation and Societal Transitions*, 47, p. 100699. Available at: https://doi.org/10.1016/j.eist.2023.100699.

Zink, R., Valdes, J., and Wuth, J. (2020) 'Prioritizing the chicken or egg? Electric vehicle purchase and charging infrastructure subsidies in Germany', *Politics and Governance*, 8(3), pp. 185–198. Available at: https://doi.org/10.17645/pag.v8i3.3025.

Karoline S. Rogge - 9781035310418
Downloaded from https://www.elgaronline.com/ at 03/27/2026 08:06:48AM
via Open Access. Chapter 8 is available for free as Open Access from the
individual product page at www.elgaronline.com under a Creative Commons
AttributionNonCommercial-NoDerivatives 4.0 International
(https://creativecommons.org/licenses/by-nc-nd/4.0/) license.
https://creativecommons.org/licenses/by-nc-nd/4.0/