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Exploring Perceptions of the Credibility of Policy Mixes: The Case of German Manufacturers of Renewable Power Generation Technologies

Karoline S. Rogge and Elisabeth Dütschke

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Exploring perceptions of the credibility of policy mixes: the case of German manufacturers of renewable power generation technologies

Karoline S. Rogge [a b *] and Elisabeth Dütschke [b]

a - SPRU– Science Policy Research Unit, University of Sussex, Brighton BN1 9RH, UK
b - Fraunhofer Institute Systems and Innovation Research ISI, Karlsruhe, Germany
* - Corresponding author: k.rogge@sussex.ac.uk

Abstract

The credibility of climate policy has been identified as paramount factor for low-carbon investment and innovation and is thus key for the cost-effective achievement of the decarbonization objectives set out in the Paris Agreement. Yet, despite its importance we have only limited insights into how such policy credibility is formed. To address this gap we explore whether and to what extent corporate perceptions of policy credibility depend on the current policy mix with its national targets, concrete policy instruments and their consistency as well as policy making and implementation. For this, we use the case of the German *Energiewende* and rely on data collected in 2014 through a survey of German manufacturers of renewable power generation technologies. We analyze the answers of 390 companies through a linear regression to identify policy mix related determinants of perceived policy credibility - measured by a novel indicator based on four survey items. We find that corporate perceptions of policy credibility are mainly shaped by two characteristics of the policy mix, namely the coherence of policy making and implementation, followed by the consistency of the policy mix. Elements of the policy mix matter as well, in particular changes in the design of the core demand pull instrument (the Renewable Energy Sources Act, EEG) and the nuclear phase-out policy, but also the German targets for the expansion of renewable energies play a role. These insights enable us to derive more general implications for policy makers around the world interested in promoting the innovation-led decarbonization of the economy by safeguarding and increasing policy credibility.

Keywords:

policy mix, credibility, consistency, coherence, comprehensiveness, energy transition

Highlights:

- Using company survey data, we construct an indicator of perceived policy credibility.
- Companies' perceptions of credibility heavily depend on policy mix characteristics.
- The coherence of policy processes is most influential for credibility perceptions.
- The consistency of the policy mix also plays an important role for credibility.
- The design of the core instrument, the nuclear phase-out and targets matter, too.

1 Introduction

Policy credibility has been identified to be of paramount importance for low-carbon innovation and long-term investments needed for the decarbonization of the economy (Bosetti and Victor, 2011; Cian et al., 2012; Faehn and Isaksen, 2016), and thus for the achievement of the targets set out in the Paris Agreement (Jakob, 2017; Nemet et al., 2017). Correspondingly, there is an emerging body of literature on the credibility of climate policy discussing options how to strengthen and assess such credibility (Helm, 2003; Whitesell, 2011a; Brunner et al., 2012; Nemet et al., 2014). These studies build on Kydland and Prescott (1977) who identified the time inconsistency problem of governments' optimal plans. This seminal work inspired a large body of literature investigating various mechanisms for addressing credibility (or commitment) problems present in various policy fields, such as monetary and fiscal policy (Persson and Tabellini, 1990; Drazen and Masson, 1994). Various solutions have been proposed, including building reputation through past compliance and delegating decision-making to an independent authority (Gilardi, 2002; Keefer and Stasavage, 2003; Conconi and Perroni, 2009).

Credibility has also been brought up in the literature on policy mixes for sustainability transitions aiming at "a fundamental transformation towards more sustainable modes of production and consumption" (Markard et al., 2012, p. 955) by proposing it as a policy mix characteristic which captures how believable and reliable a policy mix is (Rogge and Reichardt, 2016) - which is the definition we follow in this paper. Together with other policy mix characteristics, such as the consistency of policy strategies and instrument mixes or the coherence of policy making and implementation, these characteristics are suggested to determine the effectiveness and efficiency of policy mixes. In addition, the policy mix literature (Rogge et al., 2017) has highlighted destruction policies aimed at the destabilization of unsustainable regimes as key for guiding sustainability transitions (Turnheim and Geels, 2012, 2013; Kivimaa and Kern, 2016). Similarly, policy strategies with their long-term targets have been identified as key component of policy mixes for transitions (Nemet et al., 2014; Reichardt and Rogge, 2016). Empirical work investigating the role of policy mixes for low-carbon innovation shows that policy mix credibility matters for innovation, but that other aspects of the policy mix, such as its consistency and stability, also play a key role (Uyarra et al., 2016; Rogge and Schleich, 2017).

However, both streams of literature provide limited empirical insights on how credibility is related to the relevant policy mix governing the decarbonization of the energy system (Nemet et al., 2014; Nemet et al., 2017), and which role in particular current policy strategies, instruments and policy processes play (Rogge and Reichardt, 2016). In this paper, we take a first step to close this research gap by investigating whether and to what extent

various aspects of the policy mix are related to corporate perceptions of its overall credibility. To answer this research question we build an analytical framework which draws on the policy mix and credibility literatures.

We chose the case of the transition of the German electricity system to renewable energies, the so called *Energiewende*, and explore the perceptions of German manufacturers of renewable power generation technologies regarding the credibility of the corresponding policy mix. We argue that this case is ideally suited to provide relevant exploratory insights for a globally relevant phenomenon because of Germany's pioneering role in low-carbon energy transitions (Jacobsson and Lauber, 2006; Strunz, 2014; Quitzow et al., 2016; Kuzemko et al., 2017; Matthes, 2017). In addition, two further aspects make for a particularly well suited case for studying perceptions of policy credibility: first, Germany's ambitious long-term targets for renewable energies implemented by a rich instrument mix which also includes destruction policies (Laes et al., 2014; BMWi, 2015; Hermwille, 2016), and second, regulatory uncertainties associated with recent policy changes (Hoppmann et al., 2014; Lauber and Jacobsson, 2016) and controversial political debates about the policy mix supporting the Energiewende (Gawel et al., 2013; Kungl, 2015; Geels et al., 2016; Schroeter et al., 2016; Schmid et al., 2017).

The remainder of the paper is structured as follows. In section 2 we review the literatures on credibility and on policy mixes, based on which we develop our analytical framework and research design in section 3. We then present the research case of the German Energiewende in section 4 and explain our methodology in section 5. Our findings are presented in 6, followed by their discussion in section 7. We close by providing conclusions in section 8.

2 Literature review

2.1 Policy credibility

The notion of policy credibility can be traced back to a seminal article by Kydland and Prescott (1977) outlining the time inconsistency problem governments are faced with when dealing with dynamic economic systems. They show that government plans which appear optimal today become suboptimal once investment decisions of the private sector have been made, providing future governments with an economic incentive to divert from earlier policy commitment to maximize societal welfare. However, as current decisions of economic agents depend in part on their expectations of future policy actions, this temporal inconsistency of optimal plans may actually lead to economic instability or to

temporally consistent but suboptimal plans. Therefore, Kydland and Prescott (1977) argue that rather than letting governments select the policy decision which is best in the current situation, political decision making should be guided by rules and not discretion. This general theoretical argument has been applied in various policy fields, such as monetary and fiscal policy (Persson and Tabellini, 1990; Drazen and Masson, 1994), antitrust policy (Gheventer, 2004), utility price regulation (Levine, 2005), or commodity subsidies (Rohác, 2014). Several options for addressing the time inconsistency problem have been proposed, such as through reputation or delegation of power to independent agencies (Gilardi, 2002; Keefer and Stasavage, 2003; Conconi and Perroni, 2009).

Climate economists have early on identified policy credibility as key area of research (Toman, 1998). Pointing out that long-term climate targets will be missed in the absence of credible policies Helm (2003, p. 439) argued that a "credible carbon policy is one which solves this time-inconsistency problem and provides firms with a degree of security that promises will be met." Given the multiple objectives and party alterations of governments as well as the irreversibility of energy investments, delegation to an independent carbon agency has been proposed as promising solution to limit the government's scope for ex-post reneging on ex-ante commitments (Helm, 2003; Whitesell, 2011b). Similarly, Brunner et al. (2012) argue that governments – when faced with a lack of reputation – can deliberately engineer institutional commitment devices to enhance the level of policy commitment, but keeping in mind the tradeoffs between commitment and flexibility. This tradeoff is also addressed by Nemet et al. (2014) who analyze US energy policy targets and find that their attainment is more likely when they are binding, have longer compliance periods and are less ambitious. Finally, Nemet et al. (2017) derive four categories for assessing the credibility of climate targets pledged under the Paris Agreement – clearly defined flexibility in the design of rules, transparency and trust, accounting for distributional effects, and multiple policy instruments.

Table 1: Categories and approaches for addressing policy credibility

Category	Design of rules	Transparency and trust	Political economy and distribution	Robustness
Approach	Rules on future targets	Monitoring and verification	Compensate losers	Multiple instruments
	Conditional rules	Independent authority	Create new winners	Decentralized policy making
	Discretion within rules	Reputation and experience	Two-level game	
	Periodic review of targets			
	Counter-cyclical mechanisms			

Source: Nemet et al. (2017)

The increased attention to climate policy credibility is justified by modeling results highlighting the outstanding relevance of credibility for low-carbon innovation and investment. As shown by Bosetti and Victor (2011) lack of regulatory credibility significantly increases

the costs of climate mitigation, as actors become short-sighted and make suboptimal investments in R&D and in long-lived technologies. Similarly, Cian et al. (2012) find that when the 2020 climate target is not anticipated, countries initially underinvest in low-carbon innovation, particularly in more risky R&D programs, for which they have to make up in later periods. This leads to suboptimality because the lack of credibility implies that countries must meet the same climate target within a shorter time frame. A final example concerns Faehn and Isaksen (2016) who find that the inability of policymakers to signal trustworthy ambitions leads to a tripling of abatement costs for the Norwegian economy, arising from the failure to stimulate upfront investment in new low-carbon technological solutions.

Yet, despite these recent advances on climate policy credibility and its paramount relevance for low carbon transitions we know little about how investors form their beliefs about the credibility of future policy, leading to calls for empirical research, e.g. based on surveys, interviews and experiments (Nemet et al., 2014; Nemet et al., 2017). For such an endeavor, much can be learned about the methods utilized to study other forms of credibility, such as source credibility (Lachapelle et al., 2014; Heink et al., 2015; Sutton and Rudd, 2016), institutional credibility (Ho, 2014) or corporate credibility (Newell and Goldsmith, 2001). In addition, given the importance of perceptions empirical research could be informed by comparable studies, such as those drawing on social psychology (Youtie et al., 2017) or the sociology of expectations (van Rijnsoever et al., 2014). For example, Kril et al. (2016) investigate the attitudes of laypeople regarding the credibility of the central bank of Israel through an online questionnaire, as it is their economic behavior which affects prices through expectations, therefore being central to controlling inflation. Similarly, Brunetti et al. (1998) conduct a firm-level survey on the perceived credibility of rules in 73 countries, with the aim of constructing a subjective credibility measure to be used in growth regression analysis, as what matters for investment decisions is how policy uncertainty is perceived by investors.

Table 2: Definitions of various types of credibility in the literature

Type	Reference	Definition
Policy (monetary)	Keefer and Stasavage (2003), p. 408	"The question of credible commitment (or "time consistency") has been central to discussions of monetary policy [..]."
	Kril et al. (2016), p. 69	"The measure [..] is designed to gauge [..] how people view the ability and intentions of the bank."
Policy (climate)	Helm (2003), p. 439	"Whether firms invest will depend upon whether they believe the government can be taken at its word."
	Brunner et al. (2012) 2012, p. 256	"What is credibility? In our context, individuals, or a set thereof, have credibility if others believe that they will do what they commit to."
	Nemet et al (2017), p. 48	"[..] we define policy credibility as the level of confidence that non-government actors have that governments will fulfill future commitments as specified in policies."
	Jakob (2017), p. 91	"Policy credibility, understood as the expectation that existing measures will remain in place, or that additional measures will be adopted to meet targets announced by the government, has a strong influence on the economic behavior of non-government actors [..]".
Source	Lachapelle et al. (2014), p. 676	"Individuals may accept new information depending on the source's position in society or on their perceived level of expertise [..]."
	van Rijnsoever et al. (2014), p. 640	"For this study we therefore define source credibility as the trustworthiness, expertise and reliability of an actor."
	Heink et al. (2015), p. 676	"In general, credibility can be understood as the quality or power of inspiring belief [..]."
	Widmaier and Grube (2015), p. 336	"We consider here two leaders whose policy ambitions were frustrated by 'credibility gaps' between their 'outside' popular rhetoric and 'inside' intellectual and policy deliberations."
	Sutton and Rudd (2016), p. 566	"Credibility is usually defined in terms of peer-approved methods of evidence production and claims to scientific objectivity."
	Youtie et al. (2017), p. 110	"By credibility, we mean that the believability of facts is based on the frame of reference that the decision makers bring to the process [..]."
Institutional	Ho (2014), p. 16	"Against this backdrop, credibility is here defined as "the perception of endogenously, autonomously shaped institutions as a common arrangement." Therefore, credibility is a measure of how actors' perceive institutions as a jointly shared rule."
Corporate	Newell and Goldsmith (2001), p. 235	"Corporate credibility is the extent to which consumers feel that the firm has the knowledge or ability to fulfill its claims and whether the firm can be trusted to tell the truth or not."

To conclude, while there is a substantive body of literature on policy credibility and the importance of institutional design, several of these studies have not explicitly defined credibility (Boehmer-Christiansen, 1990; Jacobs, 2016) or use the term fairly loosely, often overlapping with other concepts (Brunetti et al., 1998; van der Ven, 2015; Faehn

and Isaksen, 2016), such as regulatory uncertainty (Hoffmann et al., 2008; Engau and Hoffmann, 2009; Hoffmann et al., 2009) or predictability (Kemp and Pontoglio, 2011; Rogge and Reichardt, 2016). In addition, empirical research on the factors that influence investor's perceptions of policy credibility has remained limited. Furthermore, we agree with Nemet et al. (2017, p. 55) who argue that "understanding interactions among policies and considering policy mixes will be crucial" in future research on climate policy credibility, and therefore now turn to the policy mix literature.

2.2 Policy mixes

Transitions towards sustainability are faced with multiple market and system failures and therefore justify policy intervention (Markard et al., 2012; van den Bergh, 2016). While market failures, such as the negative externalities arising from greenhouse gas emissions or positive spillovers from knowledge generation, are typically acknowledged as rationale for environmental policy (Rennings, 2000; Jaffe et al., 2005), the broader failures in place when dealing with sustainability transitions have only fairly recently been picked up. Drawing on economics Lehmann (2012) identifies two rationales for addressing a pollution problem with multiple policies: multiple failures of private governance structures and high transaction costs associated with the implementation of single first-best policies. When combining insights from innovation and transition studies, further rationales for applying policy mixes come to the fore (Weber and Rohracher, 2012): First, structural system failures address tensions in innovation systems, including deficits in infrastructure, institutions, networks or capabilities, and are well established in guiding innovation policy. Second, transformational system failures concern tensions associated with transformative change, such as failures in providing direction, articulating demand, coordinating policies and ensuring reflexivity in uncertain transition processes These transformational system failures have led Schot and Steinmueller (2016) to call for a third frame of innovation policy, with transition management representing one governance strategy for navigating such transformative change processes (Kern and Smith, 2008).

Given these multiple rationales for policy mixes an increasing number of studies have investigated the combination of multiple policies, building on seminal work on smart regulation in environmental policy (Gunningham et al., 1998; Gunningham and Sinclair, 1999). This line of literature focuses on the interaction of policy instruments (del Río González, Pablo, 2006; Spyridaki and Flamos, 2014), with applications in several environmental policy fields, such as climate policy (Sorrell and Sijm, 2003; del Río, 2009), energy efficiency policy (del Río, 2010; Rosenow et al., 2016), renewables policy (Fischer, 2010; Palmer et al., 2011), biodiversity policy (Ring and Schröter-Schlaack,

2011) and resource efficiency policy (Wilts et al., 2016). In addition, innovation scholars have also been increasingly interested in policy mixes (Nauwelaers et al., 2009; Borrás and Edquist, 2013; Cantner et al., 2016). What these 'first generation of policy mix studies' have in common is a focus on instrument mixes and instrument interactions. In contrast, limited attention has been given to whether the analyzed combination of instruments sufficiently addresses transformational system failures.

Given these shortcomings, calls have been voiced for a reconceptualization of policy mixes for innovation (Flanagan et al., 2011) and a broader understanding of policy mixes for sustainability transitions (Rogge and Reichardt, 2016). Among others, the emerging 'second generation of policy mix studies' pays greater attention to policy processes, policy strategies, destruction policies and policy mix characteristics (Rogge et al., 2017). First, in the context of sustainability transitions greater attention to politics, learning and the co-evolution of policy mixes and socio-technical systems is seen as important research avenue (Normann, 2015; Reichardt et al., 2016; Edmondson et al., 2017; Kern and Rogge, 2017). Second, policy strategies with long-term targets and principal plans for their implementation, such as those laid out in Nationally Determined Contributions (NDCs) under the Paris Agreement (Jakob, 2017), can play an important role in providing direction to transformative change processes (Schmidt et al., 2012), and as such constitute a core component of broader policy mix concepts. Third, it has been argued that policy mixes should not only include policies aimed at the creation of green niches, e.g. by providing support for low-carbon solutions, but also policies aimed at the destruction of unsustainable practises (Kivimaa and Kern, 2016), thereby supporting the destabilization of existing regimes (Turnheim and Geels, 2012, 2013).

Finally, Rogge and Reichardt (2016) have proposed policy mix characteristics as one of three key building blocks – elements, processes and characteristics – to a broader conceptualization of policy mixes, arguing that all of these may help explain the effectiveness and efficiency of policy mixes. For example, rather than only investigating policy mix elements, including multiple instruments and long-term targets, as drivers for low carbon innovation, studies should also pay attention to the overarching characteristics of policy mixes, such as how well the instrument mix is aligned with the policy strategy. Such characteristics as consistency and coherence are also a theme in the policy design literature (Howlett and Rayner, 2007a; Kern and Howlett, 2009), development policy (OECD, 1996; Forster and Stokke, 1999; OECD, 2001; Jones, 2002; OECD, 2003; Hoebink, 2004; McLean Hilker, 2004; Carbone, 2008) and environmental policy (Mickwitz et al., 2009; Sovacool, 2009; Huttunen et al., 2014). Another policy mix characteristic included in Rogge and Reichardt's initial list is the credibility of the policy mix, for which they build on the literature on policy credibility outlined in section 2.1. As the terminology of these policy mix characteristics varies significantly in the literature, in this paper we follow the

definitions proposed by Rogge and Reichardt (2016) for the comprehensiveness, consistency, coherence and credibility of policy mixes (see Table 3).

Early empirical studies support the claim that policy mix characteristics have an impact on green innovation (Rogge and Schleich, 2017). For example, the first quantitative study finds that the balance and comprehensiveness of the instrument mix are key determinants for patents in energy efficient technologies, but also indicates a negative threshold effect arising from too high a number of instruments included in the mix (Costantini et al., 2017). One of the few qualitative studies identifies consistency as important determinant for both research and development (R&D) and adoption decisions in offshore wind in Germany, with a high level of credibility being able to partly offset negative R&D impacts resulting from inconsistencies in the mix (Reichardt and Rogge, 2016). Another qualitative study on low carbon innovation in the UK indicates the key role of stability, communication and credibility of policy mixes aimed at stimulating innovation (Uyarra et al., 2016).

While the current evidence base of these second generation policy mix studies investigating credibility as driver of low-carbon innovation and transitions is limited, their first insights are in line with model results summarized in section 2.1 (Bosetti and Victor, 2011; Cian et al., 2012). Yet, it remains to be investigated what makes a policy mix credible in the first place, indicating an overlapping research interest in the literatures of policy credibility and policy mixes.

3 Analytical framework to explore policy mix determinants of policy credibility

In this paper, we aim at addressing the identified gap in the literature by exploring whether and to which extent companies' perceptions of policy credibility depend on specific aspects of the policy mix relevant for the decarbonization of the energy system. That is, we open up the black box of how firms perceive policy credibility in a situation where they are faced with complex policy mixes that include long term targets and multiple instruments, and where they are actively or passively participating in the policy making and implementation process. To answer our research question on the perception of policy credibility – meant here to cover the credibility of the policy mix as defined in Rogge and Reichardt (2016) – we build an analytical framework which combines elements of the credibility and the policy mix literature. In particular, we argue that the literature on policy credibility has so far insufficiently considered concrete policy action as a determinant for credibility, and instead mainly focused on institutional design (McGregor et al., 2012; Grosjean et al., 2014). Exceptions include the consideration of the role of long-

term targets (Nemet et al., 2014), the use of multiple policy instruments and the nature of policy making in terms of monitoring, experience and decentralization (Nemet et al., 2017, see Table 1). We build on these contributions and enrich them by drawing on recent advances in the policy mix literature from which we derive two key points.

First, rather than only considering if a policy target is implemented through *multiple instruments* we instead ask if the instrument mix is comprehensive, i.e. if it addresses the relevant market and system failures and consistent, i.e. if instruments are mutually supportive or at least free from contradictions (Rogge and Reichardt, 2016). While there may be thresholds, limits and trade-offs in achieving these (Quitzow, 2015a; Costantini et al., 2017) policy makers which strive for an improvement of these two characteristics of policy mixes may, arguably, appear more committed to actually achieving policy targets. This may become visible by their efforts in actively removing barriers and tackling inefficiencies in the policy mix, thereby sending clear signals. One potential indicator is the utilization of the full range of instruments supporting innovation and transitions (Smits and Kuhlmann, 2004; Jacobsson and Bergek, 2011; Di Stefano et al., 2012; Wieczorek and Hekkert, 2012), including those supporting technology push (e.g. through R&D funding), incentivizing demand pull (e.g. through feed-in tariffs) and considering systemic concerns (e.g. ensuring grid access and expansion). In addition, we explicitly capture not only policy instruments aimed at the creation of low-carbon solutions but also pay specific attention to those aimed at the destruction of the old regime (Kivimaa and Kern, 2016). We argue that such destruction policies signal a strong commitment as they are more difficult to adopt and implement given the resistance of powerful incumbents with vested interests in the status quo (Geels, 2014). This implies they require greater efforts by policy makers in coalition building and compensating losers (Markard et al., 2016; Nemet et al., 2017), but also an enhanced recognition of windows of opportunities for implementing such policy changes (Sartorius and Zundel, 2005; Normann, 2015). Finally, in recognition of different and potentially conflicting policy objectives (Flanagan et al., 2011) which require distinct instruments, we not only consider climate policy instruments, but also those in related policy fields, such as innovation, education or biodiversity, as some may enhance credibility while others may question the determination of governments in pursuing a given climate policy target.

Second, we agree that the nature of *policy making* may be a key determinant of perceived policy mix credibility, and therefore explicitly include the coherence of policy processes, i.e. how synergistic and systematic they are, as credibility determinant (Rogge and Reichardt, 2016). While transparency and trust can arise from monitoring and verification, independent authorities and reputation effects of past compliance (Nemet et al., 2017), we argue that additional policy process determinants of credibility exist which

seem to have received limited attention in past monetary, fiscal and trade policy. In particular, recent policy mix research found a positive link between the participatory nature of policy processes and the performance of the technological innovation system of offshore wind in Germany (Reichardt et al., 2017). Arguably, such a participatory policy style may inform policy makers early on of problems and enables a joining of forces in finding solutions, thereby not only providing greater transparency but also actively signaling actors the willingness, competences but also potential restrictions of getting things done. In addition, we acknowledge the need for policy flexibility despite long term commitments (Brunner et al., 2012; Nair and Howlett, 2016), and thus capture the uncertainties arising from adaptive and compulsive policy making (Allen et al., 2011; Hoppmann et al., 2014). For example, the political debates prior to an upcoming amendment of the German Renewable Energy Sources Act (EEG) seem to have lead to a loss of policy mix credibility, with negative repercussions for low carbon innovation (Bröcker, 2013; Reichardt and Rogge, 2016). We therefore include the policy amendment process and resulting changes in design features of core policy instrument(s) in the framework. Finally, since decentralized policy making may play a role for credibility (Nemet et al., 2017) we argue that the operationalization of coherence should capture the distribution of policy making between different vertical and horizontal levels of governance (Howlett et al., 2015; Howlett et al., 2017). However, while on the one hand this may increase robustness on the other hand such decentralization may also be a potential source of incoherence, potentially leading to inconsistent policy mixes, so the overall impact on credibility could be either negative or positive.

Following the policy mix concept proposed by Rogge and Reichardt (2016) this leads us to an analytical framework which combines policy mix elements and characteristics as influencing factors for policy credibility (see **Error! Reference source not found.**). First, by policy mix *elements* we refer to the policy strategy and multiple instruments, but also include the design features of core instruments. Regarding the policy strategy, we focus on the ambition of long-term targets and recent changes in ambition levels (Nemet et al., 2014; Nemet et al., 2017). Regarding policy instruments we not only include instruments aimed at supporting green niches by addressing technology push, demand pull and systemic concerns (Taylor, 2008; Peters et al., 2012; Costantini et al., 2015; Cantner et al., 2016), but also explicitly include instruments targeting the old regime to assess the role played by destruction policies (Kivimaa and Kern, 2016), such as carbon pricing and phase-out policies. We also include instruments in related but potentially conflicting policy fields, such as nature protection. Finally, regarding instrument design features (Kemp and Pontoglio, 2011; Rogge and Reichardt, 2016) we focus on recent changes in the design of the core instrument(s) in the policy mix.

Second, as policy mix *characteristics* we include comprehensiveness, consistency and coherence as determinants of policy credibility (for definitions, see Table 3). Regarding comprehensiveness we limit the analysis to the instrument mix to capture how extensive and exhaustive it is (Costantini et al., 2017), thereby complementing the idea of the robustness of instrument mixes as derived in Nemet et al. (2017). Regarding the consistency of policy mix elements we follow Rogge and Reichardt (2016) in distinguishing between three levels: first, the consistency of the policy strategy which captures how well aligned different policy objectives are; second, the consistency of the instrument mix which assesses whether instruments reinforce rather than undermine each other; and third, the overarching consistency of the policy mix which covers whether the instrument mix and its interplay with the policy strategy support the achievement of policy objectives. Last but not least, we include the coherence of policy processes as determinant of policy mix credibility (Rogge and Reichardt, 2016), thereby alluding to the nature and style of policy making and implementation processes (Jänicke et al., 2000).

Table 3: Definitions of the policy mix characteristics included in this study

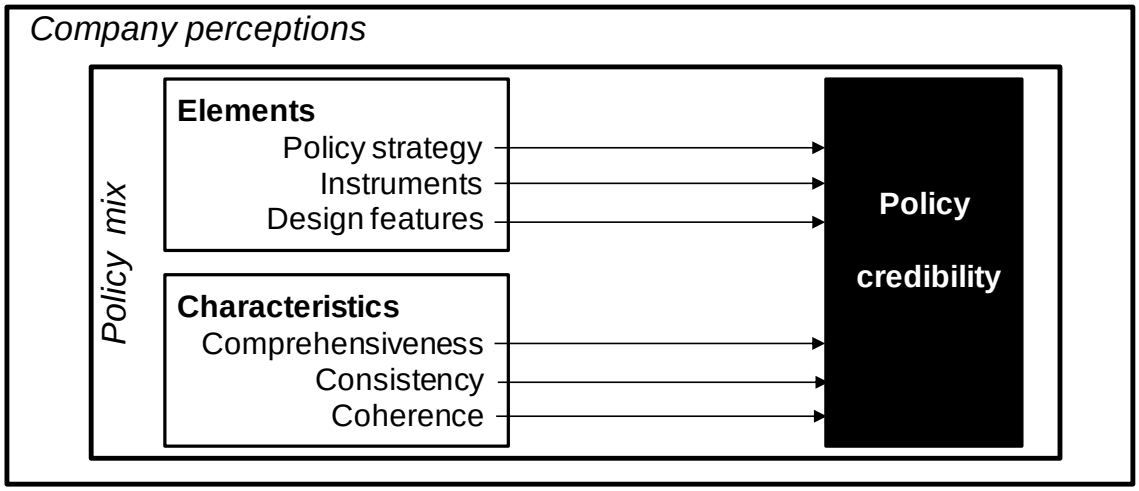
Definitions
Consistency "captures how well the elements of the policy mix are aligned with each over, thereby contributing to the achievement of policy objectives. It may range from the absence of contradictions [weak consistency] to the existence of synergies [strong consistency] within and between the elements of the policy mix." (p. 1626)
Credibility refers to "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 its elements are [of the policy mix] and the degree to which its processes are based on extensive decision-making" (p. 1627)
Coherence refers "to synergistic and systematic policy making and implementation processes contributing – either directly or indirectly – towards the achievement of policy objective." (p. 1626)

Source: Rogge and Reichardt (2016)

In conclusion, the analytical framework developed here is intended to shed more light on whether and to what extent companies' perceptions of policy credibility are related to the policy mix for the low-carbon energy transition. We recognize two key limitations of this framework: First, it represents only a first step in opening the black box of perceptions on policy mix credibility. Indeed, given the exploratory nature of our research we have restrained from postulating hypotheses. Second, to enable an in-depth analysis of the

relevance of policy action for companies' perceptions of policy credibility we limit the scope of our framework, implying at least an implicit exclusion of other determinants of policy credibility, such as institutional, distributional and reputational ones.

Figure 1: Analytical framework to explore policy mix determinants of policy credibility

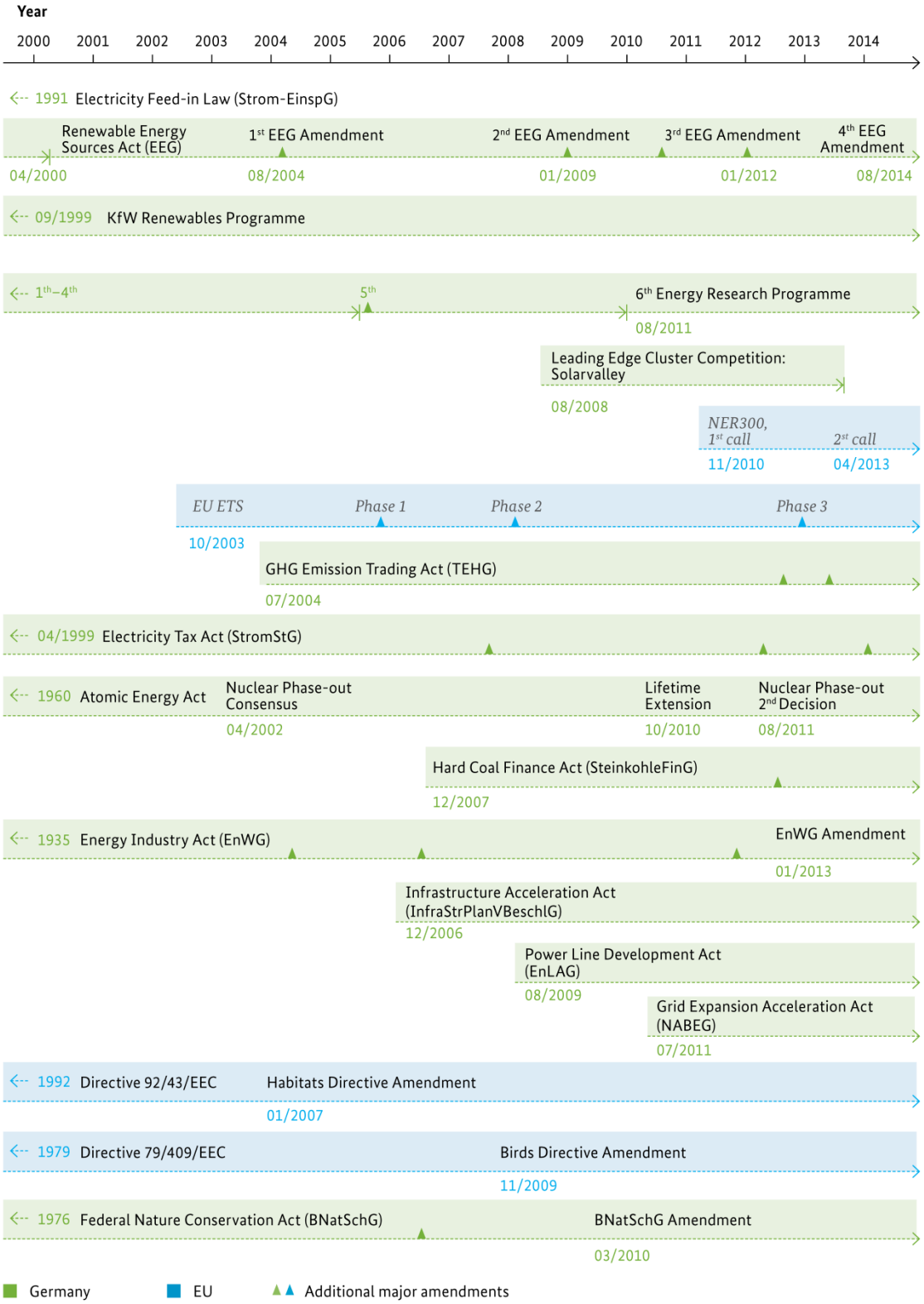


Source: Own

4 Research case

As research case we have chosen the German energy transition towards renewable energies and the perceived credibility of the corresponding policy mix for three main reasons. First, we use the case of the *Energiewende* as Germany has been implementing a rich policy mix to achieve an ambitious policy strategy aiming at a share of electricity generated from renewable energies of 80% by 2050 (BMWi and BMU, 2010; BMWi, 2015). By the end of 2014, the expansion of renewables in Germany's electricity generation had reached a share of 27.4% and the country was on track to meet its interim target of 40-45% by 2025 (BMWi, 2014). Arguably, the core policy instrument for the German energy transition has been the Renewable Energy Sources Act (EEG) introduced in 2000 (Jacobsson and Lauber, 2006) and regularly amended since then (Hoppmann et al., 2014; Lauber and Jacobsson, 2016), but many other instruments are in place which are also of relevance (for an overview, see Figure 2). For example, by 2014 federal public R&D support for low-carbon innovation had risen to above 800 Million Euro per year, with a good third of this going to renewable energy (BMWi, 2016b). In addition, Germany pursues the phase-out of nuclear energy until 2022 (Hermwille, 2016), providing an example of a destruction policy.

Figure 2: Evolution of the instrument mix relevant for renewable energies in Germany



Source: Rogge et al. (2015)

Second, in the past few years Germany has seen a dynamic policy making process which lends itself particularly well to studying perceptions of the policy mix and its credibility. After the Fukushima accident the previously abandoned nuclear phase-out until 2022 was reinstated in 2011 (Hermwille, 2016; Quitzow et al., 2016). Globally declining technology costs and increased international competition, particularly for solar PV, led not only to an accelerated expansion of renewable energies in 2012 (BMWi, 2015), but also to unscheduled reductions in feed-in tariffs for solar PV and industry consolidation (Hoppmann et al., 2013; Grau, 2014; Hoppmann et al., 2014; Quitzow, 2015b). In addition, the increase in the levy for the EEG surcharge led to fierce political debates about the retrospective adjustment of previously guaranteed feed-in tariffs (set for 20 years) which prior to that had been unthinkable (Bröcker, 2013). While not implemented, this electricity price debate may still have left some marks on the perceived predictability and associated investment security of the EEG (Reichardt et al., 2016). In addition, given the federal elections in the fall of 2013 its next regular reform was postponed, leading to considerable regulatory uncertainty. After the elections the new Grand Coalition government merged all *Energiewende* related activities under one roof. In the beginning of 2014, this new Federal Ministry of Economics and Energy (initially led by Gabriel, the former Minister of the Environment) published first pillars of the revision of the EEG (also dubbed as EEG 2.0). However, the uncertainty about its design features remained high until the Federal Cabinet adopted the amended EEG on April 8, 2014. [1] Regulatory uncertainty was also addressed through the publication of a 10-point-energy agenda providing an *Energiewende* roadmap of the planned policy changes of the new government (covering May 2014 until December 2016), including, for example, EU ETS reform, electricity market reform, grids and monitoring (BMWi, 2016a).

Finally, since we focus on perceptions of private investors regarding the credibility of the policy mix, which have been shown to be key for innovation decisions (Cian et al., 2012; Ulph and Ulph, 2013), we aim to analyze those companies who are key for innovation in renewable energies. Since the energy sector is a supplier dominated sector (Pavitt, 1984) we chose to study manufacturers of renewable power generation technologies. For this, Germany is a particularly suitable country as it has a pronounced manufacturing industry for renewable energies (Bruns et al., 2011; Doblinger et al., 2015).

1 The regulatory uncertainty was fully resolved with the decision of the Federal Parliament (Bundestag) on July 4, 2014.

5 Research design and methodology

In our study, we aim at exploring subjective perceptions of policy credibility by corporate actors rather than objective facts or expert opinions, as it is these corporate perceptions which influence companies' decision making (Kaplan and Tripsas, 2008; Nooteboom, 2009), and are core to low-carbon innovation (Schmidt et al., 2012). Clearly, such a focus on corporate perceptions has implications for our research design.

In that sense, our study is most closely related to empirical research on perceived policy credibility, which has mainly relied on survey analysis (Brunetti et al., 1998; Newell and Goldsmith, 2001; Ho, 2014; van der Ven, 2015; Kril et al., 2016). As abstract concepts such as credibility, but also consistency, comprehensiveness and coherence are difficult to measure, they require proxies (Ho, 2014). For example, Brunetti et al. (1998) construct a credibility indicator based on the average answers of multiple questions for five sub-indicators, for which a 6-point answer scale was used. The first sub-indicator on the predictability of changes in laws and policies is most closely related to our definition of policy mix credibility, as it covers, for example, unexpected policy changes, information provided in the policy making process or the consideration of concerns by parties affected by policy change. Another example concerns Newell and Goldsmith (2001) who develop and test proxies for perceived corporate credibility using a 8-point Likert-like scale including the two dimensions of expertise and trustworthiness.

We therefore suggest to explore our research question on whether and to what extent company decision makers perceptions of policy credibility are shaped by the elements and characteristics of policy mixes by designing and conducting a survey of companies involved in the low-carbon energy transition. More specifically, we integrate questions on companies' perceptions of policy credibility and key aspects of the policy mix into an otherwise fairly standardized innovation survey which is based on the Community Innovation Survey (CIS) conducted regularly in EU Member States (Horbach, 2015).

5.1 Data collection

For our explorative study we employ data from a sample of German manufacturers of renewable power generation technologies. [2] For collecting this company specific data, we proceeded in three steps. In a first step, we compiled a data base of all German

[2] This survey data was also utilized in Rogge and Schleich (2017) to investigate the impact of policy mix characteristics on innovation.

companies producing components, final products and production equipment for electricity generation based on renewable energies, including on- and offshore wind power, solar PV, hydro, bioenergy, wave and tidal energy, geothermal energy and concentrated solar power. For this, we drew on multiple data sources, including four German business directories [3], membership of the German Engineering Federation (VDMA) and technology-specific associations, business fair catalogues and professional journals. We performed several quality checks to eliminate companies not fitting with our target group, including a screening question at the beginning of the survey. This resulted in a sample population of 1,092 manufacturers active in renewable energies in Germany in 2014.

In a second step, we designed a questionnaire which draws upon and extends the CIS, which represents an established tool for measuring corporate innovation activities (Horbach et al., 2013). However, the CIS includes only few items on policy and does not capture policy mix thinking in general, nor credibility in particular. Therefore, building on the policy mix concept proposed by Rogge and Reichardt (2016) we designed novel questions aimed at elucidating companies' perceptions about credibility and other policy mix components. While concepts such as consistency and comprehensiveness seemed fairly straightforward to operationalize, for our fairly abstract dependent variable credibility we established seven items for its measurement. Similarly, given the broad scope of the coherence of policy processes as one explanatory variable we included eight items to operationalize it. These policy mix questions were inserted as a new question block right after some questions on general information about the company. Companies were asked to provide technology-specific perceptions on the policy mix based on their main renewable power generation technology. The novel question block started by asking about companies' perception of political targets and their consistency, the consistency and comprehensiveness of the instrument mix and perceived support by various policy instruments and an assessment of selected design features of the core instruments, particularly the Renewable Energy Sources Act (EEG). In addition, the policy mix block included questions about the policy making process to capture its coherence, followed by questions on the perceived credibility of the policy mix. [4]

In a third step, we collected company responses through a computer assisted telephone survey (CATI) which was implemented by the experienced research institute SOKO.[5] After a day-long pre-test the survey was in the field from April 9, 2014 until July 22, 2014. Initially, all companies in our data base of manufactures were contacted by a postal letter

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3 „Wer liefert was" (WLW), businessdeutschland.de (BD), diedeutscheindustrie.de (DDI), and Hoppenstedt (HS).

4 The original questionnaire (and its translation into English) is available upon request.

5 http://www.soko-institut.de/

with a supportive flyer explaining the rationale and sponsor of the study. Companies with an email address also received this information via email. After this, each company was contacted via phone to arrange for an interview appointment with the CEO or a top level manager responsible for the company's strategy, R&D or sales and with an overview of products, innovation and corporate policy. Overall, the survey was answered by 390 German manufacturers of renewable power generation technologies (response rate 35.7%). [6]

Our sample is made up of approx. 70% small and medium sized enterprises (SMEs). The large majority of all responses concerned solar PV (37.2%), biogas (22.3%) and onshore wind (17.4%). In 2013, only 11.1% of companies operated exclusively on the German market, with exports constituting - on average – nearly 40% of sales. Four fifths of respondents had engaged in innovation activities in the last three years (2011-13), with three quarters of manufacturers having introduced product innovations and two-thirds process innovations for the selected renewable power generation technology. About a quarter of the respondents received public R&D funding (from Germany or the EU) to pursue innovation activities in the main renewable power generation technology in the period 2011-13. Finally, regarding the competitive environment respondents stressed the dependence on the political framework conditions.

5.2 Data analysis

For our analytical approach we draw on procedures well established in the behavioral sciences, mainly in psychometrics (Nunnally and Bernstein, 2008). As perceived policy credibility is not directly measurable but can be operationalized via indicators like typical latent constructs in the psychological literature we argue this is a suitable approach.

As usual in empirical samples, not all respondents answered all questions. Therefore, in order to secure a high level of data quality and in line with standard recommendations from the literature (Roth, 1994) we applied a technique to replace missing data. More precisely, we implemented the Expectation Maximization (EM) imputation approach which draws on Z-standardised values in SPSS. For this, we included all variables that were part of the multivariate analyses in this paper. The amount of values missing for these variables added up to 6.5 % overall.

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6 To test for sampling bias, the data allowed us to examine regional representativeness of our sample. The shares of participants per federal state in the sample are very close to the share of all companies per federal state in the population. Based on a χ^2 test we find no indication that our sample may suffer from a sampling bias ($p>0.99$).

As outlined above we draw on newly developed items to measure policy credibility and the elements and characteristics of the policy mix, and therefore applied explorative factor analysis to check whether the items intended to measure a certain construct converge on the same factor, thereby also ensuring internal consistency by using Cronbach's α (see section 5.2.1.2)

In this paper, we apply linear regression models (ordinary least square OLS) for answering our research question. It is important to note that even if the wording independent or dependent variable seems to imply it (as well as the often used predictor and criterion), regression analysis with cross-sectional data as in this study is merely a correlational approach and does not give an indication of causality. Inferring causality could only be argued on theoretical grounds or by applying more complex research designs, such as longitudinal studies and different data sources.

5.2.1.1 Dependent variable

To measure the dependent variable *policy credibility* the questionnaire included seven items. These were developed by combining two approaches: on the one hand we asked for the perceived support for the Energiewende from different societal actors (political parties, federal states, municipalities, national government); on the other hand we asked for companies' assessments on synonyms often utilized in reference to credibility (political will, vision, signals), and for these focused on the national level. To analyze whether these form a consistent indicator of the credibility construct we conducted an exploratory factor analysis with varimax rotation, leading to a solution with two factors with Eigenvalues >1, explaining 45 % (Eigenvalue of 3.2) and 21 % (Eigenvalue 1.5) of the variance. The first factor - the stronger one - consisted of the items referring to credibility synonyms (captured for the national level) together with the perception regarding the federal government. As the main decisions regarding the Energiewende are taken on the federal level this is consistent from a conceptual point of view. Thus, these four items (see Table 4) were aggregated into a scale by using the mean value across items. This scale showed high internal consistency (α=.858, where values above .7 are regarded as acceptable (George and Mallery, 2003; Nunnally and Bernstein, 2008)). Additional factor analyses supported this conclusion.

Table 4: Measurement of policy credibility [own translation of German survey questions]

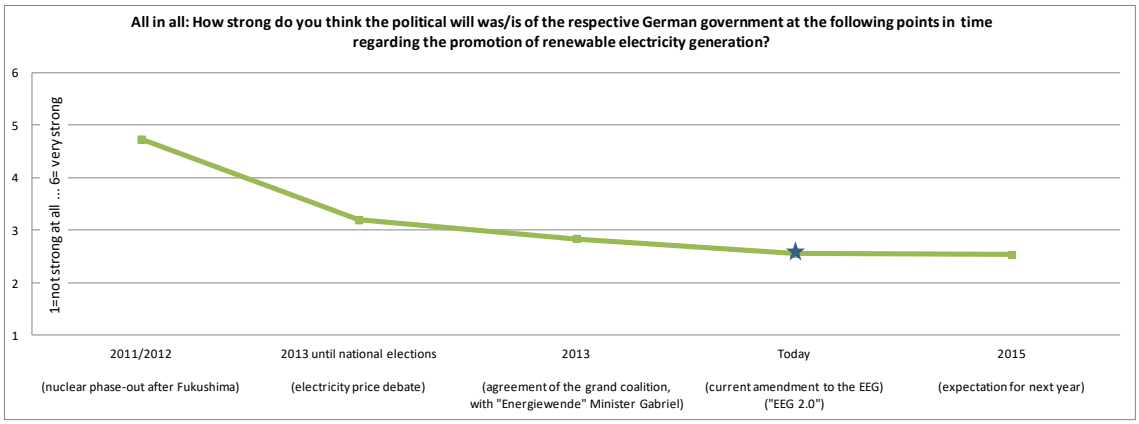
Please say how much you agree with the following statements about the policy framework conditions for supporting renewable energies in Germany at the present time for the renewable branch [you have chosen as your main one].		Mean [3]	SD
Concerning the increase of electricity generation from renewable energies in Germany, there is … [1]	...a clear political vision	2.57	1.33
	...a firm political will	2.61	1.26
	...unambiguous political signals	2.57	1.27
	...strong support from the German government	2.53	1.27
	Credibility indicator	*2.57*	*1.07*
All in all: How strong do you think the political will was/is of the respective German government at the following points in time regarding the promotion of renewable electricity generation? [2]	2011/2012 (nuclear phase-out after Fukushima)	4.73	1.23
	2013 up to federal elections (electricity price debate of the Environment Minister at that time, Altmaier)	3.19	1.19
	2013 (coalition agreement of the grand coalition with Gabriel, the Minister for the "Energiewende")	2.84	1.24
	Today (current amendment to the EEG) (EEG2.0)	2.56	1.29
	And how strong do you expect the government's political will to be next year (2015)?	2.53	1.21

1) Respondents answered on a scale from 1=do not agree at all to 6=fully agree.
2) Respondents answered on a scale from 1=not strong at all to 6=very strong.
3) For the descriptive statistics we present here the mean value for a scale that is aggregated across original values. For the further multivariate analyses we used Z-standardised values with imputed missing values.

In addition to this multi-item measurement for policy credibility as perceived at the time of the survey, additional items addressed the development of credibility over time, by including post- and ante measures. This was accomplished by referring to distinctive periods in time, to assist respondents in recalling the policy mix situation at the time. By drawing on empirical studies (Geels et al., 2016; Hermwille, 2016; Lauber and Jacobsson, 2016; Reichardt et al., 2016) and by being close observers of the policy process we identified three distinct periods in the past. First, we chose the decision on reenacting the nuclear phase-out after Fukushima 2011/12 as critical time we expected companies to remember reasonably well, despite the passing of time. Second, we capture the shift in the political debate towards the costs of the expansion of renewable energies, and the EEG surcharge in particular, by including the electricity price debate initiated by Federal Ministers in the run up to the federal elections in the fall of 2013. Third, our last point in the past was the time of the announcement of the coalition agreement between the conservatives (CDU/CSU) and the social democrats (SPD) in the end of 2013 which resolved some of the policy uncertainty by providing direction for the next legislative period. As for the present, we simply asked about companies perceptions of the perceived strength of the political will at the time of the survey (i.e. 2014), which was intentionally designed to coincide with our earlier policy credibility items asked for 2014. Finally, to

also capture the near future we asked companies for their expectations for the development of the strength of the political will of the German government for the next year (i.e. 2015).

Figure 3: Development of perceived credibility of the policy mix (2011 – 2015)



Note: The star indicates our credibility indicator (2.57) representing the average of four credibility items (vs 2.56).

Overall, as can be seen in Table 7, the mean values for our dynamic policy credibility measure with five items show a constant decline with a decreasing gradient (see Figure 3 and Table 4). This decline is also statistically significant: pairwise t-tests suggest that all later points in time significantly differ from earlier ones. The policy credibility indicator (based on four items for 2014) is significantly related to all other credibility items (based on development over time), with a closer relationship to the most recent ones which is highly plausible (see Table 5). These findings underline the reliability of our proxy for policy credibility.

Table 5: Relationship between different credibility measures

	2011/2012	2013 until national elections	2013	Today	2015
Credibility indicator	.240**	.529**	.627**	.677**	.654**

** p<.01; * p<.05

5.2.1.2 Independent variables

It is the aim of this study to explore the policy mix related determinants of policy credibility for which we distinguish between elements and other characteristics of the policy mix. Regarding the *elements* of the policy mix we include the policy strategy, policy instruments and design features of the core policy instrument EEG (see Table 6). The two

items on the *policy strategy* capture the ambition level of the 2025 expansion target for renewable energies in Germany, looking at the absolute ambition level and its recent downward adjustment. It can be seen that on average respondents thought the target was fairly ambitious, but that its ambition level had been reduced.

As for *policy instruments* the survey included a question asking about respondents' opinion on how much the current form of eight different instruments support the expansion of renewable electricity generation. Given that this list of policy instruments addresses not only demand pull (e.g. EEG), technology push (e.g. public R&D funding) and systemic instruments (e.g. grid extension), but also destruction instruments (e.g. nuclear phase-out) and instruments from policy fields other than energy or innovation policy (e.g. nature protection), we did not aggregate these items into a scale. What is noteworthy is that on average respondents thought that the nuclear phase out would support the further expansion of renewable energies strongest, despite this policy instrument being listed last. Furthermore, on average companies thought that public R&D support (technology push), skills training (systemic) and the EEG (demand pull) were seen as more or less equally important for the further expansion of renewable energies in the German electricity system.

As for the *design features* we focused on the EEG as core demand pull instrument, asking for companies' assessments of some of the key foreseen and previously heavily contested changes in its design. [7] As all of these referred to the same policy instrument we tested via an exploratory factor analysis whether it is advisable to aggregate items to prevent multicollinearity. The factor analysis supports this assumption by leading to a one-factor solution, with an internal consistency of the design scale of α=.80 (representing a good value). For further interpretation it is important to note that the items on the EEG design asked about in how far negative consequences from the EEG amendment are expected, i.e. high values on this scale mirror a negative evaluation of the changes. On average, companies' were expecting some negative consequences from the amendments in the EEG for their domestic sales.

7 The design features included the declining level of feed-in tariffs, the introduction of tenders to determine the support level, the introduction of technology-specific expansion corridors, the stepwise introduction of mandatory direct marketing, and disadvantages for those supplying their own power.

Table 6: Measurement of the elements of the policy mix [own translation of German survey questions]

Policy strategy [1)]	Mean [4)]	SD
The planned expansion target for renewable energies in Germany up to 2025 is very ambitious. *[Ambitiousness]*	4.10	1.80
The planned expansion target for renewable energies in Germany up to 2025 is lower than the expansion target of the previous legislative period. *[Reduction in ambitiousness]*	4.11	1.66
Policy instruments [2)]		
Renewable Energy Sources Act (EEG)	3.26	1.31
Public R&D / innovation funding	3.38	1.33
Energy Industry Act (EnWG) and other policy initiatives to expand the grid	2.92	1.11
Promoting the training of skilled workers for the renewable branch	3.34	1.43
Federal Nature Conservation Act and its implementation	2.49	1.09
EU Emission Trading System for the reduction of greenhouse gas emissions	2.33	1.34
Policy framework conditions for fossil electricity generation	2.32	1.28
Phase-out of nuclear energy by 2022	4.17	1.55
Design features of the core policy instrument EEG [3)] ***- scale***	3.89	1.24

1) The following questions refer to the policy conditions for renewable energies in Germany. To start with, we consider Germany's target for expanding the share of renewable energies in the electricity supply up to 2025, i.e. the targeted share of 40-45 percent in the power supply until 2025 that is cited in the current EEG draft. Please evaluate the following statements from today's perspective using a scale from 1 (do not agree at all) to 6 (agree completely).
2) I will now name different policy instruments and measures that could be relevant for the expansion of renewable energies. Please say how much you think these support the expansion of renewable electricity generation in their current form. Please answer using a scale from 1 to 6. 1 means "no support at all" and 6 "fully supports".
3) The German cabinet passed draft legislation to reform the EEG {EEG 2.0} at the beginning of April. Please say how much you think the following changes in the EEG will negatively affect sales of your products on the German market in your branch? Please answer using a scale from 1 to 6, where 1 means probably "no negative effect at all" and 6 means probably "a very negative effect".
4) For the descriptive statistics we present here the mean value for a scale that is aggregated across original values. Only for the further multivariate analyses we used the scale which is based on the Z-standardised values calculated with imputed missing values.

The second set of determinants of policy mix credibility included in our analysis concerns other *characteristics* of the policy mix. For these, we differentiate between comprehensiveness, consistency and coherence (see Table 7). Regarding *comprehensiveness*, we focus on the instrument mix for which we asked respondents if they thought important instruments were missing to support the expansion of renewable energies. On average, companies felt that some flanking measures were missing.

For *consistency* we differentiate between three levels of consistency, for each of which the survey included a statement – one for the consistency of the policy strategy, one for the consistency of the instrument mix and one for the overarching policy mix consistency, i.e. the consistency of the policy strategy with the instrument mix. On average, respondents thought that the policy strategy was fairly consistent, with the target for renewable

energies thought to be a pretty good match with other climate and energy targets. In contrast, the instrument mix and broader policy mix were thought to be only somewhat consistent. We also initially included a fourth item assessing the temporal consistency of the medium-term and long-term targets for renewables (2025 vs 2050), which, however, based on results of the factor analysis (see below) was excluded from the subsequent analysis. [8]

Finally, to operationalize the *coherence* of policy processes we developed eight items which cover a range of aspects attempting to assess how synergistic and systematic policy making and implementation processes are, as viewed by companies. These items range from information exchange over problem awareness and solving to more formalized stakeholder engagement procedures and cooperation among ministries and multiple governance levels (see Table 7). On average, respondents provided lower scores than for the other policy mix characteristics, suggesting some discontent with policy making and implementation processes at the time of the survey, as perceived by manufacturers.

In total, to operationalize the three policy mix characteristics thirteen items were developed (for details, see above and Table 7) for which we applied exploratory factor analysis to extract scales. Findings led to a four factor solution splitting up the items on coherence into two dimensions which can be characterized as informational and procedural coherence. However, one of the coherence items ("The last amendments of the EEG (2012 and today) were made in a transparent procedure.") [9] showed a factor loading >.30 on both coherence factors and was therefore deleted for reasons of clarity. Furthermore, one of the consistency items (temporal consistency of long-term targets) emerged as a common factor together with comprehensiveness.

In a next step we aggregated the remaining items into four scales based on the results from the explanatory factor analysis by calculating the arithmetic mean across the items. We also calculated Cronbach's α for the respective scales to check internal consistency for the scales. However, the combination of the consistency item and the comprehensiveness item showed a weak Cronbach's α. (.31) in the next step, when we analysed internal consistency. We therefore decided to draw on the original item for comprehensiveness only. For the other scales, they emerged to be .54 for consistency, .81 for informational coherence and .74 for procedural coherence. This means that the internal

8 „The planned expansion target for renewable energies in Germany up to 2025 seems too low in relation to the long-term expansion target of 80% renewables by 2050."

9 As this item (mean value of 2.38) is not included in further analysis, it is omitted in Table 7.

consistency is good for both coherence scales, however, weak for consistency. A deletion of one of the items would not have improved the consistency scale and the three items are positively interrelated. Therefore, and as the three items were derived from theory, we decided to use the scale in further analysis in spite of the relatively weak internal consistency. Obviously, this limitation needs to be kept in mind when interpreting our findings and we also estimated the alternative regression model using the single items instead of the scale (see footnotes below).

Table 7: Measures on the characteristics of the policy mix [own translation of German survey questions]

Comprehensiveness [1) 2)]	Mean [4)]	SD
Important flanking policy regulations are missing that push the expansion of renewables (e.g. on power market design or for grid expansion).	4.69	1.50
Consistency [1) 2)] ***- scale***	2.77	1,03
The planned expansion target for renewable energies in Germany up to 2025 is a good match with other energy and climate policy targets of the German government. *[Consistency of the policy strategy, 1st level consistency]*	3.58	1.64
The existing policy instruments reinforce each other in their positive effect on supporting renewables' expansion. *[Consistency of the instrument mix, 2nd level]*	2.38	1.26
The planned expansion target for renewable energies in Germany up to 2025 can be achieved with the help of existing policy instruments and measures. *[Consistency of the policy strategy with the instrument mix, 3rd level consistency*]	2.37	1.38
Coherence informational [1) 3)] ***- scale***	2.27	0.87
There is a continuous exchange of information between policymakers and manufacturers.	2.57	1.21
Policymakers are well informed about developments in the branch.	2.53	1.34
Emerging problems are spotted early on by policymakers.	1.85	1.00
Policymakers always strive to remove obstacles.	2.06	1.10
The search for solutions to problems takes place in a constructive exchange between policymakers and representatives of the RE branch.	2.36	1.07
Coherence procedural [1) 3)] ***- scale***	2.41	1.14
The responsibilities for the branch are clearly regulated in the relevant Federal ministries.	2.83	1.36
National and regional governments are pulling in the same direction.	2.07	1.16

1) Please evaluate the following statements from today's perspective using a scale from 1 (do not agree at all) to 6 (fully agree).
2) The following questions refer to the policy instruments to promote renewable electricity generation in Germany and are always with regard to your branch [for your main renewable power generation technology].
3) Please say how much you agree with the following statements at the present time for the renewable branch [of your main renewable power generation technology]. Please answer using a scale from 1 to 6, where 1 is "do not agree at all" and 6 means "fully agree".
4) As before, for the descriptive statistics we present here the mean value for a scale that is aggregated across original values. Only for the further multivariate analyses we used the scale which is based on the Z-standardised values calculated with imputed missing values.

6 Results

6.1 Role of policy mix elements for perceived policy credibility

We start by presenting the results of our first set of linear regression models for the link between policy mix elements and credibility, and will do so in a stepwise manner to make the contribution of each partial step visible. We start by including a block on the policy strategy, then add the block on policy instruments, and finally also include the design features of the core policy instrument EEG. Results of the final stepwise linear regression model are presented in Table 8.

Table 8: Stepwise linear regression model with policy mix elements as determinants of policy credibility

Step	Independent variables	β	S.E.	p
1	Ambitiousness	.123**	.038	.007
	Reduction in ambitiousness	-.065	.041	.154
ΔR^2	***Policy strategy***	**.079****		
2	Renewable Energy Sources Act (EEG)	.107*	.041	.028
	Public R&D / innovation funding	.043	.044	.402
	Energy Industry Act (EnWG) and other policy initiatives to expand the grid	.128*	.050	.024
	Promoting the training of skilled workers for the renewable branch	-.078	.046	.141
	Federal Nature Conservation Act and its implementation	.002	.044	.966
	EU Emission Trading System for the reduction of greenhouse gas emissions	.131*	.043	.011
	Policy framework conditions for fossil electricity generation	.061	.041	.200
	Phase-out of nuclear energy by 2022	.135**	.039	.004
ΔR^2	***Policy instruments***	**.144****		
3	Design features of EEG - scale	-.305**	.053	.000
ΔR^2	***Design features of EEG***	**.081****		
R^2		**.304**		
(adj R^2)		**(.283)**		
R		**.551****		
F		**14.9**		

Cells give βs, i.e. standardized regression weights, S.E., p-values from final equation. Levels of significance are indicated as follows: ** - p<.001, * - p<.050
ΔR^2 denotes the increase in variance explained by including the variables from the respective step; R=regression coefficient; F=Test statistics
To check for multicollinearity VIF was calculated and resulted to be <2 for all variables.

Overall the regression model leads to a highly significant model which explains a substantial amount of variance in our indicator for policy credibility (30.4 %). We find that

from the two items for policy strategy the perceived ambition of the expansion target is significantly positively related to credibility, while its recent reduction in ambitiousness exhibit's the expected negative sign but is not significant. This implies that companies which judge the ambition to be higher also tend to judge the credibility to be higher, and vice versa. From the range of policy instruments covered, the EEG (demand pull), support of grid extension (systemic instrument), the EU Emission Trading System (EU ETS) as well as the nuclear phase out (both destruction policies) are significant positive predictors of the level of perceived credibility of the policy mix. Finally, the scale summarizing the design features of the EEG significantly contributes to explaining variance in policy credibility, and is actually the factor which has the highest influence in this model (β=-.305). Here, the negative link implies that the more negative companies think the consequences of the pending changes in the design of the EEG will be, the lower their perception of the credibility of the policy mix.

6.2 Role of policy mix characteristics for perceived policy credibility

We now turn to the results of our second set of regression models for the link between policy mix characteristics and credibility, and will again do so in a stepwise manner. As before, regressing policy credibility on the other characteristics of the policy mix leads to a highly significant model that explains about 43 % of the variance (see Table 9). While the comprehensiveness of the instrument mix is not significant, the other four variables included in the regression are confirmed as significant predictors of the level of perceived policy credibility. Among them informational coherence shows the strongest influence (β=.402), followed by the scale for policy mix consistency (β=.275) and finally procedural coherence (β=.140).[10]

[10] As the internal validity of the scale for consistency was not very high (α<0.6) we also estimated a regression model where we added all four items from the questionnaire intended to measure consistency. The results are highly similar to Table 7. R=.659**, R^2=.434; β-values (and significance levels) for the four independent variables are: comprehensiveness -0.056 (n.s.), informational coherence 0.422 (**), procedural coherence 0.143 (**), and for the four consistency items: (1) consistency of the policy strategy 0.132 (**),consistency of the instrument mix 0.126 (**), consistency of the policy strategy with the instrument mix 0.064 (n.s.) and temporal consistency of long-term targets -0.049 (n.s.).

Table 9: Linear regression model with policy mix characteristics as determinants of policy credibility

Independent variables	**β**	**S.E.**	**p**
Comprehensiveness of the instrument mix	-.075	.033	.000
Consistency of the policy mix - scale	.275**	.049	.056
Informational coherence of policy processes– scale	.402**	.049	.000
Procedural coherence of policy processes – scale	.140**	.041	.001
R^2	**.428****		
(adj. R^2)	**(.422)**		
R	**.655****		
F	**72.1**		

Cells give βs, i.e. standardized regression weights, S.E., p-values from final equation. Levels of significance are indicated as follows: ** - p<.001, * - p<.050
R^2 denotes the variance explained; R=regression coefficient; F=test statistic
To check for multicollinearity VIF was calculated and resulted to be <2 for all variables.

6.3 Combined influence of policy mix elements and characteristics for explaining perceived policy credibility

In final step the two components of the policy mix considered here – its elements and characteristics – are combined in an overall model. Varying the order in which the two sets of components are added to a respective stepwise regression model makes it possible to compare the added value of the two approaches against each other (see Table 10 for comparison of determination coefficients). It turns out that combining the two policy mix components leads to a higher amount of explained variance (49.6 %). However, the additional gain is higher for the elements of the policy mix if the characteristics are added on top (adding 19.3 % of explained variance), while the elements only add 6.8 % of additional variance explained on top of what is already explained by policy mix characteristics.

Table 10: Comparison of determination coefficients of stepwise linear regression models combining policy mix elements and characteristics as credibility determinants

		ΔR^2		ΔR^2
Step 1	Elements	.304**	Characteristics	.428**
Step 2	Characteristics	.193**	Elements	.068**
R (corr. R^2)	.705** (.476)			
F	24.6			

Levels of significance are indicated as follows: ** - p<.001, * - p<.050
ΔR^2 denotes the increase in variance explained by including the variables from the respective step; R=regression coefficient; F=test statistic

The combined model shows a slightly changed picture regarding significant contributions from different policy mix components (see Table 11). From the two policy strategy items the level of ambitiousness is no longer significant, but the reduction of the ambition level of the target becomes significant (keeping the negative sign) for explaining the level of perceived policy credibility. That is, the more companies agree with the 2025 expansion target having been reduced, the lower they judge the credibility of the policy mix. Perhaps somewhat surprisingly, most of the policy instruments do not add significantly to explaining variance in policy credibility, with the exception of the nuclear phase out – and thus a destruction policy – remaining predictive, indicating a positive effect on credibility perceptions. The scale on the ratings of the EEG design features also remains significant (equally keeping its negative sign). Finally, the pattern of influence of the variables measuring policy mix characteristics remains the same as before – all but the comprehensiveness of the instrument mix are experiencing a statistically significant link with credibility, again with informational coherence evidencing the highest impact (β=0.335).

Table 11: Final linear regression model with policy mix elements and characteristics as determinants of policy credibility

Policy mix elements	**β**	**S.E.**	**p**
Policy strategy			
Ambitiousness level of mid-term renewables expansion target	.069	.033	.079
Reduction in ambitiousness of mid-term renewables expansion target	-.079*	.035	.044
Policy instruments			
Renewable Energy Sources Act (EEG)	.059	.035	.164
Public R&D / innovation funding	-.004	.038	.932
Energy Industry Act (EnWG) and other policy initiatives to expand the grid	-.003	.045	.955
Promoting the training of skilled workers for the renewable branch	-.081	.039	.073
Federal Nature Conservation Act and its implementation	-.013	.038	.758
EU Emission Trading System for the reduction of greenhouse gas emissions	.076	.037	.084
Policy framework conditions for fossil electricity generation	.037	.035	.363
Phase-out of nuclear energy by 2022	.110**	.034	.007
Design features			
Design features of EEG - scale	-.159**	.048	.000
Policy mix characteristics			
Comprehensiveness of the instrument mix	-.047	.032	.221
Consistency of the policy mix – scale	.202**	.052	.000
Informational coherence of policy processes– scale	.335**	.050	.000
Procedural coherence of policy processes – scale	.137**	.040	.001

Cells give βs, i.e. standardized regression weights, S.E., p-values from final equation. Levels of significance are indicated as follows: ** - p<.001, * - p<.050
To check for multicollinearity VIF was calculated and resulted to be <2 for all variables.

7 Discussion

Our regression analysis indicates that companies' perceptions of policy credibility are mainly shaped by two characteristics of the policy mix, namely the coherence of policy making and implementation, followed by the consistency of the policy mix. Elements of the policy mix matter as well, in particular changes in the design of the EEG and the existence of the nuclear phase-out policy, but also the expansion targets for renewable energies. In the following, we discuss three main implications of our findings in light of the credibility and policy mix literature, while keeping in mind the exploratory nature of our research.

7.1 The coherence of policy processes may be most influential for perceptions of policy credibility

We find an outstanding relevance of the coherence of policy processes for shaping companies' perceptions of the credibility of the policy mix, and here in particular the informational type. Arguably, such informational coherence may be captured by Nemet et al.'s (2017) category of transparency and trust. However, this category largely refers to the government providing information about its climate performance (through monitoring, verification, reporting, etc.). In contrast, informational coherence goes beyond this by covering how well the government is informed about what is going on in a certain sector, how actively it pursues a two-way exchange of information, how quickly it responds to emerging challenges, and to what extent it engages in joint problem solving with the actors in the sector. As already alluded to by Nemet et al. (2017), for this the experience of the government paired with its capacity for such an informed and participatory policy making style may be key (Rayner and Howlett, 2009; Quitzow, 2015a; Howlett and Ramesh, 2016; Reichardt et al., 2017).

In addition, procedural coherence, here measured as horizontal and vertical coherence of policy making and implementation, also shapes companies' perceptions of policy credibility. This adds to Nemet et al.'s (2017) insight on the decentralization of policy making safeguarding credibility by providing robustness. More specifically, our findings point to the importance of all governance levels working towards the low-carbon energy transition, and of responsibilities clearly being laid out between different Ministries. We argue that these are important additional aspects which deserve further attention as determinants of policy credibility more broadly, drawing inspiration from the policy mix literature as well as the literatures on (environmental) policy integration and coordination (Mickwitz et al., 2009; Bouckaert et al., 2010; Magro et al., 2014; Rogge and Reichardt, 2016; Howlett et al., 2017).

7.2 Credibility may be lost through adjusting institutionalized elements of the policy mix

A second implication of our findings concerns the loss of credibility for which our case points to two determinants, thereby confirming that “credibility is fragile” (Nemet et al., 2014, p. 531): the recent reduction in the ambition level of the expansion target for 2025, and the adoption of less favorable design features of the core demand pull instrument EEG in 2014.

Regarding the first determinant our research indicates a negative effect arising from the reduction of the ambition of the medium-term expansion target, thereby complementing insights from Nemet et al. (2014) on building up credibility by sequentially increasing ambition levels of policy targets after less ambitious targets have been achieved. In our particular case, Germany had built up a strong reputation for achieving its targets set for the expansion of renewable energies, with a pattern of target overachievement to which until 2012 it had reacted by tightening the ambition of its targets for the share of renewable energies in the electricity system. In such a context of institutionalized expectations of an increase in ambitions it could be argued that simply stopping this pattern would have already reduced credibility, but breaking this institutionalized pattern may have shed serious doubts on the commitment of the government. At a first instance this may appear surprising given that the long-term target for 2050 was left unchanged, and henceforth only the pathway towards that target was adjusted so as to shift the further expansion of renewable energies somewhat to the future (Anonymous 2015). While cost minimization was provided as an obvious reason, at a deeper level this policy change may have revealed delays in grid expansion and limited progress with wider changes in the network and consumption regime needed to accommodate the increasing share of renewable energies, arguably because of insufficient policy attention (Kuzemko et al., 2017), thereby possibly raising doubts about the strength of the government’s commitment to the *Energiewende*.

Regarding the second determinant our results suggest that recent changes in the design of the EEG have led to a lower belief in the credibility of the policy mix, despite policy makers following the amendment procedures for such a policy change laid out in the EEG (Hoppmann et al., 2014). Therefore, the negative impact on credibility can only be understood when considering the broader context. In this case, the policy change was embedded into heightened concerns regarding costs, consolidations in the domestic PV industry and resurging attention to the interests of incumbents (Quitzow, 2015b; Geels et al., 2016; Lauber and Jacobsson, 2016). In this context, the combined effect of all EEG design changes pointed to a pending policy regime shift towards tendering (instead of institutionalized feed-in tariffs) and limits to growth to better control the cost and speed

of the expansion, leading to anticipated negative consequences for domestic sales of renewable power generation technologies. The resulting effect on the perception of policy credibility then may have arisen from the government sending – willingly or unwillingly - multiple signals of wanting to slow down the energy transition.

Our findings underline that target ambition and instrument design – and changes therein – may be more important for credibility than simply looking at the existence of certain targets and multiple instruments. But they also show that negative effects could potentially be mitigated or even offset by the coherence of policy making and implementation processes, underlining the importance of how policy change is implemented (White et al., 2013). Finally, our findings also highlight the limits to safeguarding policy credibility by clearly defining the flexibility of how rules can be (re)designed (Nemet et al., 2017), particularly when such changes are in conflict with institutionalized expectations about future policy change in core elements of the policy mix.

7.3 Destruction instruments and policy mix consistency seem to be key for policy credibility

Our findings also provide two new insights regarding the relevance of multiple instruments for credibility, thereby complementing Nemet et al.'s (2017) focus on their role for generating robustness.

Our first insight concerns the outstanding relevance of destruction instruments, as of all the eight policy instruments included in our regression only one – Germany's nuclear phase out policy (Hermwille, 2016) – proofed to be unambiguously related to policy credibility. This goes to show the important albeit in many sectors and countries so far neglected role of destruction policies (Kivimaa and Kern, 2016) which may unfold their power not only through providing space for green technologies in future markets, but also by showcasing a credible commitment of governments to the low-carbon energy transition. After all, they may often represent a strong form of market intervention which is likely to be heavily politically contested, with policy makers having to overcome strong resistance from powerful incumbents with vested interest (Geels, 2014; Howlett, 2014). Finally, the example of the partly significant EU ETS – another destruction instrument – points to the importance of the stringency of such instruments, as only with the proper design may they truly support policy credibility.

Our second insight concerns the key role played by policy mix consistency. Regarding policy instruments this implies that what matters for credibility seems to be their alignment with each other (and with the policy strategy), rather than simply having multiple

overlapping instruments in place. This points to the importance of policy design (Howlett and Rayner, 2007b; Howlett and Rayner, 2013; Kern et al., 2017) for avoiding negative interactions of instruments and striving for synergies between them (Gunningham and Sinclair, 1999; Oikonomou and Jepma, 2008; Antonioli et al., 2014). Another aspect concerns the relevance of having policy instruments in place which are stringent enough to be able to achieve long-term targets, which is, for example, clearly not yet the case for the EU ETS due to a surplus of allowances (Grosjean et al., 2014; Koch et al., 2014), thereby leading to limited incentives for low carbon innovation (Rogge, 2016). A final aspect of instrument mix design is the consideration of the complementary nature of demand pull, technology push and systemic concerns, with the partly significant findings on instruments supporting grid expansion making the case for using systemic instruments and paying attention to system complementarities (Cantner et al., 2016; Markard and Hoffmann, 2016).

7.4 Overarching reflections on analyzing policy credibility

We close our discussion by offering three overarching reflections relevant for future research on climate policy credibility. First, while much can be learned about policy credibility from policy fields which have traditionally dealt with it, such as monetary policy, research in *innovation and transition studies* (Markard et al., 2012; Weber and Rohracher, 2012) investigating directed, long-term transformative change offers additional insights which can enrich our understanding on policy credibility. Second, our findings underline the meaningfulness of the *second generation of policy mix research* which includes policy processes and characteristics as key building blocks, thereby going beyond a pure focus on instruments and their interactions (Rogge and Reichardt, 2016; Reichardt et al., 2017). Indeed, in our case policy mix characteristics had a much greater explanatory value for perceived credibility than concrete policy instruments, and here in particular the coherence of policy processes, pointing to a need to pay closer attention to procedural rather than only substantive policy instruments (Gunningham et al., 1998; Smits and Kuhlmann, 2004; Howlett and Rayner, 2007a). Finally, and in a similar vein as has been suggested by Kern and Rogge (2017) for transition and policy studies, we argue that for research to be able to shed more light on the coherence of policy processes as influential determinant of policy credibility calls for more *interdisciplinary research* combining economics and policy studies.

8 Conclusions

Given the relevance of policy credibility for low-carbon innovation as key means addressing climate change, we need to better understand how such credibility is formed. In this paper, we have presented a first step in this endeavor by exploring whether and to what extent the existing policy mix helps explain companies' perceptions of policy credibility. In the context of the German energy transition we find that credibility is shaped by a number of policy mix elements, including changes in expansion targets, design changes in the core demand pull instruments and the existence of the nuclear phase-out policy. Yet, the informational and procedural coherence of policy processes and the consistency of the policy mix constitute even more influential determinants of manufacturers' perceptions of policy credibility.

Our paper makes two main contributions to the literature. First, its theoretical contribution concerns the combination of the literatures on credibility and policy mixes, thereby proposing the consideration of policy mix elements and characteristics as explicit determinants of policy credibility. Second, its empirical contribution rests in the provision of a first study employing survey data to investigating what aspects of the policy mix make companies believe in the commitment of governments to low carbon energy transitions.

While our detailed findings for Germany are specific for this case, we argue that they still provide four general insights for any policy maker interested in increasing – or avoiding the loss of – policy credibility as means to support low carbon energy transitions. First, policy makers are well advised to *stick to their targets or make them gradually more ambitious* over time (Nemet et al., 2014), but not to reduce their ambitiousness despite being in compliance with target achievement.

Second, given the aspirations of the Paris Agreement for a decarbonization of the economy, policy makers are advised to implement their commitments by *devising or strengthening destruction policies* for fossil energies (Kivimaa and Kern, 2016), may that be, for example, through the reduction of subsidies (Schwanitz et al., 2014; Coady et al., 2017) or the adoption of phase out strategies for coal (Heinrichs et al., 2017; Johnstone and Hielscher, 2017). In a similar vein, policy makers need to overcome the political resistance to increasing carbon prices, such as by fixing the problem of surplus allowances in the EU ETS (Grosjean et al., 2014; Koch et al., 2016) to make it a stringent control policy signaling a strong decarbonization commitment and providing adequate low carbon incentives.

Third, policy makers are advised to *pay greater attention to the nature of policy making and implementation processes*, rather than just policy outputs. For example, they should strive to enhance the systematic nature of policy making procedures, improve the multi-

directional information exchange with green innovators and avoid destructive discussions about the future of the policy mix (Reichardt et al., 2016). This also implies to take great care when redesigning core policy instruments, as the process of such redesign, such as a participatory policy style, may matter even more for perceptions of credibility than actual policy changes (White et al., 2013; Reichardt et al., 2017). This may require a strengthening of procedural and informational capacities of the state and enhanced capabilities of policy makers for steering system innovation (Bradshaw, 2003; Smits and Kuhlmann, 2004; OECD, 2015; Quitzow, 2015a; Howlett and Ramesh, 2016).

Finally, since we surveyed manufacturers of low carbon technologies our findings can also be interpreted as a call for *greater attention to green industrial policy* (Pegels and Lütkenhorst, 2014; Kemp and Never, 2017), including a better anticipation of industry localization effects and international competitiveness (Quitzow, 2015b; Schmidt and Huenteler, 2016).

Our study is not free from limitations which should be kept in mind when interpreting our findings. First, since we measured many items for the first time in a policy mix survey, it may be not surprising that our data is psychometrically speaking not perfect, suggesting further research applying improved operationalizations. Perhaps most importantly, the internal consistency of our consistency scale was weak (low Cronbach's alpha), and thus future research should investigate the suitability of capturing all three levels of policy mix consistency as latent constructs. Second, given the small sample size we have refrained from including control variables into our regression model, implying that we cannot say anything about the relevance of other factors, such as firm characteristics.[11] Third, our sample only includes manufacturers and therefore does not capture differences in perceptions of policy credibility in other actor groups, such as of investors in renewable power generation technologies. Fourth, our focus on exploring the extent to which policy mix aspects play a role for perceptions of policy credibility has meant that other potentially relevant determinants, such as institutional design, were not included in our analysis. Finally, it is important to note that our study is based on a cross-sectional design and thus purely correlational. Additionally, it is a single-source-single-method design which enhances the issue of endogeneity, e.g. due to omitted variable bias. Thus, our data analysis is not able to provide results beyond relationships, i.e. drawing conclusions about causality is not possible based on the data. However, theoretical arguments can be drawn about the direction of relationships and cause and effect.

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11 On an explorative basis we included a list of firm-internal factors as control variables into the model, such as the renewables branch (solar vs. wind), number of employees, etc. If only the control variables are entered, some of these show a significant positive relationship with our credibility indicator. However, if combined with policy mix elements and characteristics in the same regression model none of the control variables remains significant.

Despite these limitations, we argue that our study provides valuable new insights into a neglected yet important area of climate and transition policy for which we see at least three fruitful avenues for future research. First, we recommend conducting similar empirical studies in different countries and with additional actors to generate insights which go beyond our specific case. Second, future studies should investigate more complex models which capture potential interdependencies between policy mix elements and characteristics, e.g. possible indirect effects of policy elements on credibility through other policy mix characteristics. Next, while we have explored whether and to what extent specific aspects of the policy mix matter for perceptions of policy credibility, future research should investigate how companies form such perceptions, for example through interviews or experiments. Finally, to critically test the validity of our findings research designs that observe companies' perceptions (credibility, policy mix), the policy mix and further indicators like innovation activities over time are needed.

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