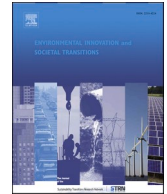


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Applying policy mix thinking to social innovation: from experimentation to socio-technical change

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ABSTRACT

So far, the emerging literature on policy mixes for sustainability transitions has paid little attention to social innovation. This seems at odds with recent claims that transformative policies should promote a wide range of innovation, and social innovation in particular. In this paper, we explore whether and how policy mix delineation and analytical approaches that were developed primarily with technological innovation in mind can be usefully applied to social innovation. We examine empirical case study evidence, and proceed in two steps: after an initial top-down mapping of the focal policy mix for social innovation in energy in Germany, we conduct a bottom-up mapping of the policy mix relevant for the social innovation field of 'participatory incubation and experimentation' in Germany's energy sector. Based on our insights we discuss the relevance and recognition of social innovation in sustainability transition policy mixes, and offer research and policy implications for accelerating socio-technical change.

1. Introduction

The urgency of environmental and other societal challenges, such as the existential climate crisis and rising inequality, require active policy intervention to address the underlying market and system failures (Weber and Rohracher, 2012). However, policies aimed at directing and accelerating transitions towards more sustainable systems of production and consumption tend to require radical change often faced with resistance (Kern and Rogge, 2016; Markard et al., 2012; Roberts et al., 2018). Despite recognizing the key role of social innovation for such processes of transformative change (Avelino et al., 2017), the emerging literature on policy mixes for sustainability transitions has so far paid very limited attention to social innovation (Kern et al., 2019; Rogge et al., 2017), and thus to the topic of this special issue (for an introduction, see Wittmayer et al. in this issue). While there is no uniformly agreed definition of what constitutes social innovation (Edwards-Schachter and Wallace, 2017), we argue that regardless of its definition the limited attention to social innovation in policy mix research seems at odds with recent claims that transformative policies, such as transformative innovation policies or transformative environmental policies, are meant to promote a wide array of innovation, and social innovation in particular (Jacob and Ekins, 2020; Schot and Steinmueller, 2018). Likewise, social innovation scholars have not yet applied the logic of policy mix thinking to their research, despite some attention to policies and policy making (Sabato et al., 2017; Jacobi et al., 2017), including in the context of energy (Matschoss et al., 2022). Consequently, policy insights generated by social innovation research have only loosely been connected to real world policy mixes governing sustainability transitions. We argue that

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these shortcomings represent a missed opportunity for accelerating transition processes as these rely on both technological and social innovation.¹ As policy mix research has so far focused on the former and neglected the latter, in this contribution we call for better connecting social innovation research with policy mix research and offer a first explorative step in this regard which culminates in the proposition of a new conceptualisation of policy mixes for socio-technical change.

For the purposes of our research, we combine two leading policy mix definitions to define policy mixes of relevance for social innovation as encompassing policy strategies and instrument mixes at different governance levels and policy domains which enable or impede the development of social innovation, and have evolved incrementally over many years (Kern and Howlett, 2009; Rogge and Reichardt, 2016). In this contribution, we explore whether and how policy mix delineation and analytical approaches developed primarily with technological innovation in mind can also be usefully applied to social innovation. To answer this research question, we investigate the case of social innovation in low-carbon sustainable energy transitions (SIE). More specifically, we examine empirical evidence from the SIE-field of participatory incubation and experimentation (PIE) as one type of social innovation, looking at evidence from Germany. This type of SIE was chosen because of its longer bottom-up history of participatory initiatives and increasing recognition and active promotion of this format by innovation policy makers, particularly in the context of sustainability. Germany with its *Energiewende* presents a suitable case where we can observe these developments and the role of policy mixes for them. Data was gathered through policy documents and other desktop research, as well as expert interviews. Policy mix delineation follows the top-down and bottom-up approach suggested by Ossenbrink et al. (2019). However, given the complexity of real world policy mixes the analysis identifies and focuses on the policies perceived as particularly relevant for enabling or impeding social innovation in our selected SIE-field. Our policy mix analysis is guided by an analytical framework that bridges policy mix elements and policy mix functions (Kivimaa and Kern, 2016; Rogge and Reichardt, 2016).

The article is structured as follows. In Section 2, we develop our analytical framework based on a literature review on social innovation and policy mixes in sustainability transitions. In Section 3, we introduce our research case, followed by an overview of our methodological approach in Section 4. Thereafter, in Section 5 we present the SIE policy mix resulting from applying the top-down approach. Our bottom-up policy mix delineation and analysis of the focal policy mix relevant for PIE in Germany is presented in Section 6. In Section 7 we discuss our findings, offer some reflections on adjustments of current policy mix frameworks to better capture social innovation phenomena, and close with a plea to move towards policy mixes for socio-technical transitions. Section 8 concludes the paper.

2. Towards an analytical framework investigating social innovation policy mixes

2.1. Social innovation research and the role of policies and policy making

Social innovation research is a heterogeneous research area, with scholars from different disciplines and intellectual communities invoking the concept, such as business and organizational management, urban studies, or social economy (Edwards-Schachter and Wallace, 2017; Moulaert and MacCallum, 2019). Witness to its diverse roots, social innovation has been defined in many ways – some focusing on the change of social relations (Moulaert et al., 2013; Pel et al., 2020), while others focus on changes of social practices (Domanski et al., 2020). In addition, most lines of research have linked the ends and means in their definitions of social innovation, understanding social innovation as leading to desirable social outcomes (Bureau of European Policy Advisers, 2011), such as civic empowerment and the general wellbeing of communities (Hoppe and Vries, 2018). However, there has also been research recommending to decouple desirable outcomes from the processes of social innovation (Franz et al., 2012; Wittmayer et al., 2020), as well as research that links social innovation directly to a certain type of transformative outcome (McGowan et al., 2017; Moulaert and MacCallum, 2019).

As an innovation category, social innovation has also gained increasing attention by policy makers, for example as expressed within the European innovation policy agenda (Harsløf, 2015), with it being understood as potential source of solutions to address complex societal challenges. That is, social innovation is nowadays regarded as a ‘driver for change’ and as a means to address societal challenges such as an ageing population, growing inequality, the climate crisis, globalisation and digitalisation (Bureau of European Policy Advisers, 2011; Mulgan et al., 2007; Murray et al., 2010). This line of thinking is illustrated, for example, by the German government who acknowledges social innovation as necessary for addressing societal challenges such as those linked to climate protection, sustainability, and energy (BMBF, 2018). In doing so, it has started to take stock of policy instruments supporting social innovation (BMBF, 2021).

From a policy-focused perspective, contributions have analysed if and how social innovation is mentioned in policy related documents and investigated how policies frame and address social innovation. In this regard, social innovation is often discussed as a way of addressing challenges related to changes of the welfare system (Borzaga and Bodini, 2014; Sabato et al., 2017). Among other aspects, studies typically take one level of policy making as starting point - mostly focussing on the role of EU policies - and critically reflect on the transformative potentials of these policies. For example, by analysing policy documents, Sabato et al. (2017) trace the role of social innovation in EU policies and find that the years 2009-2010 mark a turning point for putting social innovation on policy agendas and mainstreaming it in the Europe 2020 strategy. In addition, the role of concrete instruments supporting social innovation is

¹ Socio-ecological systems also acknowledge the great potential of emerging technological and social innovations for improving the sustainability of our way of living, but stress that this potential can only be harnessed if knowledge of social-ecological systems and planetary boundaries is taken on board for their future development (Stockholm Resilience Center 2016).

discussed (Jacobi et al., 2017; Pieri and Teasdale, 2021). For example, de Pieri and Teasdale (2021) differentiate between a market-based and empowerment-based policy approach for social innovation - the former draws on financial tools or regulatory interventions, the latter requires new models of public policy making (Pieri and Teasdale, 2021). Another example is the study by Jacobi et al. (2017) that analyses the policy design and implementation processes of EU funded policy programs. They find that even if EU policies support social innovation, they often tend to maintain and reproduce existing power structures and thus miss the transformative potential of social innovation.

From an innovation-focused perspective, contributions start from a concrete social innovation phenomenon and trace how it is influenced by policies or linked to policy making processes. Such studies might relate to different policy domains (e.g., health, urban planning, or energy) as well as to different governance levels (e.g., local, regional, national, supranational). Discussed topics are, among others, protests and social movements that aim at creating policy awareness (Becker et al., 2016; Blanchet, 2015). For example, Becker et al. (2016) analyse attempts to establish community-based energy infrastructure ownership in Berlin and Hamburg, Germany, for which they trace the strategies of policy change pushed by community initiatives. Furthermore, strategies of initiatives to increase their influence in policymaking processes are analysed, such as forming alliances and networks (Hess, 2019; Haukkala, 2018). For example, Haukkala (2018) studies the formation of a green-transition advocacy coalition in Finland and especially analyses the impact the coalition has on policy change. Overall, studies within this social innovation-focused perspective often identify context specific actor constellations, organizational forms and communication strategies that help to influence policy making processes. In contrast to the policy-focused approach, innovation-focused studies often analyse the role of local or national policies - rather than EU level policies.

Despite the climate crisis being a major societal challenge and especially the energy sector contributing to this crisis with high shares of greenhouse gas emissions, the concept of 'social innovation' has been only recently picked up in energy research (Hewitt et al., 2019; Hoppe et al., 2019; Hoppe and Vries, 2018; Wittmayer et al., 2020) and energy policy (Koukouloufakis, 2021; Mikkonen et al., 2020). Social innovation in energy (SIE) has been linked to social phenomena relating to changes in energy systems, such as community energy (Hewitt et al. 2019; Soutar 2018) and grassroots innovation (Hargreaves et al., 2013), energy collectives (Ooms et al., 2023), innovative business models (Hiteva and Sovacool, 2017), energy sufficiency (Lorek and Spangenberg, 2019; Stieß et al., 2019), energy games and green nudging (Hoppe and Vries, 2018). These social innovations relate to the engagement of citizens and multiple other actors in the production and/ or consumption of heat, electricity or mobility. Wittmayer et al. (2022) have pointed to such a broader understanding of what constitutes social innovation in energy transitions. It is their broader approach we follow in this article, and thus adopt the definition of social innovation as 'ideas, objects and/or actions which change social relations and involve new ways of doing, thinking and/ or organising' energy (Avelino et al., 2019; Haxeltine et al., 2018; Pel et al., 2020).² We aim to add to this appreciation of social innovation as a broad phenomenon and tool to address societal challenges a more systematic and comprehensive look at policy mixes influencing such social innovation and thus sustainability transitions.

2.2. Policy mix research and its application to social innovation

Over the past decade researchers working on sustainability transitions have emphasized the importance of policies for directing and accelerating transition processes (Markard et al., 2012). In response to the multiple market and system failures that provide justification for policy intervention (Weber and Rohrer, 2012) scholars have advocated the need for policy mixes (Rogge and Reichardt, 2016). Drawing inspiration from the disciplines of environmental economics (Sorrell, 2003), policy studies (Howlett and Rayner, 2007) and innovation studies (Flanagan et al., 2011), it has been argued that policy mixes for sustainability transitions need to be thought of as something broader than merely the combination of multiple policy instruments. In particular, a key message in that broader policy mix literature has been that rather than focusing on design only what requires more attention is the politics involved in making and implementing policies and its implications for the characteristics and effectiveness of policy mixes. Two special issues have contributed to the further development of this more comprehensive policy mix thinking (Rogge et al., 2017; Kern et al., 2019). In this emerging literature, policy mixes are either defined as combination of multiple goals and means (Kern and Howlett, 2009) or as combination of policy mix elements (namely strategies and instrument mixes), policy making processes and policy mix characteristics (Rogge and Reichardt, 2016), with both perspectives emphasizing the dynamic development of policy mixes over time. For the analysis of such transition-oriented policy mixes different analytical lenses have been proposed, of which we focus here on two lenses that appear particularly promising for investigating the role of policy mixes for social innovation.

The first policy mix lens goes back to Rogge and Reichardt (2013, 2016) whose framework differentiates policy outputs into policy strategies and instrument mixes. We argue that this kind of thinking can also be applied when focusing on social innovation as one important aspect of socio-technical transition processes (see Fig. 1). On the one hand, policy strategies can influence social innovation. Such strategies comprise of policy objectives, which are potentially substantiated by long-term targets and further elaborated in principal plans of how to achieve these. On the other hand, instrument mixes may be even more important for influencing social innovation. They capture the combination of instruments with certain goals and of different types (e.g. market-based vs command-and-control) and with different purposes (e.g. technology push vs demand pull). Yet, existing instrument classification schemes have not been developed with social innovation in mind, and thus may require rethinking when applied in the context of social innovation. In addition, attention is being paid to instrument design features, such as stringency or predictability, as they have been shown to matter

² For more details on the definition and different types of innovation, the contribution of Wittmayer et al in this special issue offers more detailed insights.

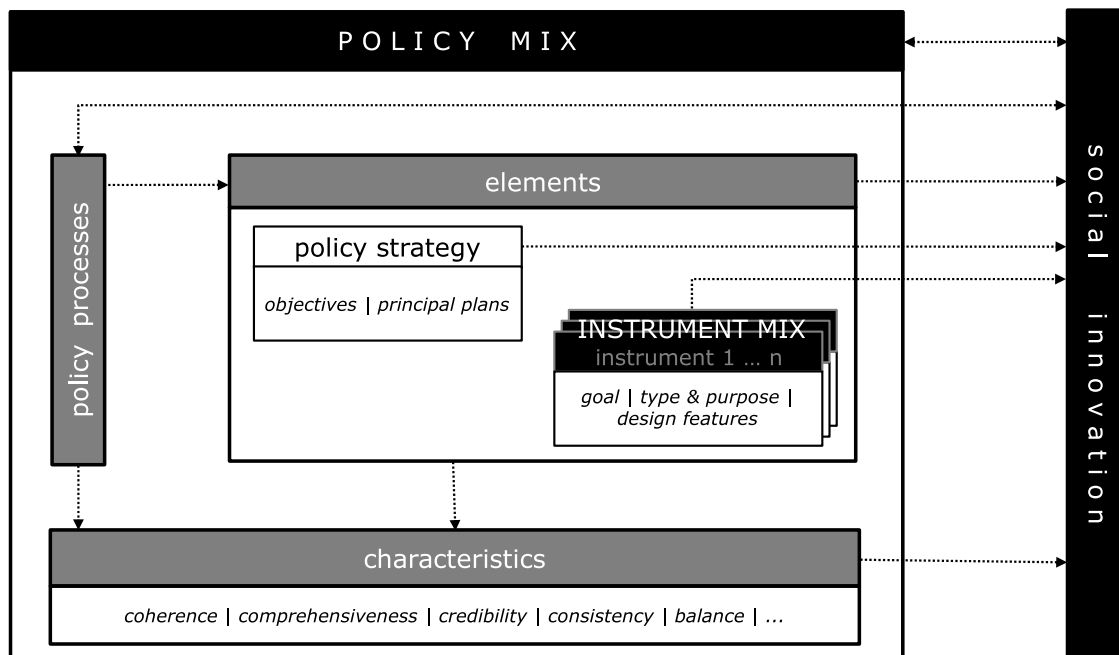


Fig. 1. Policy mix framework by Rogge and Reichardt applied to social innovation.
Source: Adjusted from Rogge and Reichardt (2013, 2016).

more for innovation than the actual instrument type (Kemp and Pontoglio, 2011). But Rogge and Reichardt (2016) emphasize two further building blocks, which are crucial for understanding policy mixes for sustainability transitions, but often still fairly neglected: First, the politics of policy processes can help explain the actual design of real-world policy mixes, providing explanations why policy mixes may be ineffective, change too slowly, or benefit incumbents over new entrants. Including such a focus on policy processes also allows to understand how such processes and the politics involved in them shape socio-technical change, for example through their effect on the credibility or coherence of policy mixes (Rogge and Dütschke, 2018). Second, policy mix characteristics have been argued to influence socio-technical change, for example the consistency and credibility of the German policy mix for renewable energies (Rogge and Schleich, 2018).

The second policy mix lens of particular relevance for sustainability transitions, and thus likely also for social innovation, has been proposed by Kivimaa and Kern (2016) as innovation policy mixes for creative destruction. This framework emphasizes that policies should not only stimulate green niche development (the creation part) but also target the destabilisation of unsustainable regimes (the destruction part), in particular in the acceleration phase of transition processes (Kivimaa and Kern, 2016). Kivimaa and Kern primarily draw on the technological innovation systems (TIS) framework with its seven TIS functions³ (Bergek et al., 2008) and complement these through four additional functions aimed at destabilisation (or destruction). These destabilisation functions include control policies (e.g. carbon pricing), significant changes in regime rules (e.g. electricity market design), reduced support for dominant regime technologies (e.g. phase out of subsidies for fossil fuels), and changes in social networks and replacement of key actors (e.g. more inclusive and transparent access to stakeholder consultations). A fifth function was later added which captures changes in organisational and institutional practises (Kivimaa et al., 2017). We argue that this fundamental distinction between creation and destruction functions is also of value for social innovation.

This emerging policy mix literature has seen increasing numbers of publications applying these and other policy mix frameworks (Kern et al., 2019). While many studies focus on analysing policy mix elements and how they can be made more transformative (e.g. Scordato et al., 2022), researchers are also increasingly drawing on policy process theories to better capture the politics of transition policy mix making (Geels, 2014). A case in point is the explanation of the failure of the UK's zero carbon homes targets through policy mix feedback (Edmondson et al., 2019). Research is also increasingly building on institutional theory (Andrews-Speed, 2016; Lockwood et al., 2017) and institutional work (Fuenfschilling and Truffer, 2016) to better understand policy mix making. For example, Kivimaa and Rogge (2022) show how policy experimentation and subsequent institutional change as well as their interplay and resulting adjustments to the existing policy mix have paved the way for the development of mobility as a service, a disruptive innovation, in Finland. However, to the best of our knowledge no study has been dedicated to applying such broader policy mix

³ These seven creation functions of technological innovation systems utilized by Kivimaa and Kern (2016) include: Knowledge development and diffusion (C1), Market formation (C2), Price-performance improvements (C3), Entrepreneurial experimentation (C4), Resource mobilisation (C5), Legitimation (C6), and Influence on the direction of search (C7).

thinking to the context of social innovation. It is this gap that we tackle in our article. We argue that investigating the phenomenon of social innovation and its role in transition processes through the lens of policy mixes has great potential to clarify how social innovation may be enabled or impeded by policy mixes. In turn, such differentiated insights may help policy makers and SIE-actors alike in deciding which policy changes they should strive for. While in this article, as a first step, we focus on policy mix elements, we acknowledge that policy mix changes promoting transformative social innovation are bound to be faced with resistance from vested interests, and that future research should thus look into power struggles around promoting social innovation (Geus et al., 2023).

Given our focus on policy mix elements, we combine the policy mix frameworks from Kivimaa and Kern (2016), and Rogge and Reichardt (2016) into a 2x2 matrix capturing policy mix functions and elements, as shown in Table 1. That is, policy mix elements are differentiated into policy strategy and instrument mix, and policy mix functions are distinguished into creation and destruction. Table 1 also lists examples of policies addressing social innovation for each of the four quadrants, such as relaxing regulatory conditions for experimenting with social innovations as an instrument supporting the creation of something new. While this simple analytical framework could also be applied to technological innovation, in this paper we use it to sharpen our policy mix thinking when it comes to social innovation. We do so by applying it to the case of participatory incubation and experimentation in Germany.

3. Case selection

Given the diversity of social innovation in energy (Wittmayer et al., 2022) and our interest in investigating the usefulness of applying policy mix thinking to social innovation we have selected one innovation type that has been heralded by researchers and policy makers as key for system transformation towards sustainability, including and beyond the energy sector: participatory incubation and experimentation (PIE).

Participatory incubation and experimentation refers to multi-actor collaborative formats that aim to experiment with and/or test novel solutions for specific energy pathways (e.g. collective energy prosuming). These solutions can be driven by technological (e.g. smart grid installations) and social developments (e.g. novel business models for prosuming energy), but are all of a socio-technical nature (Rohde and Hielscher, 2021; Karami and Madlener, 2022). A key component of these formats is that they provide a collective, physical space for experimentation and that they are time-bound. Some of the multi-actor collaborative formats have been referred to as energy clusters, living laboratories or real-life laboratories. They can involve different actors from across society, with research actors usually playing a key role.

In our analysis of this type of social innovation we focus on the role of policies by defining the impact domain as the social innovation field. Following Hielscher et al. (2020; 2021), such a field is "an arena/ space that includes a specific social innovation in energy as well as field-actors working on it and other field-actors enabling and/ or impeding it. In this space these actors take one another and their actions into account and have a shared (but not necessarily consensual) understanding of a SIE and of their relationship to other actors" (Hielscher and Wittmayer, 2021, p. 9).

Participatory incubation and experimentation (PIE) is characterized by direct, top-down influence of policies on the field, particularly due to a typically high relevance of R&D policies. While PIE has a longer history, it particularly gained importance since the 2000s and 2010s and can be seen as a relatively young SIE-field that developed along more integrated policy mixes for energy transitions. Generally speaking, this field is linked to policies that are aiming to support sustainability transitions in its early phases but remains relevant for experimenting around system transformation in later phases, too. We have chosen to investigate PIE in Germany given the ambitious Energiewende and increasing attention to PIE.

4. Methodological approach

A precondition for investigating policy mixes and evaluating their impacts is to delineate the focal policy mix. We argue that for this the top-down and bottom-up approaches for policy mix delineation outlined by Ossenbrink et al. (2019) can also be applied for studying social innovation (see Fig. 2). The former approach is ideal to capture policy mixes intentionally designed to achieve a certain intent, such as promoting social innovation (in energy). In contrast, the latter helps to assess real-world, messy, not necessarily intentionally designed policy mixes of actual relevance for a certain phenomenon, such as a certain type of social innovation in energy. In this sense, these approaches could alternatively be referred to as "design approach" vs "real-world approach" to policy mix mapping, and their choice should be driven by the research question at hand, which may sometimes also imply that both approaches should be combined.

Figure illustrates that the relationship between policy mixes (tree, with the treetop = strategy, and roots = instruments) and impact domains (=soil) is not one-to-one, that means (1) as illustrated on the left, a given policy mix (e.g. the black one) may, intendedly or unintendedly, affect multiple impact domains (e.g. I and II), and (2) as illustrated on the right, a given impact domain (here: SIE-field) can be affected by the elements of multiple policy mixes (e.g. the grey, black and blue one) – here exemplary representing different governance levels (e.g. EU, national and regional level).

4.1. Top-down approach: capturing intentional policy mix design

The basic notion of the top-down approach, depicted on the left in Fig. 2, is that a policy mix pursues an overarching strategic intent which is implemented through a combination of different policy instruments (Ossenbrink et al., 2019). Therefore, the starting point is to specify this overarching strategic intent of the focal policy mix, such as the promotion of social innovation – in our case limited to a particular impact domain, namely energy. The top-down approach could thus also be referred to as "design approach". In addition,

Table 1
Analytical framework for policy mixes promoting social innovation – with policy examples.

| | | Policy Mix Elements (with policy examples) | |
|-------------------------------|-------------|---|--|
| | | Policy Strategy | Instrument Mix |
| (Primary) Policy Mix Function | Creation | Policy strategy primarily aiming at the creation of sustainable solutions. <i>For example:</i> <ul style="list-style-type: none"> • Inclusion of social innovation as objective in existing or formulation of new policy strategy • Foresight exercises including change in social relations/practises | Policy instruments primarily aiming at the creation of sustainable solutions. <i>For example:</i> <ul style="list-style-type: none"> • Support for social innovation infrastructure such as urban experimentation labs • Feed-in tariffs easily accessible for new entrants • Relaxed regulatory conditions for experimenting with social innovations |
| | Destruction | Policy strategy primarily aiming at destruction of unsustainable practises <i>For example:</i> <ul style="list-style-type: none"> • Introduction of climate law with ambitions for transformative system change • Decarbonisation or sustainability strategy indicating technological change alone will not be sufficient for target achievement | Policy instruments primarily aiming at the destruction of unsustainable practises <i>For example:</i> <ul style="list-style-type: none"> • Carbon pricing (with revenue recycling earmarked to the promotion of social innovation) • Phasing out of environmentally harmful practises • Market reform supporting new entrants, incl. citizens and other actors • Reorienting R&D funding to include social innovation • Including greater diversity of actors in advisory groups |

**Top down approach:
Policy mix for social innovation**

**Bottom up approach:
Policy mix relevant for social innovation**

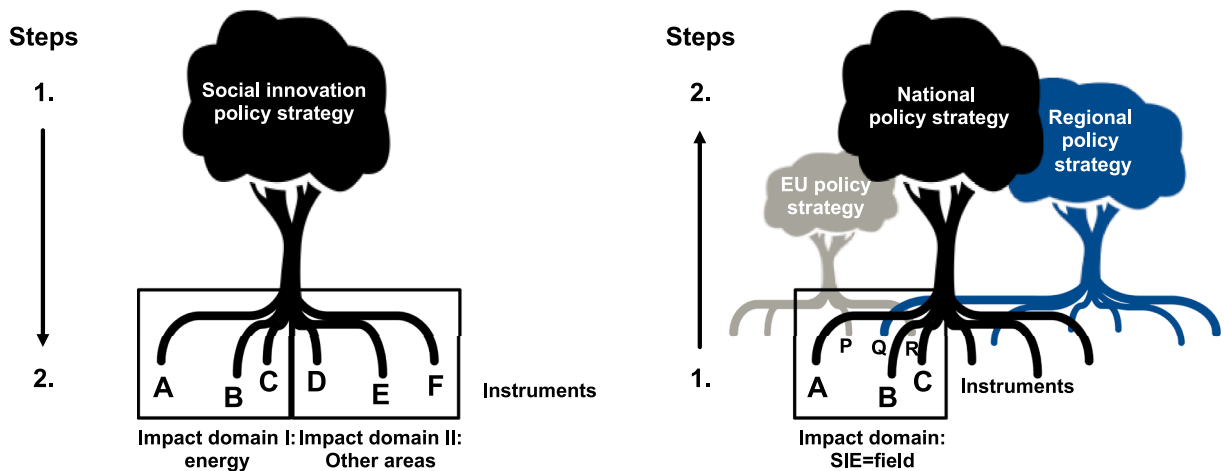


Fig. 2. Illustration of two approaches for policy mix delineation for social innovation. Source: Adopted from Ossenbrink et al., 2019.

defining the analytical scope also calls for determining the vertical and horizontal dimensions of the focal policy mix in order to then identify the relevant governing entities. Here, we focus on the national governance level in Germany and the policy domains of innovation, energy and climate policy.

These analytical boundaries, together with the chosen time frame for the analysis (in our case 2000-2020), determine the collection of policy data. In a *first step* we identify the policy strategy, i.e. in our example the strategy towards social innovation in the energy sector – or if this does not exist, the social innovation policy strategy in general. Based on this, in a *second step* we identify all relevant policy instruments implemented to achieve the identified policy strategy, particularly for the impact domain of interest, i.e., we identify instruments of relevance for the energy sector (in Fig. 2 depicted as A, B and C).

As a consequence, the policy mix identified through the top-down approach excludes strategies or instruments adopted at other governance levels, as well as those adopted in other policy domains. Therefore, the definition of the analytical scope matters quite a lot for the composition of the resulting policy mix - in our case the German policy mix for social innovation in energy.

For the top-down approach we collected data from policy documents and other policy-relevant publications. We visualize key policy mix elements in a timeline of the evolving policy mix for SIE in Germany between 2000 and 2020.

4.2. Bottom-up approach: capturing influential policies making up the relevant policy mix

The basic notion of the bottom-up approach, depicted on the right in Fig. 2, is that a given impact domain is affected by a combination of policy instruments which pursue a common or different policy strategies (Ossenbrink et al., 2019). That is, we start with defining the impact domain with its relevant actors, practises, business models and/ or technologies. We argue that the specification of participatory incubation and experimentation as a SIE-field serves this purpose well (for an introduction to the concept of social innovation field, see Section 3), but in other contexts one could instead focus on a specific niche or innovation system, for example. The impact domain then needs to be further determined in terms of its geographical scope – in our case Germany. It is for this impact domain that we attempt to capture all policies (instruments and strategies) that influence activities in the domain. As this implies that any element of influence is captured, and not only those intentionally designed to promote the field, one can also refer to this bottom-up approach as “real-world approach”.

After setting the analytical boundaries, in a first step we draw on the knowledge of field actors to help in identifying the policy instruments that - whether intentionally or not - exert an impact on the SIE-field. For this, in our interviews with SIE-field actors, one block of questions specifically asked about the most important policies that enabled or impeded the field development. In a second step, we trace back these identified instruments to the respective policy strategies. The thereby identified instruments and strategies of relevance for the development of the SIE-field PIE can originate from a variety of governing entities at various governance levels and policy fields. In our case, the delineation results in the focal policy mix relevant for participatory incubation and experimentation in Germany, which includes policies influencing the development of the SIE-field (enabling or impeding), regardless from which governance level or policy domain they originate from.

For our bottom-up policy mix analysis we rely on a qualitative case study that aimed at tracing the emergence and development of the SIE-field PIE in Germany during the years 2000 - 2020.⁴ Although the SIE-field dates back even further, this time frame was chosen because relevant policy developments that influenced the SIE-field started to emerge in the early 2000s. Data came from multiple sources, with the two main data sources being desktop analysis and expert interviews. The desktop analysis covered the academic literature, websites and policy documents. Eight expert interviews were conducted with representatives of SIE-initiatives (2) and actors with rich knowledge and/ or relevance for shaping the SIE-field (6), including policy makers (2) and researchers (4). These took place from October until December 2020 and lasted on average 65 min (see Appendix for a list of interviewees).⁵

As part of the qualitative case study, two SIE-initiatives were examined in more detail to complement the broader data on the development of the field with concrete examples of selected initiatives (see also Stadler and Rogge, 2021)⁶. The first, ‘Quartier Zukunft’, is a participatory format on the neighbourhood level started in 2011 by members of the Karlsruher Institute of Technology (KIT). The aim of this format is to transform the neighbourhood into a sustainable district. The second, ‘Reallabor Energieavantgard Anhalt’ in the region Anhalt-Bitterfeld, was established in 2012 as a collaborative network including citizens, municipalities, districts, businesses and research institutes. The network aims to push a transition towards regionally produced and consumed sustainable energy.

While policies are just one of several factors influencing the fields’ emergence and development, it is this factor that we focus on in this paper. In particular, we identify the policy mix elements, i.e., strategies and instruments, that were identified as relevant for enabling or impeding the SIE-field PIE in Germany. The resulting focal policy mix (see Fig. 4) is not limited to national-level policies but also includes relevant supranational policies as well as policies on the regional level. Furthermore, not only energy policies were indicated as relevant but also policies from other policy fields, such as climate policies and innovation policies.

Regarding this focal policy mix relevant for PIE we explore its nature by analysing it through the lens of our proposed analytical framework (see Section 2.2). For this, we created a list of policies that were identified as particularly influential for the field. Following Rogge and Reichardt (2016), we then classified the main policy mix elements - distinguishing policy strategies and instruments. In addition, based on Kivimaa and Kern (2016) we also assessed if the identified policy mix elements were supporting ‘creation’ of niches or regime ‘destruction’.

5. Policy mixes for social innovation in energy in Germany

In this section, we present the result of our top-down delineation of the German policy mix for social innovation in the energy sector (see Fig. 3). Our findings set the context for our subsequent analysis of the policy mix of relevance for participatory incubation and experimentation as one specific type of SIE (see Section 6).

⁴ This case study was conducted within the SONNET project (see <https://sonnet-energy.eu/research/case-studies/>).

⁵ In addition, three observations of webinars and discussion groups were used to further complement the analysis with background information and reflections about the development of the SIE-field (for an overview, see Appendix).

⁶ The case study report can be downloaded here: <https://zenodo.org/record/7441414#.Y5r733bMJaq>.

First, focusing on *policy strategies*, our analysis reveals that there is no, as of yet, policy that would qualify as a dedicated policy strategy for social innovation in Germany, neither in general nor for energy in particular. Yet, the topic has received increasing strategic interest in the past few years.

The first prominent mention of social innovation occurred in the new High-Tech Strategy in 2014. This overarching, cross-departmental innovation strategy came with an expanded understanding of innovation as both social and technical, with social innovation thought of as an instrument to face societal challenges (BMBF, 2014). Note though that social innovation is only mentioned very briefly: after a short definition of innovation in general, social innovation is mentioned in some parts as an example.

With the High-Tech Strategy 2025, the German innovation strategy was renewed and the definition of innovation as containing both social and technical solutions was maintained: “Our goal is to achieve technological and non-technological innovations, including social innovation, which focus on benefiting the people” (BMBF, 2018, p. 4). The attention to social innovation was “intensified” (BMBF, 2018, p. 11), with the promotion of social innovation as a strategic intent as part of an open knowledge and venture culture (BMBF, 2018, p. 16).

Most recently, a resort concept for social innovation was published by nine ministries⁷ under the lead of the Federal Ministry of Education and Research (BMBF) in 2021. This resort concept follows the definition of social innovation from the High-Tech Strategy 2025 describing it as “[...] new social practices and organizational models that aim to find viable and sustainable solutions to the challenges facing our society” (BMBF, 2021, p. 2, own translation).

However, overall social innovation appears to be underrepresented in the German policy discourse so far. Also, apart from the above-mentioned overarching strategic considerations there is no dedicated policy strategy regarding social innovation in energy; rather, energy is considered as one of many potential impact domains. It remains to be seen how the new coalition government is going to include social innovation in their policy strategies, such as regarding its mission to achieve climate neutrality by 2045 (Coalition Agreement, 2021).

Second, the *instrument mix* for social innovation appears fairly limited when it comes to the impact domain of energy⁸ - perhaps as a logical consequence of a missing dedicated policy strategy regarding SIE. These few instruments relevant for SIE are research and development funding or funding competitions. Most instruments directly address the energy sector and are open for social innovation next to other innovations (‘Energy Transition and Society’, ‘Regulatory Sandboxes of Energy the Energy Transition’ and ‘Non nuclear research funding’, see: BMWi, 2018a). Only the Idea Society (BMBF, 2020) targets social innovation, and does so with no thematical limitation and therefore is also open for the energy sector.

6. Focal policy mix relevant for ‘participatory incubation and experimentation’ in energy in Germany

In this section, we present the findings of our bottom up approach to delineating the focal policy mix relevant for the SIE-field participatory innovation and experimentation (PIE) in the energy sector in Germany. The section starts with an overview of the SIE-field’s innovation history in which we foreground the development of the focal policy mix over time (Section 6.1). We then move on to presenting (Section 6.2) and analysing (Section 6.3) the focal policy mix.

6.1. Innovation history

The innovation history of the SIE-field participatory incubation and experimentation (PIE) in Germany is influenced by three intertwined strands of development: first, the development of socio-ecological and transdisciplinary research approaches that strengthened the role of citizens in low carbon transitions, second, changes in the research and innovation paradigm that, third, also influenced changes in German energy policies.

Regarding the first strand, in Germany, the development of the SIE-field PIE is based on a longer history of participatory engagement in energy transitions that already evolved around the anti-nuclear movements starting in the 1970s. Bottom-up protests strengthened the role of citizen participation in developing answers to environmental problems and, in the 1990s, brought about socio-ecological and transdisciplinary research approaches (Di Giulio and Defila, 2019). The establishment of the German Advisory Council on Global Change (WBGU) in 1992 might be interpreted as a ‘paradigmatic’ milestone (Di Giulio and Defila, 2019), which acknowledges that environmental and social matters are to be addressed in a joint approach. It was the WBGU report ‘A Social Contract for Sustainability’ in 2011 (WBGU, 2011) which further emphasised the important interplay between politics, society, science and economy. In the beginning of the 2000s, socio-ecological and transdisciplinary approaches started to inspire national research programmes for sustainable development (e.g. as part of the FONA program⁹).

Parallel to this a second strand could be observed: with the beginning of the 2000s, research and innovation paradigms slowly started to change, encouraging innovation policies for ‘transformative change’ (Schot and Steinmueller, 2018, p. 1562). A starting

⁷ These nine ministries are: Federal Ministry of the Interior, for Construction and Home Affairs; Federal Ministry for Economic Affairs and Energy; Federal Ministry of Labor and Social Affairs; Federal Ministry of Food and Agriculture; Federal Ministry for Family Affairs, Senior Citizens, Women and Youth; Federal Ministry of Health; Federal Ministry of Transport and Digital Infrastructure; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; and the Federal Ministry of Education and Research.

⁸ Note though that for social innovation in general, several instruments exist, which we do not list here, though, as they either have no clear relation to the energy sector, or are very specific in their thematic focus (such as for health).

⁹ FONA: Forschung für nachhaltige Entwicklung (Research for Sustainability), see: <https://www.fona.de/en/>

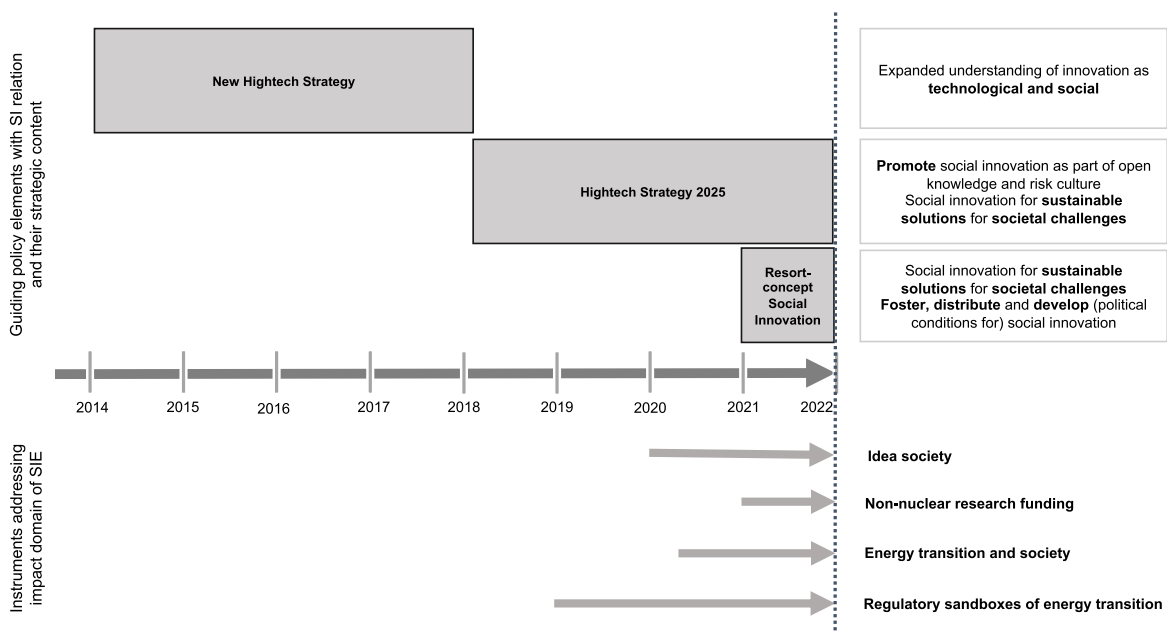


Fig. 3. Development of the German policy mix for social innovation (in energy) – outcome of top-down approach.

point for this change in the innovation paradigm was the emergence of living labs as a research format. As [Ballon and Schuurman \(2015\)](#) note, the format of living labs gained international recognition after being mentioned in a scientific publication in 2005 ([Eriksson et al., 2005](#)). These formats in an early stage mostly focused on the cooperative design of ICT technologies ([Ballon and Schuurman, 2015](#)) such as the Fraunhofer InHaus in Duisburg (established already in 1998). These research formats, however, contributed to opening up innovation processes to different actors with ‘citizens [...] starting to act [as] innovators themselves’ ([Erdmann et al., 2018](#), p. 10, own translation).

Against this backdrop of a longer history of the SIE-field, the third strand captures the increasing development of multi-actor collaborative formats in the energy sector as a more recent development. Overall, the SIE-field co-evolved with energy policies that took up a more integrated and systematic approach. Starting point for this was the energy concept of the German government in 2010 that led to an increase of funding for energy related research in the following years. As part of a growing awareness for the importance of integrating different perspectives in the development of new solutions, especially the term ‘Reallabore’ (in English referred to as either real-world laboratories (by academia) or as regulatory sandboxes (by German policy makers)¹⁰ has emerged in Germany since 2015. This term might be understood as a pendant to the German expression ‘Realpolitik’ stressing a close relation to real world contexts and at the same time being a highly political term. The first funding line for ‘Reallabore’ was, however, implemented outside of energy policy but rather with a broader sustainability remit within the policy domain of innovation policy on the regional governance level in Baden-Wuerttemberg. Similarly, the Federal Ministry of Education and Research (BMBF) introduced more experimental funding lines in their Research for Sustainability (FONA). Only later this real-life laboratory format was also adopted in energy policy at the national level by the Federal Ministry for Economic Affairs and Energy (BMWi). Therefore, next to (energy) innovation policies on the national level, also regional policies were essential for the development of PIE in Germany, and were also further supported by local policies supporting experimentation.

6.2. Resulting focal policy mix

In this section we present the focal policy mix of relevance for participatory incubation and experimentation (PIE) in Germany which we identified by applying the bottom-up approach. The overview in [Fig. 4](#) shows that this policy mix consists of a wide range of policy mix elements from different policy domains and governance levels.

First, regarding the *policy domain* we find that *energy policy* is of key relevance for PIE in energy in Germany, implying that the focal policy mix is extending beyond innovation policy, and is further complemented by climate policy. In particular, key policies in the domain of energy policy include the German regulatory sandbox strategy ([BMW 2018b](#)) and the associated instruments, such as the

¹⁰ The German phrase “Reallabore” normally used in policy discourse in Germany is being translated into English in different ways. Here we follow the translation used by the Federal Ministry for Economic Affairs and Energy (BMWi) as “regulatory sandboxes” as we want to stay true to the wording used by practitioners. However, note that in other instances official documents also refer to the English term “living lab”. In contrast, in academic research the term “real-world laboratory” is used more frequently (see e.g. [Heiskanen et al. 2018](#); [Renn 2018](#)).

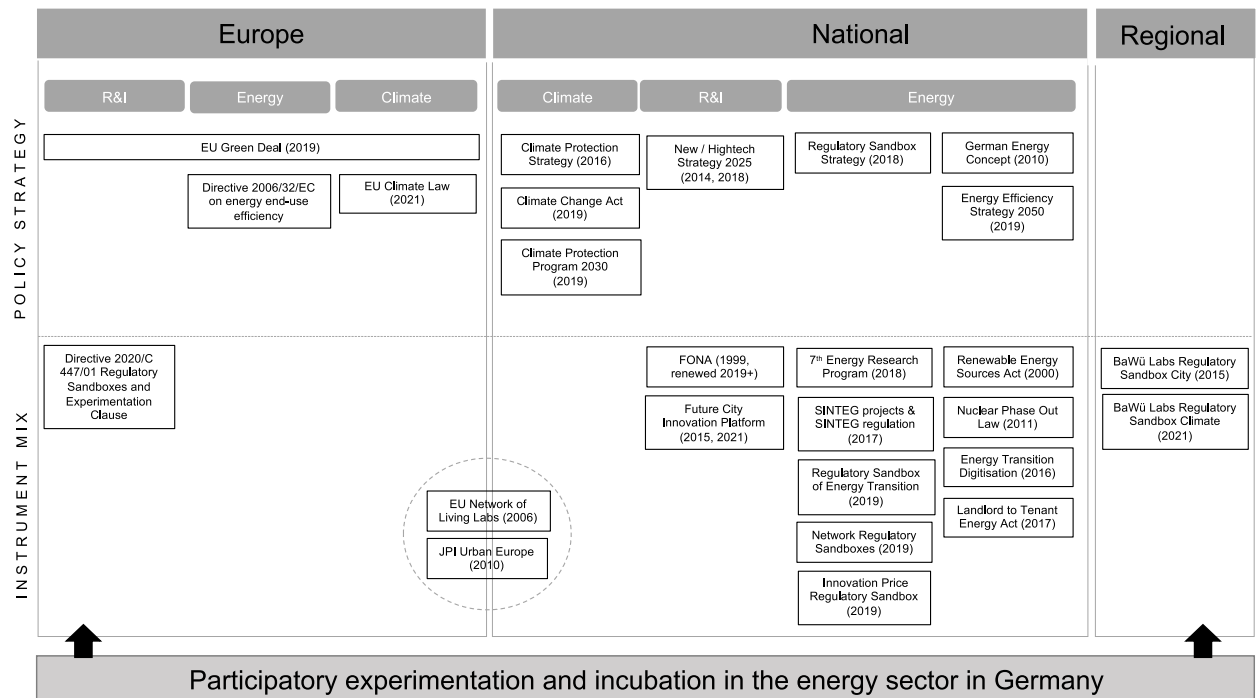


Fig. 4. Policy mix relevant for participatory incubation and experimentation in energy in Germany – outcome of bottom-up approach.

regulatory sandboxes of the energy transition or the experimentation clause which emerged from the 7th energy research program (BMW, 2018a). In addition, the SINTEG¹¹ projects and the belonging SINTEG regulation (BGBl, 2017 I 38 S. 1653-1656) – an experimentation clause especially put in place for these projects – influenced the SIE-field PIE in Germany insofar as these large scale projects contributed to establishing participatory experimentation formats in Germany more broadly and linked the approach to the introduction of novel regulatory policies. As SINTEG is not just related to the policy domain of energy but is also associated with the German digitalization agenda, it showcases the cross-departmental nature of the policy mix. Also, selected energy policy instruments were of crucial importance for the development of PIE in Germany, such as the Renewable Energy Sources Act (EEG) by providing predictable and sufficient funding for experiments and their further diffusion. Regarding *climate policy*, Germany's climate protection program 2030 foresees funding programs supporting regulatory sandboxes (BMU 2016). Germany thereby aims for the realization of the 2050 climate reduction goals of the federal Climate Change Act (BGBl, 2019 I 48 S. 2513-2521). Regarding *innovation policy*, the FONA program has encouraged multi-actor collaborative settings in sustainability-oriented research and contributed to changing the role of civil society in innovation processes (Bührer et al., 2020). Finally, it should be noted that *social policy* seems to have been of limited relevance so far, suggesting this as a future collaboration area for jointly discussing the promotion of social innovation in energy through experimentation.

Second, regarding the governance level we identified not only national level policies of relevance for SIE-field development, but also relevant policies from the European and regional governance level. Regarding the EU level, policy instruments like the EU Network of Living Labs¹² or JPI Urban Europe¹³ have provided funding for experimental projects in Germany, thereby helping to establish the field with real-life examples. But not just EU level instruments matter for PIE in Germany, but also policy strategies like the European Green Deal (European Commission, 2019) or the EU Directive on Energy End-Use Efficiency and Energy Services (EU DIR 2006/32/EC 2006) were mentioned. While the former provides guidance that influences smaller initiatives, the latter was especially influential due to the difficulties and resistance in implementing smart meter technologies, and encouraged earlier participation of citizens. Regarding the regional governance level, the BaWü labs¹⁴ appeared as key catalyst not just for experimentation on the regional level of the federal state of Baden Wuerttemberg but for the national level as well, as their evaluation provided valuable lessons-learned for future policy considerations (Defila and Di Giulio, 2019) (see Section 6.1).

¹¹ SINTEG: Smart Energy Showcases – Digital Agenda for the Energy Transition (2016-2020): the funding program comprised five large model regions known as showcases, in which model solutions for the energy supply of the future were developed and demonstrated. The SINTEG results were evaluated in five focus topics, one of them regulatory sandboxes and another participation. See: <https://www.sinteg.de/en/>.

¹² European Network of Living Labs (enoll), <https://enoll.org>

¹³ Joint Programming Initiative (JPI) Urban Europe: <https://jpi-urbaneurope.eu>

¹⁴ More information online available: <https://mwk.baden-wuerttemberg.de/de/forschung/forschungspolitik/wissenschaft-fuer-nachhaltigkeit/reallabore/>.

6.3. Analysis of the focal policy mix

Having identified the focal policy mix of relevance for the SIE-field participatory incubation and experimentation (PIE) in Germany, in this section we apply our analytical framework combining policy mix elements and creative destruction functions to further investigate its nature. Table 2 shows the results of our analysis, which we present in the following by first unpacking policy mix elements, and then by shedding light on creative destruction.

We start by shedding light on the composition of the policy mix in terms of instruments and associated policy strategies – following the terminology and definitions introduced by Rogge and Reichardt (2016). We find that the policy mix relevant for PIE is composed of a significant number of policy instruments, thereby suggesting that experimentation is not just included in policy strategies but it is also implemented through concrete policy support. Most policies originate from the national level, but we also identified a pioneering regional innovation policy instrument shaping the development of the field (see Sections 6.1 and 6.2 on BaWü labs). When taking a closer look at the instrument mix, we find the German policy mix to be dominated by economic instruments (typically funding schemes), followed by information-based instruments and some use of regulation. Most of the identified instruments are of a socio-technical, systemic nature. However, there is a striking absence of demand pull instruments (such as dedicated subsidies or public procurement favouring socially innovative solutions), which suggests these activities are not yet considered for wider diffusion in an acceleration phase. In a context where Germany's sustainable energy transition needs to be urgently accelerated such a lack of demand-pull instruments implies that the full potential of SIE is not yet harnessed. Overall, however, it should be noted that the policy mix elements identified through the bottom-up approach tend to play an enabling role for the emergence of the field – but its further development largely depends on future policy mix changes.

The second analytical lens we use is that of innovation policy mixes for creative destruction, as proposed by Kivimaa and Kern (2016). That is, we assess the extent to which policy strategies and instruments target only the creation of niches or also include the destabilisation of unsustainable regimes. For this, we assessed which of the various creation and destruction function a policy contributes to, and then categorized the instrument into the quadrant which it primarily serves – creation or destruction. That is, a black-and-white differentiation of policies in either creation or destruction ones is not always straightforward nor meaningful, and as such the entries in our matrix should be interpreted with caution.¹⁵ Notwithstanding this, we find that the large majority of policy mix elements targets the creation of novelty, while there is a relative neglect of destabilization policies, which is well aligned with this type of social innovation focusing on the new. Yet, our finding holds that the overall focal policy mix is largely focusing on creation, which suggests that niche experiments are indeed enabled. However, the increasing 'projectification' of these formats with short time frames impede long term learning and the integration of different types of knowledge in an overall strategy. In addition, successful experiments will have a hard time to scale up and diffuse further, unless the policy mix will be adjusted subsequently to enable the further development of promising initiatives. Since Germany's energy transition is already in the acceleration phase, one would thus expect quick adjustments in the future policy mix to address this shortcoming, but for this will need strong political will and power to overcome regime resistance against policy changes enabling the rolling out of such experimental but potentially disruptive solutions more widely.

7. Discussion

Our spotlight on the role of policy mixes for participatory incubation and experimentation (PIE) in Germany enables a fresh look at social innovation, its role in energy transitions and in particular its interplay with policy. In the following, we reflect upon the usefulness of applying policy mix thinking to social innovation (Section 7.1), suggest ideas for addressing conceptual shortcomings in future research (Section 7.2) and offer policy implications for expanding policy mix thinking to socio-technical change (Section 7.3).

7.1. Usefulness of applying policy mix thinking to social innovation

Applying comprehensive policy mix thinking to social innovation in our 2x2 matrix (Rogge and Reichardt, 2016; Kivimaa and Kern, 2016) helped to better understand real world policy mixes for SIE through the lens of different conceptual categories.

First, applying the *top-down and bottom-up approach* developed by Ossenbrink et al. (2019) to delineate the focal policy mix proved feasible and generated useful insights. The top-down mapping (referred by us also as "design approach") provided an overarching context for our subsequent investigation, making us aware of the fairly short history of social innovation in German policy making and comparatively low importance assigned to social innovation when compared to technological innovation. In contrast, our bottom-up mapping (also referred to here as "real-world approach") highlighted that knowledge about the design features of policy instruments was crucial to assess the enabling or impeding influence of a policy on SIE-field development. This implies that similarly to technological innovation what matters more for social innovation in terms of instrument choices is the concrete design of policy instruments and less so their type. Yet, as for the instrument type we saw an increasing understanding that financial support without changes in regulations are insufficient for transformative experimentation.

¹⁵ For example, in our case, particularly policy strategies encompass both creation and destruction, such as the climate protection strategy that primarily aims at controlling greenhouse gas emissions (thereby contributing to the first destruction function), but can also serve creation functions (directly and indirectly). Another example is the European Green Deal, which equally targets creation and destruction functions, and thus has been listed under both.

Table 2
Composition of perceived focal policy mix relevant for PIE in Germany.

| | | Policy Mix Elements | |
|--------------------------------|-------------|--|---|
| | | Policy Strategy | Instrument Mix |
| (Primary) Policy Mix Functions | Creation | <ul style="list-style-type: none"> • Regulatory Sandbox Strategy (DE) • Energy Concept (DE) • Efficiency Strategy 2050 (DE) • (New) High-Tech Strategy 2025 (DE) • EU Green Deal (EU) • Energy end-use efficiency Directive (EU) | <ul style="list-style-type: none"> • FONA (DE) • 7th Energy Research Program (DE) • SINTEG (DE) • Regulatory Sandboxes Energy Transition (DE) • Innovation Price Regulatory Sandbox (DE) • Future City Innovation Platform (DE) • Landlord to Tenant Energy Act (DE) • Regulatory Sandboxes Directive (EU) • Network Living Labs (EU) • JPI Urban Europe (EU) • Regulatory Sandboxes City & Climate (Bawü) |
| | Destruction | <ul style="list-style-type: none"> • Climate Protection Strategy (DE) • Climate Change Act (DE) • Climate Protection Program 2030 (DE) • EU Green Deal (EU) • EU Climate Law (EU) | <ul style="list-style-type: none"> • Nuclear Phase Out Law (DE) • Energy Transition Digitisation (DE) |

Second, analysing policy mixes in terms of them targeting *creative destruction* (Kivimaa and Kern, 2016) showed a lack of policies targeting destruction. That is, the identified policy mix favours niche creation policies alongside the continuation of supporting existing unsustainable regimes. At first glance this fits the type of social innovation we studied here, but applying the analytical lens of creative destruction allows us to identify the need for future adjustments to the overarching policy mix if policy makers are interested in further upscaling and diffusion of successful experiments. Yet, at the moment it is unclear if and how learning from such experiments will lead to changes in the broader policy mix, as has happened for example for the policy experimentation conducted in the context of Mobility-as-a-Service (MaaS) in Finland, where administrative restructuring has ultimately enabled major regulatory change allowing market creation for MaaS, and where cognitive and normative learning over time informed further institutional change beneficial for the further diffusion of this disruptive innovation (Kivimaa and Rogge, 2021).

Third, our innovation history analysis suggests that applying broader policy mix thinking can enable further useful insights that go beyond the mere composition of the policy mix. On the one hand, it helped to gain better insights into the predominant policy style, with Germany having largely focused on technological solutions but more recently embracing socio-technical experimentation as one innovative element of its policy mix. Yet, Germany's still rather hierarchical policy style somewhat constrained the participatory nature of such incubation and experimentation. On the other hand, an initial assessment of policy mix characteristics supported the assessment of strengths and shortcomings of the focal policy mix. For example, the focus on the creation function and on funding as preferred instrument type reveals a limited comprehensiveness of the instrument mix. Another example is the lack of a clear strategy on social innovation which is casting doubts on Germany pursuing a socio-technical transformation pathway. Rather, this is signalling that the country seems to continue to hold on to the hope that a technological substitution pathway could deliver its decarbonisation target. However, as acknowledged by the latest IPCC assessment report, achieving the Paris Agreement requires technological and social changes (IPCC AR6 WG III, 2022) and policy mixes therefore need to tackle both technological and social innovation.

7.2. Conceptual shortcomings and avenues for future research on policy mixes for social innovation

Applying policy mix thinking to social innovation showcased that some adjustments in our current instrument typologies and policy mix frameworks developed primarily with technological innovation in mind may be needed.

First, the well-known *classification of innovation policy instruments* into technology push, demand-pull and systemic instruments (Smits and Kuhlmann, 2004; Rogge and Reichardt, 2016) did not fit well for social innovation, which is why we did not use it in our analysis. However, in our initial attempts to classify identified instruments we more often than not would categorize policy instruments relevant for social innovation as systemic instruments, as the typical dichotomy of technology push and demand pull did not seem to capture the instruments' purpose well enough. In our view, social innovation may deserve its own purpose, for example by introducing a fourth category of "social change". Obviously, one could also consider to capture both a push and pull dimension for social innovation, and thus rather distinguish technology vs social push on the one hand and demand pull for technological innovation vs social innovation on the other hand. Yet, ultimately, we argue we should move on to a more holistic and transformative understanding of system innovation as being socio-technical in nature. As such, we propose that future research should differentiate between socio-technical push vs socio-technical pull.

Second, while our analysis here was largely limited to policy mix elements, future research should combine this with the *politics of policy mix change*. With social innovation being heralded as key for transformative change, it is likely to be faced with significant regime resistance. Such resistance may manifest not only in a lack of majorities to adopt destruction policies but also in a continuation or even strengthening of regime stabilising policies, such as novel support for fracking and increased subsidies or continued tax benefits

for fossil fuels. Such inconsistencies in policy mixes question the credibility of decarbonisation policy mixes, thereby hampering sustainability transitions but also calling to action campaigns for more ambitious climate policy – a form of social innovation in energy (Hielscher et al., 2022; Rogge et al., 2022). We argue that regime stabilising policies should receive more scrutiny in general, but in particular when focusing on social innovation. For this, research can draw on the literature on the politics of transitions (Geels, 2014), on institutional work (Fuenfschilling and Truffer, 2016), on policy mix feedbacks (Edmondson et al., 2019) and on the role of incumbents (Ampe et al., 2021). That is, future policy mix research should aim to overcome this blind spot in current analytical frameworks focusing on creation and destruction, and no longer neglect regime stabilisation efforts. More attention to social innovation seems a natural entry point to such an endeavour.

7.3. Towards policy mixes for socio-technical change

Our exploration of the role of policy mixes (relevant) for social innovation in the energy sector enabled new insights which directly speak to the emerging debate about the need for comprehensive innovation policy targeting technological and social innovation (Howaldt et al., 2015). We aim to contribute to this debate by calling for a move towards policy mixes for socio-technical change.

First, while in this article we have focused on policy mixes for social innovation, what we ultimately need is policy mixes that bridge technological and social innovation to enable transformative socio-technical system change geared towards sustainability objectives. Policy makers and researchers alike are thus called to design comprehensive *policy mixes for socio-technical change* that support technological and social innovation as two sides of the same coin. These should pave the way for transformative change that not only breaks with unsustainable technologies and practises, but also with existing unbalanced power relations.

Second, preceding such comprehensive socio-technical policy mix design would be the enhancement of policy makers' and researchers understanding of social innovation as a phenomena – especially understanding the role policies play and the relation between social and technological innovation. For now, social innovation in energy seems a well-intended but not fully grasped concept that has made it into some policy circles and research niches but still requires more widespread engagement, as the example of the Fit for 55 package illustrates (Rogge et al., 2023). The policy mix thinking applied in this article may be a useful stepping stone towards this requirement. Importantly, awareness needs to go beyond policy makers and researchers in the innovation policy domain, but must include first and foremost sector experts – in our case energy and climate policy makers and researchers. Another aspect should be the recognition that social innovation, similarly to technological innovation, may require policies specifically tailored to different types of social innovation. Policy-makers and analysts would be well advised to design field-specific social innovation policies, and could focus on those types of social innovation that have proven particularly promising (Guetlein and Schleich, 2022).

Third, when designing policy mixes for socio-technical change we suggest to tailor their composition to *transition phases* (see Table 3). Similarly to Markard et al. (2020), here we focus on differentiating between the emergence and acceleration phase. While still in the emergence phase, Table 3 acknowledges that policy mixes would primarily promote technological, social and socio-technical innovations in niches, thereby experimenting with and learning from novel sustainable solutions. Yet, when transitions are entering the acceleration phase – as is the case for the Energiewende in Germany – effective policy mixes for accelerating socio-technical change should also include the phase-out of previously existing policy support for unsustainable regime technologies and social practises. In the face of the urgency of addressing our sustainability challenges such a focus on destruction is crucial for acceleration, and should be accompanied by the promotion of the societally desirable socio-technical system changes, including provisions for just transitions of socially vulnerable groups.

8. Conclusion

In this article, we have applied policy mix thinking to social innovation in the energy sector, taking the example of participatory incubation and experimentation in the energy sector in Germany. We thereby contribute to the literature in three ways.

Conceptually, we combine the Kivimaa and Kern (2016) approach on innovation policy mixes for creative destruction with the differentiation of policy mix elements into policy strategies and instrument mixes proposed by Rogge and Reichardt (2016). We conclude that policy mix and instrument typologies should be adjusted to comprehensively cover both technological and social innovation, and have suggested some initial ideas towards this goal. More importantly, however, we argue that what is needed for sustainability transitions is research and policy making working towards policy mixes for socio-technical change that balance and bridge technological and social innovation, particularly but not only in the acceleration phase of transitions (see Table 3).

Table 3

Policy mixes for sustainability transitions in emergence and acceleration phase.

| | | Primary Innovation Type | | |
|------------------|--------------|--|--|---|
| | | TECHNOLOGICAL INNOVATION | SOCIO-TECHNICAL INNOVATION | SOCIAL INNOVATION |
| Transition Phase | Emergence | Policies supporting experimenting with and learning from novel <i>technological</i> sustainability solutions | Policies supporting experimenting with and learning from novel <i>socio-technical</i> sustainability solutions | Policies supporting experimenting with and learning from novel <i>social</i> sustainability solutions |
| | Acceleration | Policies <i>phasing-out unsustainable technologies</i> | Policies <i>supporting sustainable socio-technical system changes</i> | Policies <i>phasing-out unsustainable social practises and/or social relations</i> |

Methodologically, we demonstrate the applicability of the top-down and bottom-up approaches to delineating policy mixes (Ossenbrink et al., 2019) as suitable for social innovation, and offer the supplementary terminology of design vs. real world approaches to policy mix mapping.

Empirically, we find that national but also EU funding for various forms of experimentation serve as enabling policy instruments, which in Germany are mainly originating from innovation and energy governing entities. As the policy mix focuses on niche support, a main challenge therefore is the question of how to scale up and diffuse successful experiments in line with the objective of accelerating the energy transition.

Our study is not free from limitations. First, in our bottom-up analysis of the policy mix of relevance for PIE in Germany, we included the perceptions of SIE-field actors regarding policies they considered as particularly relevant for their field. While this helps in highlighting important policies, it also implies our list of key policy mix elements is not exhaustive. Second, given the diversity of social innovation in energy, we recognize our focus on one type of social innovation only – PIE – limits the generalisability of our findings to other types of SIE. Nonetheless, we are convinced that our analytical framework and reflections on applying policy mix thinking to social innovation will also be useful for different types of social innovation and can yield equally insightful results on these.

Ultimately, we hope that our explorative analysis serves as a first step for further empirical and conceptual research on policy mixes for socio-technical change aimed at stimulating social and technological innovation to accelerate sustainability transitions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Karoline Rogge and Maria Stadler report that financial support was provided by European Union (SONNET project, grant agreement no. 837498).

Data availability

This study combined existing data, which is openly available at locations cited in the reference section, and new data, which cannot be shared due to the sensitive nature of the research and associated confidentiality of our expert interviews. Additional details on the data are available from the Zenodo Data Archive: 10.5281/zenodo.7441414 and 10.5281/zenodo.6553457.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.eist.2023.100723](https://doi.org/10.1016/j.eist.2023.100723).

Appendix

List of interviewees

| Interview No. | Empirical description of case | Type of actor according to SONNET | Date of interview | Duration of interview |
|---------------|--|-----------------------------------|-------------------|-----------------------|
| DE_PIE_1 | Researcher involved in projects on Living Labs in Germany | SIE-field actor, Researcher | 22/10/2020 | 54 min |
| DE_PIE_2 | Member of Programming Initiative (European level) | SIE-field actor, Policymaker | 06/11/2020 | 89 min |
| DE_PIE_3 | Member of SIE-initiative, engaged in different Lab formats on the local level | Member of SIE-initiative | 10/11/2020 | 67 min |
| DE_PIE_4 | Researcher involved in energy related research projects, including 'Reallabor'-formats | SIE-field actor, Researcher | 18/11/2020 | 32 min |
| DE_PIE_5 | Member of SIE-initiative, engaged in a Lab format on the regional level | Member of SIE-initiative | 30/11/2020 | 65 min |

(continued on next page)

(continued)

| Interview No. | Empirical description of case | Type of actor according to SONNET | Date of interview | Duration of interview |
|---------------|---|-----------------------------------|-------------------|-----------------------|
| DE_PIE_6 | Researcher involved in transdisciplinary research related to sustainability | SIE-field actor, Researcher | 02/12/2020 | 75 min |
| DE_PIE_7 | Researcher involved in projects on regulatory sandboxes | SIE-field actor, Researcher | 03/12/2020 | 76 min |
| DE_PIE_8 | Member of project management agency (National level) | SIE-field actor, Policymaker | 04/12/2020 | 61 min |

List of observations

| Event name | Event organiser | Type of event | Date of event |
|---|------------------------------|--------------------|---------------|
| Wie kann ein digitales Web-Tool Sachsen helfen, nachhaltiger zu werden? post-projectification – new normal in urban experimentation urban lunch talks #7 – from Test to Success | SEBIT, Zukunftsstadt Dresden | Online-Workshop | 26/11/2020 |
| | IST conference session | Conference | 20/08/2020 |
| | JPI urban Europe | Webinar (recorded) | 08/10/2020 |

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