SONNET – Social Innovation in Energy Transitions

Co-creating a rich understanding of the diversity, processes, contributions, success and future potentials of social innovation in the energy sector

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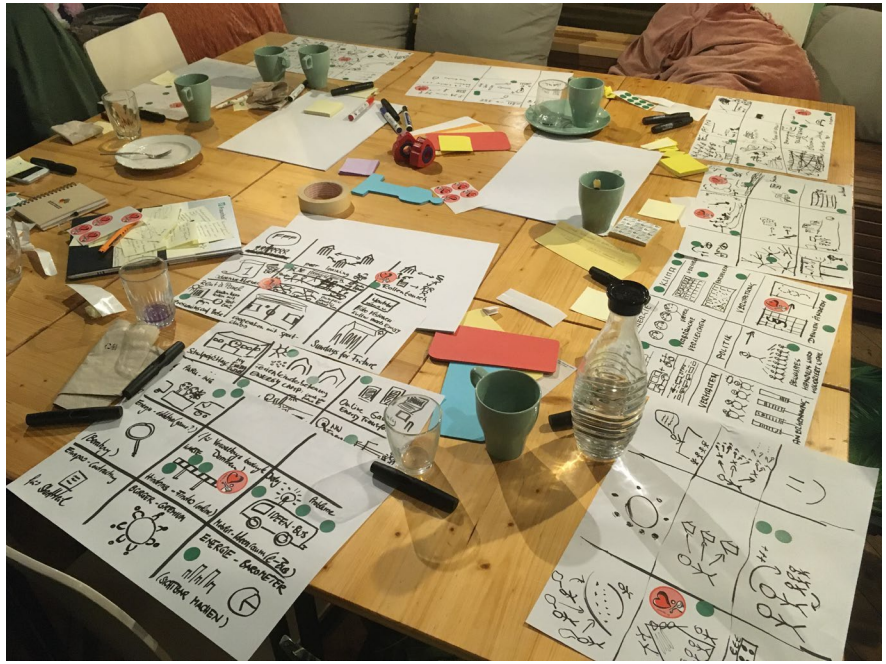
Research report on Participatory Incubation and Experimentation in Germany



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About SONNET:

SONNET is a research project that aims to develop an understanding of diversity, processes, contributions and future potential of social innovation in the energy sector. It is co-funded by the European Commission and runs for three years, from 2019-2022. The SONNET consortium consists of 12 partners across Europe, including academics and city administrations. For more information, please visit our website: https://sonnet-energy.eu

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1 FORWARD

SONNET (Social Innovation in Energy Transitions) brings diverse groups together to make sense of how social innovation can bring about a more sustainable energy sector in Europe. The project aims to co-create a rich understanding of the diversity, processes, contributions, successes and future potentials of social innovation in the energy sector (SIE). We define SIE as combination of ideas, objects and/ or actions that change social relations and involve new ways of doing, thinking and/ or organising energy. As part of this work, we make use of an embedded case study approach to build a better understanding of the development of diverse SIE-fields (e.g. participatory incubation and experimentation, framings against specific energy pathways, local electricity exchange) over time. Our research questions that frame the case study work are:

- How do SIEs and SIE-fields emerge, develop and institutionalise over time?
- How do SIE-field-actors and other field-actors interact with the 'outside' institutional environment and thereby co-shape the SIE-field over time?
- What are the enabling and impeding factors for SIE-field-actors and other field-actors to conduct institutional work and change the 'outside' institutional environment?

A SIE-field is an arena/space that includes a specific SIE as well as SIE-field-actors working on it and other field-actors enabling and/or impeding it. In this arena/ 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. They recognise (but not necessarily follow) shared norms, beliefs and rules. SIE-fields are often not homogenous but are composed of actors with diverse and contradictory aims and interests. An example: The UK cooperative energy field includes SIE-initiatives and SIE-field-actors (e.g. Brighton Energy Co-op, Cooperative UK, Community Energy England, UK Government, City of Brighton), who have a shared understanding of an SIE, which exists as 'organising under cooperative principles to generate renewable energy'.

The structure of this report is as follows. Section 2 provides a summary of the SIE-field relevant for this report and lists some key insights. Section 3 outlines the boundaries of the SIE-field and shows how it has been studied in the country context. Section 4 shows a visual development of the SIE-field. Section 5 tells the historical development of the SIE-field over time, including analytical/ interpretive reflections from the SONNET researchers and quotes from the actors involved in the field developments. Section 6 outlines key research findings, providing answers to the three research questions. Section 7 outlines recommendations for policymakers based on the findings. Finally,

Section 9 outlines the methodological approach and includes a more detailed timeline of the SIE-field and its actors.

The following boxes are used within the report:

Conceptual work

...

Introduction to SIE-initiative

...

2 Participatory Experimentation and Incubation in Germany

In SONNET, we investigate the development of the SIE-field called 'participatory experimentation and incubation', i.e. multi-actor, collaborative formats that aim to experiment with and/or try out novel energy solutions in specific (local and temporal limited, project-like) settings. This report analyses formats that bring together actors from different societal spheres to collaborate (rather than to have a dialogue only) in a project-like setting. To qualify, a collaboration needs to be considered by at least one of the actors as an 'experiment' meaning that it aims at testing, investigating or trialling a specific solution and/or clearly aiming at learning from putting certain solutions in practice. To be included in this report, the experimentation clearly focuses on energy topics and takes place in Germany. Although terms and concepts are often not clearly defined, we could distinguish and trace the developments of at least five collaborative multi-actor experimentation formats during the last twenty years.

Key insights

For the SONNET project, Participatory Experimentation and Incubation is particularly interesting because through its aim to bring diverse stakeholder groups together to develop energy-related topics and its close interlinkage with national energy policies, it reveals a number of important issues for social innovation in energy transitions. In particular, it illustrates that:

- The SIE-field development in Germany is based on a long tradition of bottom-up claims for participation e.g. through grassroots movements or protests against specific (urban) planning projects. These bottom-up protests are rooted among others in the 1970s and 1980s anti-nuclear protests as well as in protest for participation in urban development projects that came up as a reaction to the technocratic planning approaches which dominated urban planning until the 1960s and 1970s. These bottom-up claims for participation strengthened socio-ecological and transdisciplinary research approaches and, in the beginning of the 2000s, inspired national research programmes for sustainable development (FONA[1]).
- Energy related research and development projects in Germany are, however, traditionally rather technology concentrated. They build on a strong belief in progress and economic growth through technological innovations. Research and Development (R&D) policies in Germany for a long time concentrated on key technologies. However, developments such as the failure of smart meter implementations and the often quite critical public perception of

1 FONA: Forschung für nachhaltige Entwicklung (Research for sustainability), see: https://www.fona.de/en/

wind projects were important turning points that encouraged research programmes, which aimed at integrating user perspectives in R&D projects.

- As the SIE-field in Germany is strongly linked to national R&D policies, it is also strongly institutionalised. Today, 1) participatory and transdisciplinary research for sustainability (funded by BMBF[2]) and 2) the development of new energy technologies which are now also aiming to integrate different actors in innovation processes (funded by BMWi[3]) are slowly moving towards similar targets. Examples are large scale projects like the BMBF funded Kopernikus project, which integrated 'Reallabor'-approaches or the BMWi funded energy program that stresses the importance of 'Reallabore' for energy research. Even if there is ongoing competition between BMBF and BMWi funding approaches, they are currently converging in the format of 'Reallabor' (real world laboratory) for energy transition research. It is important to notice though, that the approach of 'Reallabore' reach beyond the integration of different actor groups. Another aspect is to consider real market conditions or regulatory exception clauses. The 'Reallabor'-approaches might differ largely depending on the aims of the projects.
- While the SIE-field of participatory incubation and experimentation institutionalises around the concept of 'Reallabore', lab approaches are also diffusing and start blurring the lines between research and innovation projects for energy transitions (public interests) and lab approaches used by private actors to investigate consumer behaviours in short term project settings.
- While the multi-actor formats in which learning happens bring different stakeholders together, only recently approaches emerged, which integrate policy learning in these settings and it remains difficult to integrate policy actors into these settings.

2 BMBF - Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
3 BMWi – Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)

3 Introduction to Participatory Incubation and Experimentation in *Germany*

This report investigates the development of the SIE-field 'participatory experimentation and incubation' and its social innovation in the energy sector (SIE, see analytical box 'SIE changing social relations' below). This SIE-field stands for multi-actor, collaborative formats that aim to experiment with and/or try out novel energy solutions in specific local settings. It includes formats that bring together actors from different societal spheres to work together (rather than to have a dialogue only) in a project-like setting. To qualify, a collaboration needs to be considered by at least one of the actors as an 'experiment' meaning that it aims at testing, investigating or trialling a specific solution and/or clearly aimed at learning from putting certain solutions in practice. Such experimentation focuses on energy topics and within SONNET is researched in Germany, Poland and the Netherlands & Flanders.

SIE changing social relations

In the context of the SONNET project, social innovation in the energy sector (SIE) are defined as 'a combination of ideas, objects and/ or actions that change social relations and involve new ways of doing, thinking and/ or organising energy' (Wittmayer et al. 2020b, p. 4). In order to observe the diversity of SIE, the SONNET project first developed a typology of contrasting SIE (Wittmayer et al. 2020a). One identified type of SIE is called 'participatory incubation and experimentation'. A main characteristic of this type is that activities focus on organising experimentation and incubation of ideas and/ or technology (as object) through multi-actor constellations, including different actors across society like researchers, policy makers, private companies or citizens. Insofar, changing social relations is at the core of these formats as they explicitly aim for changing innovation processes by integrating different stakeholders in research and innovation settings.

In the German context, multi-actor collaborative formats have been referred to as e.g. labs, living labs, urban labs, regulatory sandboxes[4], showcases or 'Reallabore' (real-life laboratories). The term Reallabore so far is used mostly in Germany (McCrory et al. 2020) and describes an hybrid form of experiments between generating and applying knowledge (Schneidewind 2014, p. 2). The term might also be interpreted as a pendant to the German expression 'Realpolitik', emphasising that research has to be closely interlinked to the conditions of the real world (see Interview DE_PIE_1). These relatively young terms are, however, often neither clearly defined (Parodi et al. 2016) nor used in a consistent way and there is still ongoing change in naming and framing experimental approaches (see Interview DE_PIE_1). Changes in these formats refer to: 1) the actors involved (e.g.

[4] In German often also referred to as 'Reallabore'

energy and technology companies, research institutes, citizens, municipalities, foundations), 2) the roles of actors (e.g. citizens as test users vs. citizens as generators of ideas, policy actors as funders vs. policy actors as learning actors), 3) the aims of experimentation (e.g. testing and experimenting with technologies vs. testing and experimenting with regulations, integrating user perspectives in experiments vs. users generating the ideas of change), 4) the representation or integration of 'real world settings' into these formats (e.g. experimenting within in real-world market conditions and regulatory settings vs. experimenting in controlled test environments or representations of the real world in settings), 5) the geographical and temporal scope of activities and degree of local embeddedness. However, what links these formats is that 'these hybrid arrangements [are] framed as settings, where radical alternatives can be co-produced and shaped in limited space and time' (McCrory et al. 2020).

In Germany, the development of these experimentation formats is based on a long history of a) participatory approaches, which especially emerged in the context of urban development and inspired transdisciplinary research approaches for sustainable development and b) technology focused research and innovation funding programmes for sustainable energy. In the beginning of the 2000s, approaches emerged, which aimed at integrating user perspectives in technology development projects. In 2004, the term 'living lab' first appeared to describe these forms of test environments for innovation processes, which were soon picked up in German research and innovation programmes. These early living labs, are to be understood as material arrangements or experimentation and innovation infrastructures (see Interview DE_PIE_1). At the same time, in the later 1990s and early 2000s, transdisciplinary approaches for socio-ecological research emerged in the social sciences. Since 1999, the German Federal Ministry of Education and Research (BMBF) funds the transdisciplinary programme 'research for sustainable development' (FONA). In contrast, the Federal Ministry for Economic Affairs and Energy (BMWi) concentrated for a longer time on funding the development of key energy technologies. Several developments such as the failed implementation of smart meters' technologies (due to lacking societal support) or the difficulties around the acceptance of wind farms influenced a shift towards a better and earlier integration of user perspectives in innovation processes in BMWi funded projects. In 2018, the BMWi strategy and funding programme 'Reallabore der Energiewende' (real world laboratories of the energy transition), was launched. Next to other aspects, it makes use of lab approaches to systematically integrate multiple stakeholders in R&D processes.

In the German context, lab-approaches have been picked up by diverse actors such as municipalities, foundations, private companies and energy providers. In some cases, (e.g. concerning labs carried out by municipalities), these approaches include educational as well as participatory aspects and try to raise awareness for energy or sustainability related problems. At

the same time, however, lab-like formats are also contributing to blurring the boundaries between public engagement and private interests. While 'living labs' first described a form of research projects with a certain degree of public interest, the term later diffused to more market oriented private companies (see Interview DE_PIE_1). Here the term 'lab' more generally refers to temporal and spatially bounded projects, which integrate user perspectives and not necessarily have to include research partners (see Interview DE_PIE_3). What links these formats is, however, the recognition that energy, or more generally, sustainability transitions are to be understood as highly complex processes. Developing, planning and implementing solutions must therefore also 'represent' these complexities, as one of our interviewees describes it: "*Well, if anyone says that they know how to mechanically implement the policy, then they're either lying or they don't know what they're talking about. Because if you just open your eyes to see it, well, there's so many moving parts in this system. It's so fluid, but also so much friction as so many kind of bushfires that can start that. No way you can do it without moving forward in a kind of an open experimental approach*" (Interview DE_PIE_2).

The innovation history of the SIE-field 'participatory experimentation and incubation' outlined in this report covers the development of different multi-actor collaborative experimentation formats in Germany during the period between 2000 and 2020.

We started this innovation history in the year 2000 because one important early milestone is the birth of the term living lab and its introduction to the German context. The birth of the term is 'ascribed to MIT's prof. dr. Mitchell, who used it to refer to a purpose-built lab where the routine activities and interactions of everyday home life can be observed, recorded for later analysis, and experimentally manipulated [...]' (Ballon and Schuurman 2015). This concept was picked up in Germany in the early 2000s, however the transdisciplinary research programme FONA (research for sustainability), starting in 1999, already laid the foundation for experimental and collaborative multi-actor formats in energy related R&D policies. Therefore, this innovation timeline starts around 2000 and traces different formats. This is especially difficult as terms are in most cases neither clearly defined nor used in a consistent way. Furthermore, one characteristic of the SIE-field development is that approaches are starting to diffuse to different contexts, blurring the line between R&D projects with public funding interest and diverse private interests (see analytical box: Key changes in the SIE-field over time, page 14f). However, for this report we mainly concentrate on experimental formats and concepts linked to R&D policies and traced their changes and how these changes contributed to blurring the lines between different formats.

The table below gives an overview of the five different formats, including central terms and concepts

and provides definitions or explanations by actors involved. Even if more terms exist to describe lab-like settings, we focus on the following five concepts which play a key role in the German context and can relatively well be distinguished from one another.

Format	Actors	Aims	Definitions and example
Living Labs (no German translation)	• Academic researcher • Users • Businesses	Integration of user perspectives in technological innovation processes	'A user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts' (Eriksson et al. 2005) Originally not necessarily focused on energy related topics but e.g. on ICT technologies or consumption behaviours; concept picked up for energy research Energy related example in Germany: Living Lab Walldorf (see: www.living-lab-walldorf.de)
Urban labs (Stadtlabor)	• Academic researchers • Citizens and civil society actors • (Local) policy makers • (Local) businesses	Participation in energy transitions and awareness raising in local urban contexts	'Urban labs … explore alternative futures in a collective approach, without fixed ideas or preconceived solutions… provide opportunities for diverse and marginal actors to participate in and influence processes and activities… are hybrid niches positioned at the boundary between local administration and society…. have transparent leadership and organizational structures tailored to specific goals and local conditions… carry out time-limited experiments with the ambition of creating long-term relationships… aim to maximize learning from lab experiments by multiple actors … co-create public values, distributed transparently and fairly… disseminate and anchor lab lessons throughout urban governance structures' (Scholl et al. 2017) Focus often on broader sustainability issues than on energy (technologies) only, transdisciplinary approach as key component as well as embeddedness in local context Energy related example in Germany: urbane Wärmewende (urban heat transition), Berlin (see: www.urbane-waermewende.de)
Showcases (Schaufenster)	• Academic researcher • National, regional, localgovernments • technology providers	Large technology demonstration projects for new energy technologies	'The idea behind it is to promote showcases in which you can actually show the application of digital technologies. It is more about the integration of renewable energies, but also about participatory concepts for promoting energy [technologies]' (interview DE_PIE_4). Development and demonstration of large scale technologies, especially concentrating on ICT technologies and the digitalization of the German energy system Example in Germany: SINTEG projects (see: www.sinteg.de)

	• Grid operators • utilities		
'Reallabore'	• Academic researchers • Policy actors • Civil society actors • Businesses	Can be either technology or societal focused; real world contexts as key component	'The idea of 'Reallabore' transfers the scientific term laboratory to the analysis of social and political processes. It is rooted in the experimental turn in social and economic sciences. There are close links to concepts in field and action research.' (Schneidewind 2014) Reallabore can either be technology oriented or focus on social and political questions. The concept saw its first larger scale implementation in 2015 in the German federal state Baden-Württemberg with their R&D funding programme 'Reallabore, BaWü-Labs' which included projects on energy but also many other topics in other sectors. In 2019, the new BMWi funding line 'Reallabore of the energy transition' started and shaped the term in a technological sense (see: https://www.energieforschung.de/spotlights/reallabore). In the same year, a network of sustainability oriented real world laboratories (Reallabore der Nachhaltigkeit) was founded by the Karlsruhe Institute for Technology (KIT), Leuphana University Lüneburg and Wuppertal Institute, following a broader societal approach (see: www.reallabor-netzwerk.de). Energy related example in Germany: Energielabor Tübingen (see: https://uni-tuebingen.de/einrichtungen/zentrale-einrichtungen/internationales-zentrum-fuer-ethik-in-den-wissenschaften/forschung/natur-und-nachhaltige-entwicklung/energielabor-tuebingen/)
Regulatory sandboxes (no German translation, often also referred to as 'Reallabore')	• Academic researchers • Policy actors • Businesses • Users	Regulatory and policy learning as important part of the experiment	'[Regulatory] sandboxes mainly arise from experimentation or flexibility clauses in laws. Such experimentation clauses authorize the executive to deviate from the existing law by a predefined degree' (Bischoff et al. 2020). Still upcoming form of experimentation, integration of policy makers in experimental settings currently remains difficult in Germany. Energy related example in Germany: tender procedure for promoting renewable energy systems (see: https://www.ikem.de/wp-content/uploads/2018/06/20180719_WGB.pdf)

Given that the innovation history described in this report takes the year 2000 as its starting point, it concentrates on the last 20 years of the development of the SIE-field 'participatory experimentation and incubation' in Germany. These developments are, however, nested in broader developments beyond the German context. These developments mainly consist of two strands: 1) the development of transdisciplinary approaches for social-ecological research and 2) changes in research and

innovation paradigms. These broader developments were important to lay the foundation for the later development of participatory experiment formats and are therefore briefly outlined here:

An important starting point for international attempts towards the development of socio-ecological research approaches for sustainability was the 1987 Brundtland report (World Commission 1987), which stressed the interconnected and complex nature of environmental problems and their possible answers (see Interview DE_PIE_6). While the foundation of transdisciplinary research for sustainability was rooted in the 1980s, especially the 1990s were key for increasing the role of citizens participation in developing answers to environmental problems (Di Giulio and Defila 2019). The 1992 UN conference on Environment and Development in Rio de Janeiro increased the global awareness for the need to take action towards sustainability and 'Agenda 21' identified the local level as key to address activities for sustainable change (United Nations 1992) – just as participatory formats later also highlight the importance of local approaches. The role of cities thereby changed and discourses starting to shift from framing 'the city as sustainability problem to the city as sustainability solution' (Angelo and Wachsmuth 2020). Indeed, urban contexts have been increasingly recognised to play an important role in increasing participatory claims, e.g. in the tradition of the IBA (international building exhibition)[5], and city labs and urban experiments will later be seen as important building block for encouraging change towards sustainability (Bulkeley 2013; Hodson and Marvin 2010). In Germany, especially the German Advisory Council on Global Change (WBGU), established in 1992, can be seen as an important and 'paradigmatic' (Di Giulio and Defila 2019) milestone for acknowledging the interconnectedness of environmental and social issues. The WBGU also later influenced the SIE-field development with its report 'a social contract for sustainability' in 2011 (WBGU 2011), which emphasised the importance of a new interplay between politics, society, science and economy.

While the transdisciplinary approaches strengthened the acknowledgment of different types of knowledge in sustainability research (Di Giulio and Defila 2019), R&D policies adopted this development towards participatory and transdisciplinary research much later. As Schot and Steinmueller (2018) describe it, an early framing of 'innovation for growth' arose after World-War II, which built on 'a clear division of labour and responsibility' (Schot and Steinmueller 2018, p. 1557) between scientists, public and private sector stakeholders. A second framing of 'national systems of innovation' emerged in the 1980s and emphasised the role of 'sticky' tacit knowledge as well as the

[5] During the 1970s the importance of the social dimension of urban planning increased (Häußermann et al. 2008) and later, the IBA 1987 Berlin played an important role in participatory urban planning approaches as it introduced the concept of ‚cautious urban renewal' (behutsame Stadterneuerung) which ended the trend of large scale urban housing project popular since the 1960s. These developments of participatory urban planning also strengthened the role of the social sciences (Siebel 2010.

integration of users in innovation processes, even if their role was mainly seen in providing feedback (Schot and Steinmueller 2018, pp. 1558–1559). Finally, a third framing of policies for 'transformative change' is emerging in the context of directing innovation to address sustainability challenges, with a key focus being an experimental approach and the integration of multiple actors in the innovation process (Schot and Steinmueller 2018, p. 1562). This third framing clearly points towards the emergence of the SIE-field under study. In the German context, approaches which took the diffusion of knowledge into account appeared in the 1990s and inspired larger research programmes (e.g. the FONA programme) which are still continued today (Schot and Steinmueller 2018). However, integrated and cross-sectoral R&D policies were often missing (see Interview DE_PIE_7). At around the same time, in the 1990s, the first living lab formats appeared in Germany, such as the Distributed Artificial Intelligence Laboratory (DAI) which was founded in 1992 at TU Berlin or in 1998 the Fraunhofer InHaus in Duisburg (see Interview DE_PIE_1), many of those concentrating on ICT technologies (Ballon and Schuurman 2015). With these Living Labs, the first settings occurred, that used the term 'lab' to describe a space for experimental R&D approaches.

Rooted in these two strands of development, the integration of multi-actor experimental formats in energy related experimentation formats increased during the last five years and gained importance. In this report, we do however trace earlier steps that enabled these changes and the institutional structures which these developments are nested in, taking a closer look from the start in the 2000s.

'Outside' institutional environment shaping the development of the SIE-field

SONNET looks at the interactions and relations between actors, working on a SIE and a broader institutional context in which the SIE is nested in (Wittmayer et al. 2020b, p. 7). An empirical focus lies on the development of SIE-fields. Following Fligstein and Adam's field definition (Fligstein and McAdam 2011), an SIE-field within the SONNET project is understood as 'an arena/space that includes a specific SIE as well as SIE-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. They recognise (but not necessarily follow) shared norms, beliefs and rules. SIE-fields are often not homogenous but are composed of actors with diverse and contradictory aims and interests' (Hielscher et al. 2020, p. 17). While the SIE-field is constituted by SIE-actors and SIE-field-actors' activities, it is also influenced by the outside institutional environment, which can interact, shape, enable or impede the development of the SIE. This institutional environment is constituted by formal as well as informal institutions (Hielscher et al. 2020, p. 19).

The SIE-field 'participatory incubation and experimentation' is nested in broader societal trends such as increasing participatory engagement or protests for climate protection activities. These trends are influencing the SIE-field. Furthermore, for the development of the SIE-field, a number of **external shocks** have been crucial: In the beginning of the 2000s investments in energy related research projects was comparatively low and focused on single technologies rather than on integrated socio-technical transitions. After the *financial crisis in 2008*, the German government started an investment programme for municipalities, which also helped investments in new energy technologies (see Interview DE_PIE_8). The *2011 Fukushima nuclear catastrophe* had a major influence on changing energy policies in Germany. It led to the decision for nuclear phase-out and the revision of the German energy concept. Energy related R&D funding significantly increased during the following years, leading to large scale projects for the energy transition such as the 'Kopernikus' projects[6] (BMBF funded) or the SINTEG showcases[7] (BMWI funded – see table p. 9-10). This was a turning point insofar as energy research was not necessarily a subject of larger political debates (see Interview DE_PIE_8) and a more systemic approach to energy research started to develop. Also the *2015 migration 'crisis'* had an impact on the SIE-field development. As a reaction to the large amount of people in need arriving in Germany and the lack of administrative capacities to react to this, civil society actors started to get involved in significant ways. Much of these engagement happened on the local level in cooperation of NGOs, municipalities and individual citizens, This strengthened the overall engagement of citizens and the role of municipalities which later transferred to an increase of engagement also in the field of sustainability related activities (see Interview DE_PIE_2).

Concerning its **institutional embeddedness** - referring to the nested character of an SIE-field as being situated within larger institutional structures - the SIE-field builds on a long tradition of participatory engagement and a strong role of municipalities in the German federal system. Furthermore, the SIE-field is shaped by the institutional structures of German research and innovation policies as well as EU funding policies, e.g. in terms of depending on funding possibilities

[6] See: https://www.kopernikus-projekte.de/en/home; „Just as Nicolaus Copernicus brought about a transformation of science and society by introducing the heliocentric model of the solar system, the Kopernikus projects aim to cause a paradigm shift – towards research projects that can prompt a transformation of our entire society [...] Economists, scientists, and civil society work in close cooperation in all of the projects. Together they develop solutions to the point of market maturity, in three phases spread over ten years [...]."

[7] See: https://www.sinteg.de/en/; „The funding programme "Smart Energy Showcases – Digital Agenda for the Energy Transition (SINTEG)" comprises five large model regions known as showcases, in which model solutions for the energy supply of the future are developed and demonstrated. The focus of the programme is on digitalising the energy sector. More than 300 project partners are involved in the project, in which they seek to tackle the technical, business-related and legal challenges that digitalisation brings."

for concrete activities. It is closely linked to R&D activities and thereby also to decisions of the national government, e.g. the nuclear phase out law after the Fukushima catastrophe in 2011 (BGBl 2011 I 43 S. 1704-1705) or the decision for the digitalisation of the energy transition in 2016 (BGBl 2016 I 43 S. 2034-2064). In terms of funding lines, especially the differences in the FONA-related BMBF funded research on societal questions and BMWi funded research for energy technologies influence the SIE-field. The tensions between the two approaches also represent more generally the debate on how transitions towards sustainability can be achieved: by either societal change or technological change. Participatory approaches so far only partially influenced this setting insofar as they also start to diffuse to technological oriented research activities. This seems to have been especially influenced by developments such as the failed implementation of smart meter technologies due to lacking societal acceptance among other aspects (see Interview DE_PIE_4).

To define the boundaries of the SIE-field, the experimental character of the multi-actor constellations under study is a key element. One important debate around the role of experimentation concerns the use of the term vs. the process itself: on the one hand, activities might be *labelled* as experiments in order to stress their innovative and inclusive character (e.g. by using the terms Living Lab, 'Reallabor' etc.; see table above). On the other hand, the process of experimenting with energy pathways is described as an important new way of encouraging change (see Interview DE_PIE_2). As this case study asks about the institutionalisation of the SIE over time, we therefore have to put the focus on "the institutionalisation of experimentation [which] sets contemporary activities apart from more broadly experimental approaches [...] practiced in previous decades" (Evans et al. 2018, p. 2). This does not mean that we are interested in the label more than in the modes and processes of experimentation, but rather, that the uptake of *experimental* approaches in energy related policies and energy research approaches is of key interest.

In doing so, we furthermore ask about key changes in energy related experimentation and the development as well as re-interpretation of experimental approaches in the German context. This especially concerns the changing role and integration of 'real world' contexts in experimental settings in the process of the institutionalisation of the SIE-field as well as the diffusion of the concept.

Key changes in the SIE-field over time
One of the central research questions and empirical foci within the SONNET case studies is to understand the development of the SIE and its SIE-field over time (Hielscher et al. 2020, pp. 15–18). We therefore take a 'process perspective' and investigate change through focusing on the

emergence of the SIE-field and the activities of SIE-actors shaping them (Wittmayer et al. 2020b, p. 33). For example, we look at external shocks, internal field events and key changes in the development of the SIE-field and its relationship with the 'outside' institutional environment (Wittmayer et al. 2020b, pp. 29–30). Moreover, changes in the SIE-field also concern changed narratives and societal trends that enable or impede the development of the SIE and its SIE-field.

In the case of the SIE-field of 'participatory incubation and experimentation' in Germany, we have identified two key changes in the SIE-field development. These are especially crucial to the development of the SIE-field, as they describe 1) the institutionalisation of transdisciplinary approaches in large nationally funded research projects as well as 2) the diffusion of these formats, which contribute to blurring the boundaries of the SIE-field. We have chosen these two processes as major changes as they describe how approaches have been take up and (re-) interpreted by different stakeholders.

Firstly, lab approaches have been picked up by national ministries and influenced large scale funding programmes, such as the new BMWi programme 'Reallabore der Energiewende' (real world laboratories of the energy transition). While lab approaches first described innovation infrastructures for user-centric innovation as 'Living Labs' (Ballon and Schuurman 2015), the term was picked in Germany in sustainability oriented projects. In 2015, the first funding line for 'Reallabore' was launched in Baden-Württemberg (Wagner and Miller 2018). Since then, it inspired funding by national ministries and over time institutionalised as new state-of-the-art research format. What changed in this process was the integration of 'real world' contexts in research processes. While living labs focus on simulating real life conditions, the 'Reallabor' approach is rather oriented towards defining 'real-world' problems (see Interview DE_PIE_1) and gather stakeholders to create ‚sound processes' for finding answers for real-world problems (Interview DE_PIE_2). Most interviewees describe this format as 'sexy' (see Interview 6), 'trendy' (see Interview DE_PIE_8) or part of the current 'Zeitgeist' (see Interview DE_PIE_1). In 2019, a network for 'Reallabore' was founded by the Karlsruhe Institute for Technology (KIT), Leuphana University Lüneburg and Wuppertal Institute. Also funding on the European level promotes the approach and is currently supporting research activities addressing 'energy citizenship' as well as 'transition super labs', which are described as promising avenue for tackling sustainability challenges.

Secondly, parallel to the increasing institutionalisation of participatory approaches in energy research, lab-like approaches have also been picked up by a number of different actors (such as private companies or energy providers but also municipalities and foundations). With changes in the actor constellations, in some cases, also the aims of these labs are changing. While the transdisciplinary character was originally in core of the lab-approach, in these newly emerging approaches the involvement of academic research partners is no longer a necessary condition (see

Interview DE_PIE_3). Some labs e.g. might rather aim for exploring market interests. Due to the lack of clear definitions, the concept thereby diffuses and often describes more generally temporally and spatially limited projects settings which are interested in analysing the interests or energy behaviour of citizens. In some cases, this might make it more difficult to distinguish between public and private interests around the analysis of energy behaviour (see Interview DE_PIE_1).

As the SIE-field is quite strongly linked to institutional structures of R&D policies and research activities, it was important to take the perspectives of actors involved in these institutional settings into account. Besides actors involved in SIE-initiatives, we identified two groups of actors as crucial for better understanding the development of the SIE-field over time, namely researchers with long term experiences in energy research and transdisciplinary research and actors involved in managing national and European funding frames. Besides interviewing SIE-field-actors, strategy documents, funding programmes and conference reports were, among others, important documents analysed for this report.

To get deeper insights in the formats, processes and actors involved, we exemplarily describe two SIE-initiatives and their development more in-depth. One is the '**Quartier Zukunft**' in Karlsruhe. This initiative is especially interesting to study in the context of the innovation history of the SIE-field, as it was part of the first German lab funding line for 'Reallabore' in Baden-Württemberg in 2015. The lab itself, however, was established already in 2011 and its founders were key actors in the establishment of the German network 'Reallabore'. Furthermore, with its embeddedness in an urban context and its open and participatory approach, it represents the transdisciplinary strand of the SIE-field development, which was inspired by urban participation attempts. The lab puts a focus on urban energy transformation pathways which are, however, one topic among other related topics such as mobility and climate change.

The second SIE-initiative under study is the Reallabor '**Energieavantgarde Anhalt**'. This 'Reallabor' was established in 2012 and aims for establishing a decentralised energy system in the region Anhalt-Bitterfeld-Wittenberg. Its multi-actor constellation includes municipalities, utilities, (energy) businesses, foundations and research institutes. It also aims for including citizens in an energy dialogue. Furthermore, this 'Reallabor' is linked to national energy innovation funding as it was involved in the SINTEG project WindNODE (funded by BMWi). Therefore, it represents the energy technology oriented strand of development of the SIE-field.

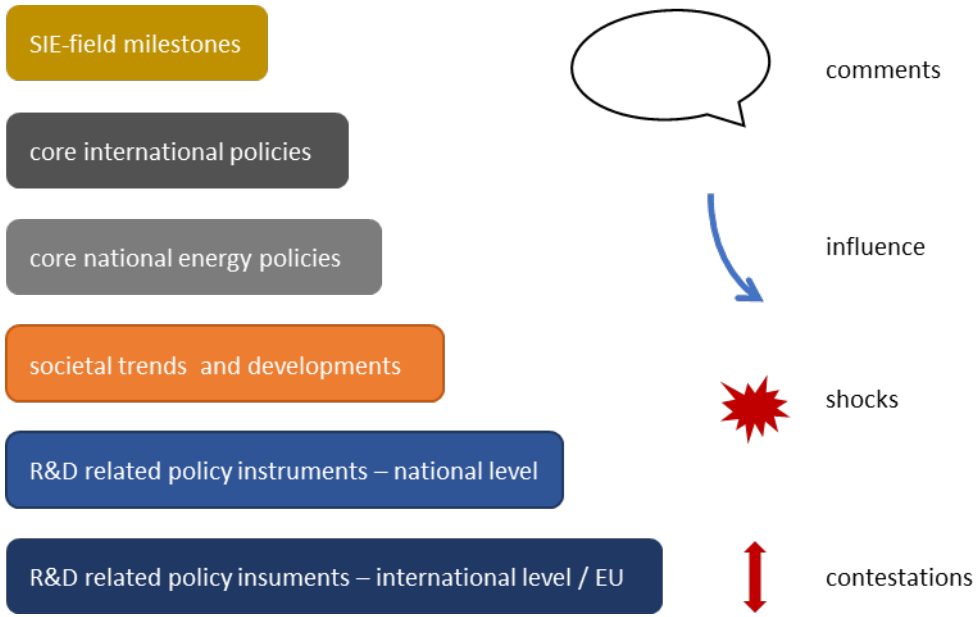
To summarise, for this report, we interviewed the following types of actors (8 in total):

- Actors involved in SIE-initiatives (2 interviews)
- Researchers involved in energy and transdisciplinary research (4 interviews)
- Actors involved in managing national and European funding frames (2 interviews)

The innovation history outlined in this report is structured around four phases:

- **PHASE A)** describes the early phase of SIE-field development in the beginning of the 2000s that laid the foundations for transdisciplinary formats, which were later picked up in more energy focused R&D policies.
- **PHASE B)** is characterised by small budgets for energy research which lasted until 2010. One important milestone in this phase is, however, the emergence of living lab approaches at the beginning of the 2000s that, at this time, were rather focused on single technologies.
- **PHASE C)** starts with the increase of activities around energy related R&D activities in 2010. It is closely linked to the development of larger frames for energy policies on the national level, such as the energy concept of 2010 and the decision for the nuclear phase out after the Fukushima nuclear catastrophe in 2011. In this phase, the term 'Reallabore' first appears in German research programmes.
- **PHASE D)** describes the current situation, which is characterised by the increasing institutionalisation of multi-actor collaborative formats for experimenting with alternative energy pathways. This is marked by a new BMWi-strategy for 'Reallabore der Energiewende', published in 2019, and the foundation of the network 'Reallabore' in the same year.

The next section, will present a visualisation of the innovation timeline. Thereby, the following colours and symbols are used to explain the SIE-field development:


SIE-field milestones
core international policies
core national energy policies
societal trends and developments
R&D related policy instruments – national level
R&D related policy insuments – international level / EU
comments
influence
shocks
contestations

4 Timeline of Participatory Incubation and Experimentation in Germany

This is a visualisation of the innovation history of participatory incubation and experimentation in Germany. An overview of the listed events can also be found in Appendix 2.

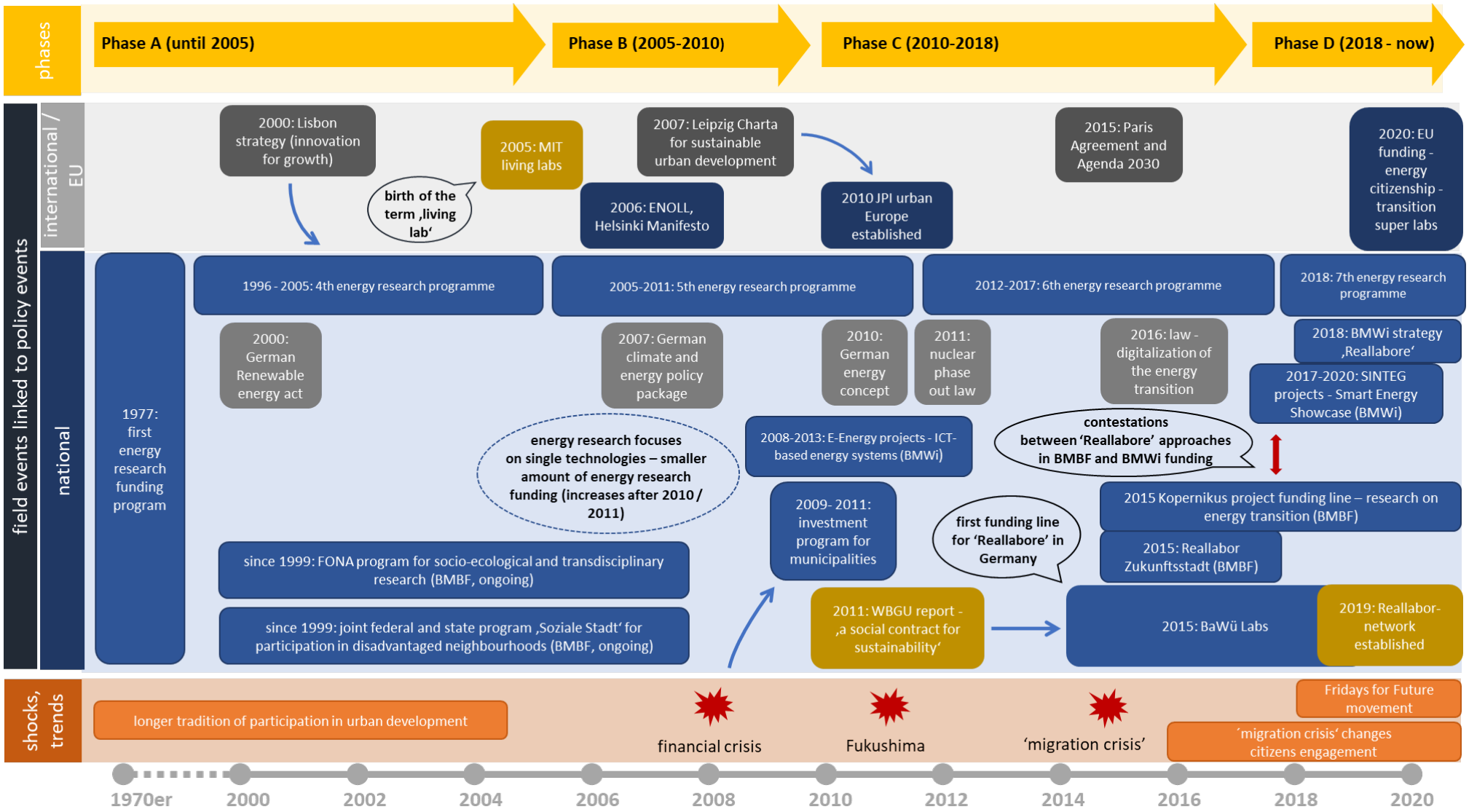


Figure 1: Timeline of Participatory Incubation and Experimentation in Germany

5 Emergence and development of participatory incubation and experimentation in Germany over time

The innovation history of the SIE-field 'participatory incubation and experimentation' in Germany is structured around four phases.

PHASE A: technological energy research and participatory formats as separated SIE-fields (2000-2005)

Looking at the development of the SIE-field, the starting point in the early 2000s is characterised by the existence of two separated SIE-fields: one focusing on the funding of technological energy R&D activities and the second on socio-ecological research activities. Participatory approaches at this time, were mostly present in the context of urban development projects.

Energy research was funded in Germany in a national funding programme starting in 1977 (first German energy research programme). The early programmes were concentrated on the aim of increasing economic competitiveness through providing low-priced energy. An important aspect to achieve this was seen in increasing R&D activities around nuclear technologies. Three separate phases are identified: research, development and demonstration, each of them was said to possibly taking 'decades' (BMWi 2017, pp. 10–21). In the beginning of the 2000s, the fourth energy research programme was running (1996-2005). It framed energy research activities in relation to the 1992 'Conference on Environment and Development' in Rio de Janeiro and to Germany's commitment to reduce CO_2 emissions (BMWi 2017, p. 232). According to Geels (2020), the election of the 'red-green' coalition government in 1998 can be seen as 'landscape shock, which disrupted the cosy regime-level relations between utilities and policy makers' (Geels 2020, p. 15). With the 'Renewable Energy Sources Act' (EEG) in 2000 the generation of renewable electricity was encouraged through feed-in tariffs and complementary measures such as priority access to the grid (Agora Energiewende 2015). This was the start for enabling private households to become 'prosumers' and therefore an important part of the energy transition. Furthermore, the liberalisation of the electricity market from 1998 started to contribute to transforming and diversifying the actors of the German energy market (e.g. new actors entering the market such as green electricity provider or energy cooperatives; for further information on this process see SONNET case study report on energy cooperatives in Germany (Heidary et al. 2021)).During this time, however, only small amounts of funding were available for energy R&D activities. As one interviewee summarises it: '*At the beginning of the 2000s, or actually since the end of the nineties until about 2007, only small amounts of money were invested in energy research. Of*

course, this also left little room for greater accompanying socio-ecological research' (Interview DE_PIE_8).

At the EU level, the Lisbon strategy of 2000 was another turning point. It aimed for transforming the EU into a knowledge-based economy and society, and thereby also had an impact on increasing triple-helix[8] collaborative arrangements, i.e. between research, business and policy (Hervás Soriano and Mulatero 2010). Furthermore, it encouraged investments in research activities, which also influenced the development of funding for energy research activities. The Lisbon strategy is therefore described as '*the basis of which the funds for energy research have gradually increased*' (Interview DE_PIE_8).

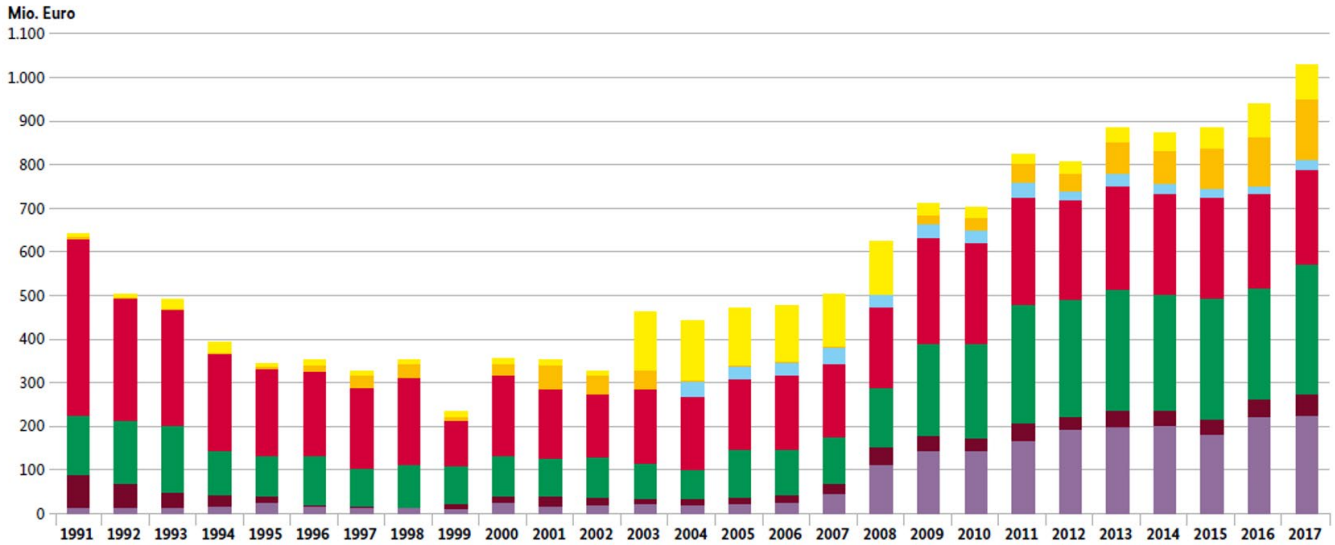


Figure 2: Expenditures for energy research from federal funds in Germany

Source: (BMWi 2019a, p. 78)

8 The term 'triple- helix' describes a collaborative format of university-industry-government relations for joint R&D activities (see Etzkowitz and Leydesdorff 1998).

Energy efficiency Fossil energy sources Renewable energies Nuclear technology

Hydrogen and fuel cells Other energies and storage technologies Other cross-cutting technology research

The year 2000 also marked an important milestone for the development of the transdisciplinary research community with the International Transdisciplinary Conference held in Zurich (see Interview DE_PIE_6). This conference contributed to the aim of making it 'scientifically acceptable to deal with environmental issues in a transdisciplinary manner' (Di Giulio and Defila 2019, p. 158, own translation). Earlier transdisciplinary approaches were, however, not necessarily characterised by transformative attempts (see Interview DE_PIE_6), but more generally based on developing solutions for societal problems 'in collaboration with the people involved' (Akademie der Naturwissenschaften Schweiz 2000).

In Germany, an important step for the institutionalisation of participatory approaches took place at the urban level, with the establishment of the neighbourhood programme 'Soziale Stadt' (Social City) in 1999 (still running today). It went along with an increasing awareness of regional patterns of development, especially against the background of globalisation processes, but also an increasing manifestation of social problems in a regionally concentrated manner (Häußermann et al. 2008, pp. 8–21). In this context, the programme 'Soziale Stadt' can be understood as (socially) innovative, as it aimed for overcoming the boundaries between different urban departments (such as the boundaries between the different authorities responsible for urban planning, building, social affairs etc.) in managing change as well as the boundaries between civil society actors, administration and businesses (Häußermann et al. 2008, p. 254). More precisely, it explicitly aimed for 'activating' the local population to participate in change processes and anchored the motor of change in cooperative formats on the local level. This new form of urban governance also contributed to changing the role of social sciences (Siebel 2010).

While the neighbourhood programme 'Sozial Stadt' focused on socio-structural aspects, in 2000 the FONA programme for socio-ecological research was launched by the German Ministry of Education and Research (BMBF). FONA took the complex interrelations and embeddedness of social and ecological developments into account and had as its 'explicit goal [..] the continuous improvement of social and technical systems by processes and factors that are significant according to sustainability indicators" (Bührer et al. 2020, p. 15). Energy related research activities were part of the programme, while funding concentrated on broader topics around climate protection and sustainability research

(Bührer et al. 2020, p. 22). The FONA research programme can be understood as counterpart of the linear model of technological innovation for economic growth, promoted by the Lisbon strategy (Wächert and Janowicz 2012, p. 306), and complemented traditional R&D funding programmes of the BMBF, including in energy technologies.

Insofar, these two strands of development – (1) technological research related to energy technologies, and (2) socio-ecological as well as participatory and transdisciplinary research - at this early time exist as separated SIE-fields.

Regulative, normative and/ or cultural cognitive institutions

SONNET draws on Scott's conceptualisation of institutions, which consist of regulative, normative and cultural-cognitive elements (Scott 2014). Regulative institutions include laws, rules, standards and policies while normative institutions describe social norms, duties, and value systems (Wittmayer et al. 2020b, p. 21). The third element is referred to as cultural-cognitive institutions such as shared expectations and common beliefs (Wittmayer et al. 2020b, p. 22). In SONNET, we assume that SIE have the potential to transform existing institutions while they will also maintain parts of existing institutions (Wittmayer et al. 2020b, p. 20). We are therefore interested in understanding existing regulative, normative and cultural-cognitive elements that shape the SIE and its SIE-field.

Regulative institutions play a crucial role in the development of the SIE-field as it is heavily influenced and shaped by regulative frameworks that shape the conditions for experiments in the energy sector. In the context of '*regulatory sandboxes*' as well as '*showcases*' these regulative institutions slowly start moving into the focus of experiments and becoming themselves subject of experimentation (Bauknecht et al. 2020). In some cases, e.g. in the context of the SINTEG projects, 'experimentation clauses' enabled exploring new pathways through temporal exemptions from existing regulatory frameworks. On the other hand, lab approaches in the broader sense are also applied to overcome bureaucratic institutions and increase the speed of innovation with the help of its temporally and spatially bounded character. As one interviewee describes it: '*If you start to involve a municipality more intensively in the project, then you come to nothing. [...] That's nothing personally but based on the functioning of the [bureaucratic] system itself*' (Interview DE_PIE_3).

A key **cultural-cognitive institution** influencing the SIE-field is that policy makers recognize different types of knowledge valuable for transforming energy pathways. The question here is,

"how we set boundaries around the legitimate contribution of the general public to the technical debates" (Collins and Evans 2009, p. 113). Barriers and prejudices around this question also exist in the academic field (see Interview DE_PIE_6). Transdisciplinary research attempts are contributing to changing this point of view, however, leading to the paradox situation that 'transdisciplinarity' still is an academic concept: *'Other [non-academic] actors don't really understand what transdisciplinary is because it doesn't make sense because they just work with each other. [They say:] So what?"* (Interview DE_PIE_2).

A **normative institution** can be identified when looking at the juxtapositions of socio-economic interests in the development of energy technologies (innovation for growth) and the socio-ecological interests of participatory engagement for sustainable transitions (innovation for sustainability). Both build on different normative assumptions, which currently meet in multi-actor experimental formats. Still, the two different strands underlying the SIE-field development (technological development and participatory engagement) shape different conditions for the modes of interaction between actors.

PHASE B: Birth of the term 'Living Lab' whilst energy research in Germany was focusing on single technologies (2005-2010)

In the second half of the 2000s, funding for experimental approaches in energy research was still rather low, especially in technology-focused research projects. On the international level, however, especially the birth of the term 'Living Lab' changed research settings and approaches. This later also influenced the German development around 'Reallabore'.

As Ballon and Schuurman (2015) note, the format of Living Labs already appeared earlier, but the term itself was first mentioned in a scientific publication in 2005 (Eriksson et al. 2005). Following the definition of Ballon and Schuurman, 'living labs typically refer to co-creation and appropriation of innovations by users, often in an (online or offline) community setting, and involving also business stakeholders' (Ballon and Schuurman 2015). Living Labs of this early type often focused on ICT technologies or smart homes with its co-creative approaches focusing on questions of cooperative design (Ballon and Schuurman 2015) rather than on, for example, user innovations. However, in 2015, Schuurman et al. identified 'a new type of Living Lab constellation, based on multi-stakeholder collaboration and knowledge sharing, rather than on user involvement' as 'emerging' (Schuurman et al. 2015, p. 24). Living Labs therefore contributed to opening up innovation processes to users,

stakeholders from civil society in which 'citizens are starting to act [as] innovators themselves' (Erdmann et al. 2018, p. 10). Erdmann et al. (2018) therefore also identify a 'real-world-turn' in sustainability research and analyse Living Labs as part of the Green Economy.

While Living Labs in Germany, such as the Fraunhofer InHaus in Duisburg (established in 1998) or the Distributed Artificial Intelligence Laboratory (DAI) (established in 19992) existed much longer and concentrated on ICT technologies and smart home technologies, these early Living Labs did not necessarily concentrate on energy or sustainability topics. One important milestone for applying Living Labs to energy related research was the flagship project 'Effizienzhaus Plus' in Berlin funded by the German environmental ministry (BMUB 2016, pp. 21–27). Since 2011, it serves as test environment for energy efficient and energy producing building technologies and was inhabited by two families, each of them testing the building in a one-year test phase. Since then, further projects followed which also experimented with integrated neighbourhood solutions such as the Living Lab 'FertighausWelt Wuppertal', funded by BMUB (BMUB 2016, p. 54).

In 2006, with the establishment of the European Network of Living Labs (ENOLL) the research approach started to institutionalise in Europe. In the same year, the 'Helsinki Manifesto' by the Finnish EU Presidency proposed the 'renewal of the European innovation system to create a new open, user-centric and networked innovation environment in Europe' (Finnish EU Presidency). This was understood as a revitalisation of the Lisbon strategy. Living Labs were framed as an important aspect of a future European R&D strategy where 'the users are involved in and contribute to the innovation process' (Finnish EU Presidency).

Even if these early living labs served as test environments and innovation infrastructures rather than spaces for participatory experimentation around alternative energy pathways, with the term 'living lab' user integration in innovation processes started to institutionalise. Since then, '*you can almost say that this laboratory term is hype*' (Interview DE_PIE_1).

Institutional work conducted by SIE-field actors and other field-actors
SONNET investigates how SIE-initiatives, SIE-field-actors and other field-actors 'perform institutional work – meaning they engage in creating, maintaining and transforming institutions to be able to work on, enable and/or impede SIE developments' (Hielscher et al. 2020, p. 20). This analytical focus emphasises that institutional changes are actively influenced by actors within the SIE-field (Wittmayer et al. 2020b, p. 31). The term 'institutional work' refers to these activities of

creating, maintaining and transforming institutions and can include diverse types of institutional work, such as material, relational and symbolic work. Examples might be attempts to influence policy makers or the general public through lobbying activities or to influence informal institutions such as norms and values.

Institutional work in the case of participatory incubation and experimentation strongly refers to activities that target alliance building, networking and the promotion of different participatory and experimental formats, e.g. through specific narrative and metaphoric framings of approaches. The empirical findings show that especially the 'Laboratory'-metaphor is part of institutional work of SIE-field actors in Germany. It serves as a narrative for funding policies and is often described as a 'sexy' term (see Interview DE_PIE_6), 'trendy' (see Interview DE_PIE_8) or part of the current 'Zeitgeist' (see Interview DE_PIE_1). The metaphor frames energy research formats as innovative themselves. While the first energy concept of 1977 described energy research as a process that takes 'decades' and is separated in research, development and demonstration before being available for its use, lab approaches stress the flexibility of activities. The message now is: Research does not have to be transferred to real world contexts but rather directly takes place where the real world is. This, however, might mainly express a political interest while the methodological approaches still differ between lab types (see Interview DE_PIE_1). Here, the strong metaphor turns into a 'label' that stands for an innovative approach but at the same time also helps to distracts from more clearly describing the exact processes that stand behind the label.

In many cases, the parameters that are important for conducting institutional work (e.g. the resource needed to build alliances) get visible by the difficulties that actors have in conducting institutional work. In the context of Living Labs, especially the material and socio-economic factors come into account as it is extremely cost intensive to establish and maintain large scale research infrastructures that are especially important for Living Lab approaches (with other experimental formats depend less on cost-intensive infrastructural settings). Therefore, alliances with private companies have to be found in order to share the infrastructure as well as the expenses (see Interview DE_PIE_1). Shaping alliances is, however, considered a time and effort consuming process. The aim to establish a German Living Lab network e.g. failed because of lacking time resources of actors involved in them, who are described as 'hopelessly overworked' (Interview DE_PIE_1). Therefore, it is seen as important to carefully consider who should be involved at which point of the process. Especially the involvement of actors from the 'bureaucratic systems' (e.g. policy makers working in public administration) might be seen as a barrier for the flexibility of the innovation process (see Interview DE_PIE_3). Thereby, however, the boundaries between public and private interests – between research activities for the common good vs. market interests - are starting to blur.

Institutional work in terms of networking activities between key stakeholders furthermore happens in the context of the academic research community, e.g. by establishing conferences and journals for transdisciplinary research or for research in Living Labs (e.g. the International Transdisciplinarity Conference, the Open Living Lab Days or the STRN research community). These activities are directed towards establishing research in multi actor formats in scientific communities and therefore contribute to institutionalizing these approaches. On the national level in Germany, only recently in 2019, the network 'Reallabore' was established by the Karlsruhe Institute for Technology (KIT), Leuphana University Lüneburg and Wuppertal Institute. Among others it aims at strengthening 'Reallabor'-research by increasing network activities, joint discussion paper series and annual meetings (see: https://www.reallabor-netzwerk.de/).

PHASE C: Energy transition projects with increasingly more integrative and transformative approaches (2010 – 2018)

The years 2010 and 2011 mark a milestone for the German energy transition. With the German energy concept and the nuclear phase out decision after the Fukushima nuclear catastrophe the German 'Energiewende' approached a more 'integrated policy framework' (Agora Energiewende 2015, p. 5). Funding for energy research increased in the following years. In addition, the WBGU report 'a social contract for sustainability' started to link participatory approaches to transformative attempts (WBGU 2011), thereby also supporting the development of the SIE-field 'Participatory Incubation and Experimentation'.

Policies and policy making

One important cross-cutting theme addressed in SONNET are the socio-political aspects and conditions of social innovation in energy. In SONNET, we are in particularly interested in identifying enabling or impeding factors and how they influence social innovation processes. This case study therefore aims for identifying important policy events and policy making processes (Wittmayer et al. 2020b, p. 43). This includes asking about broader political debates, the role of different government levels involved in policy making, particular policy strategies and instruments used and how they enable or impede the development of SIEs.

As the SIE-field is closely linked to R&D policies, next to national level energy policies also innovation policies and policy making processes have played a crucial role for the field development. The following table provides a selective overview of key policies influencing the SIE-field under study.

Year	Short description of policy	Relevance for SIE-field	Source
2000	Renewable Energy Sources Act (EEG): generation of renewable electricity encouraged through feed-in-tariffs		(BGBl 2000 I 13 S. 305-309)
2006	EU directive on energy end-use efficiency and energy services (energy savings through implementation of smart meters and more customer engagement, not binding)		(EU DIR 2006/32/EC 2006)
2010	Energy concept of the German government (for an environmentally friendly, reliable and affordable energy supply)	Turing point for more integrated energy policies	(BMWi 2010)
2011	Nuclear phase out law and announcement to close all of German nuclear power plants by December 2022 (thereby roughly reinstating the earlier nuclear phase-out decision of 2002)	Funding for energy research increases after nuclear phase out decision	(BGBl 2011 I 43 S. 1704-1705)
2013	Baden-Württemberg Ministry of Science, Research and Arts: funding line for real-world labs entitled BaWü Labs	First funding line for 'Reallabore' in Germany	(Wagner and Miller 2018)
2015	Initiative by BMBF and BMU to establish the Innovation platform 'Zukunftsstadt' (future city), which includes ‚Reallabor'-formats	Reallabor'-formats are getting picked-up in national policies	(BMBF 2015)
2016	Smart metering and the Energy Transition Digitisation Act		(BGBl 2016 I 43 S. 2034-2064)
2017	SINTEG projects with its ‚experimentation clause', funded by the German Federal Ministry for Economic Affairs and Energy (BMWi)	Showcase format highlight integrated approach, linking technical, business-	(BGBl 2017 I 38 S. 1653-1656)

		related and legal challenges	
2018	Launch of 7th energy research programme	includes a funding strategy for ‚Reallabore‘	(BMWi 2018b)
2019	Climate action law: Germany's first climate law makes emissions reduction legally binding		(BGBl 2019 I 48 S. 2513-2521)

Note: As this overview table only starts in 2000 it excludes an important earlier policy development: the liberalisation of the electricity market from 1998 which started to contribute to transforming and diversifying the actors of the German energy market. For example, in earlier days, many companies understood themselves as electricity suppliers ("Versorger") without customers but rather as measuring units and grid connection points ("Messstellen" and "Netzanschlusspunkte"), implying that back then companies typically did not speak with their customers, but only fullfilled their supply obligations ("Versorgungsauftrag").

The importance but lack of integrated approaches to address the energy transitions was frequently mentioned. Here, especially contestations between societal and technological approaches, pushed by different Federal Ministries, hinder integrated policy approaches: '*In the energy sector in particular you have to somehow organise that things don't develop in fragmented ways*' (see Interview DE_PIE_7). This is seen as a barrier for speeding up change processes. The SIE-field under study points in the opposite direction of multi actors formats that allow to follow more integrated and systematic approaches in experimentation settings. More systematic approaches, however, only started around 2010 and after the Fukushima nuclear catastrophe in 2011, but still developments are rather pushed within the frameworks and 'silos' of different national Ministries or European Directorates (interview DE_PIE_2). One aspect that is currently still developing is to directly address policy learning in experimental approaches (Bauknecht et al. 2020). There is, however, '*awareness that you have to work in a different way to make plans and policy work*' (Interview DE_PIE_2).

Besides activities on the national level, also policies on the European level have impacted the SIE-field development in Germany. Especially the Joint Programming Initiative (JPI) Urban Europe put a focus on lab formats and the co-creation of knowledge on the urban level to encourage systemic change (Bylund 2020). More recently, especially the European Green Deal links economic development with sustainability and is mentioned also by small scale SIE-initiatives as influential for their activities (see Interview DE_PIE_3).

The financial crisis in 2008 impacted the general economic situation and thereby also the development of budgets for energy related R&D activities. However, an investment programme for municipalities was launched and from 2009 until 2011. Municipalities are also moving into focus in terms of decentralised and participatory approaches for alternative energy pathways and a number of policies increased the attention for the urban level and its role in sustainability transition. One step in this process was the Leipzig Charter on Sustainable European Cities in 2007. It was an initiative by the ministers responsible for urban development in the EU Member States that suggested an integrated urban policy approach (BMUB 2007). The development of the Charter itself was considered a 'very open process' (Interview DE_PIE_2). It furthermore empathised the role of participation for integrated urban development processes. Another step on the European level was the establishing of the Joint Programming Initiative (JPI) Urban Europe in 2010 with its mission 'to develop knowledge, tools and platforms for dialogue on urban transitions' (JPI Urban Europe).

One important impulse for the development of participatory and more integrated approaches in the SIE-field of energy pathways was the 2011 WBGU[9] report 'a social contract for sustainability' (WBGU 2011). It stressed the need for a new interplay of politics, society, sciences and the economy (WBGU 2011, p. 1) and furthermore, emphasised the need for policy-mixes to push fundamental systemic change: The WBGU recommended to focus not exclusively on technologies here, but also on encouraging changes in behaviour and social innovations (WBGU 2011, p. 193). The report empathised the link between participatory approaches and transformative attempts and later inspired the first funding for 'Reallabore' in Germany, the Baden-Württemberg Labs. It is described as 'decisive' for a turn towards *transformative* transdisciplinary research approaches (Defila and Di Giulio 2018b, p. 11).

Quartier Zukunft - Karlsruhe

'Quartier Zukunft' aims at establishing a multi-actor collaboration for transforming an urban neighbourhood into a sustainable urban district. Sustainability is thereby understood as including economic, ecologic, social, cultural and institutional aspects. Energy in this SIE-initiative is one aspect embedded in a broader understanding of sustainability. It is addressed e.g. by integrated research activities such as the 'energy dialogue' (see: https://www.dialog-energie.de/). Further activities are different open formats such as the ''Nachhaltigkeits Experiment Second Future' (sustainability experiment second future) for promoting second-hand products or the production of podcasts. Initiated in 2011 by the Karlsruhe Institute for Technology (KIT), further actors included

9 WBGU: Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen – German Advisory Council on Global Change

in the participatory approach are the municipality of Karlsruhe, civil society actors and private businesses (Parodi 2011). In line with the 2011 WBGU report ‚a social contract for sustainability' its vision is to establish a participatory and cooperative process of transformation. The project describes itself as 'Reallabor' and defines the term as follows:

'Reallabore' experiment. They provide a frame for collectively developing, testing and researching conditions for a good life. Through a variety and density of sustainability experiments in the 'Reallabor', synergies and conflicts between individual and independent "sustainability solutions" are identified and processed (keyword: "dense sustainability"). The primary goal is to initiate and support the development of future cultures of sustainability - and, where possible, to already live them (see: https://www.quartierzukunft.de/quartier-zukunft/reallabor/; own translation).

The initiative officially is a project by KIT and understand itself as initiator of change, providing space for experimentation. A subsidiary project called 'Reallabor 131' was funded in the first German funding line for 'Reallabore' by the Baden-Württemberg (see Interview DE_PIE_6). In 2019, the initiators of 'Quartier Zukunft' founded the Network 'Reallabore der Nachhaltigkeit' and thereby institutionalised networking activities between sustainability oriented Labs in Germany. One aspect of institutional work conducted by the actors involved is to define the term 'Reallabor' and develop methodological approaches that target co-design and co-production to conduct research in these participatory settings.

During this phase of development, technological oriented funding programmes put increasing attention to aspects of digitalisation of the energy system. These attempts already started earlier, e.g. in 2008 with the pilot project E-Energy, funded by BMWi and BMUB (BMWi 2014). ICT technologies were considered to have great potential for efficient energy systems. Therefore, joint research teams, mainly consisting of business and academic partners worked on developing smart grid solutions. The SINTEG projects in 2017 continued the attempt to build smart Energy systems. However, one important learning from earlier projects especially with smart meter technologies was, that social aspects and questions of social acceptance are to be integrated into the development process of energy technologies. As one interview formulates it: '*There were people who [...] actually believed in smart meter technologies. They made first attempts with the E-Energy project which then failed due to data protection issues and because people didn't go along. There were really big protests [...] because of data protection issues and people were afraid they would be spied and such things and then this first wave of smart meters actually faded*" (Interview DE_PIE_4). The experiences of the failed smart meter implementation increased the awareness for questions of social acceptance and encouraged accompanying research in technological development projects. Still, technological

oriented projects set the stage and define much clearer frames for societal questions in energy related research. Thereby, they differ from more transdisciplinary approaches.

Contestations and relations between actors

SONNET is interested in understanding interactions between SIE-field-actors and/ or other field-actors. These relations can be formal or informal, take different forms (e.g. formal alliances, networks, collaborations) and might differ in their quality (e.g. conflicting, competitive, collaborative or exchange-oriented relations; Wittmayer et al. 2020b, p. 14) as well as in their content (e.g. concentrating on learning, networking, lobbying etc.). Furthermore, SIE-field contestations between SIE-field-actors and/ or other field-actors are of interest as they can 'unsettle' the existing 'outside' institutional environment (Hielscher et al. 2020, p. 19). Contestations are debates among relevant actors over SIE-field structures and processes such as disagreements about common aims or approaches to lobbying policymakers. Both, contestations and relations can provide an indication of how institutionalised (or not) the SIE-field is (e.g. are there formal networks).

As the example of smart meter technology developments indicate, contestation between SIE-field actors are targeting the role of citizens or users in energy related experimentation settings. While transdisciplinary requires an open process in which practitioners are more than just the target group (Defila and Di Giulio 2018a, pp. 10–11) (e.g. in their role as users), accompanying research in technological project rather addresses people as users and asks about acceptance for technological developments. As both approaches use the term 'Reallabore' for describing their approaches, this makes it easier to distinguish between different processes. The 'contestation' – in this case not a direct conflict but rather two separate developments – therefore also is about the use of the use of the term 'Reallabor' as a 'label' for innovative research approaches versus 'the processes' of transdisciplinary co-creation.

In the German case, the different uses of the term 'Reallabor' and the actors involved in shaping them becomes clearer when also considering the institutional work these actors conduct. In 2018, the BMWi established a network 'Reallabore' which includes business, research partners and municipalities (BMWi 2019b, p. 16). Its aim is to increase economic competitiveness through joint R&D activities. In 2019, another network 'Reallabore' was established by the Karlsruhe Institute for Technology (KIT), Leuphana University Lüneburg and Wuppertal Institute. This second network focuses on transformative sustainability research and aims for transdisciplinary approaches. As the term starts to diffuse, further actors such as foundations, municipalities, urban planning agencies,

private companies e.g. energy providers are picking up 'lab'-like settings and further contribute to shaping different meanings related to the term 'Reallabor'. These networks exist in parallel and rather shape different research directions than interact in order to jointly shape the SIE-field development.

Furthermore, contestations are to be understood as elements that characterises the process of policy making per se. Therefore, as the SIE-field is closely linked to R&D policies, contestations are also part of this processes. One interview describes it as follows: *"Of course, not formal contestation in that sense, but I mean, if you start looking at the political practice you come down to people and people who sometimes have very good intentions then starting playing soap opera games around their policy lines" (Interview DE_PIE_2)*

PHASE D: 'Reallabor' research approach institutionalises in energy related research activities (2018 – now)

With the start of the Fridays for Future movement in 2018, an important societal shift started to get visible which boosted the participatory dimension of sustainability attempts, which increased the involvement of bottom-up participation by civil society actors across different societal spheres and stakeholder groups (see 'scientists for future, 'farmers for future' etc). For the year 2019, the yearly report by Agora Energiewende about the development of the German energy transition describes 'climate protection and energy transition' as the number one political topic (Agora Energiewende 2020).

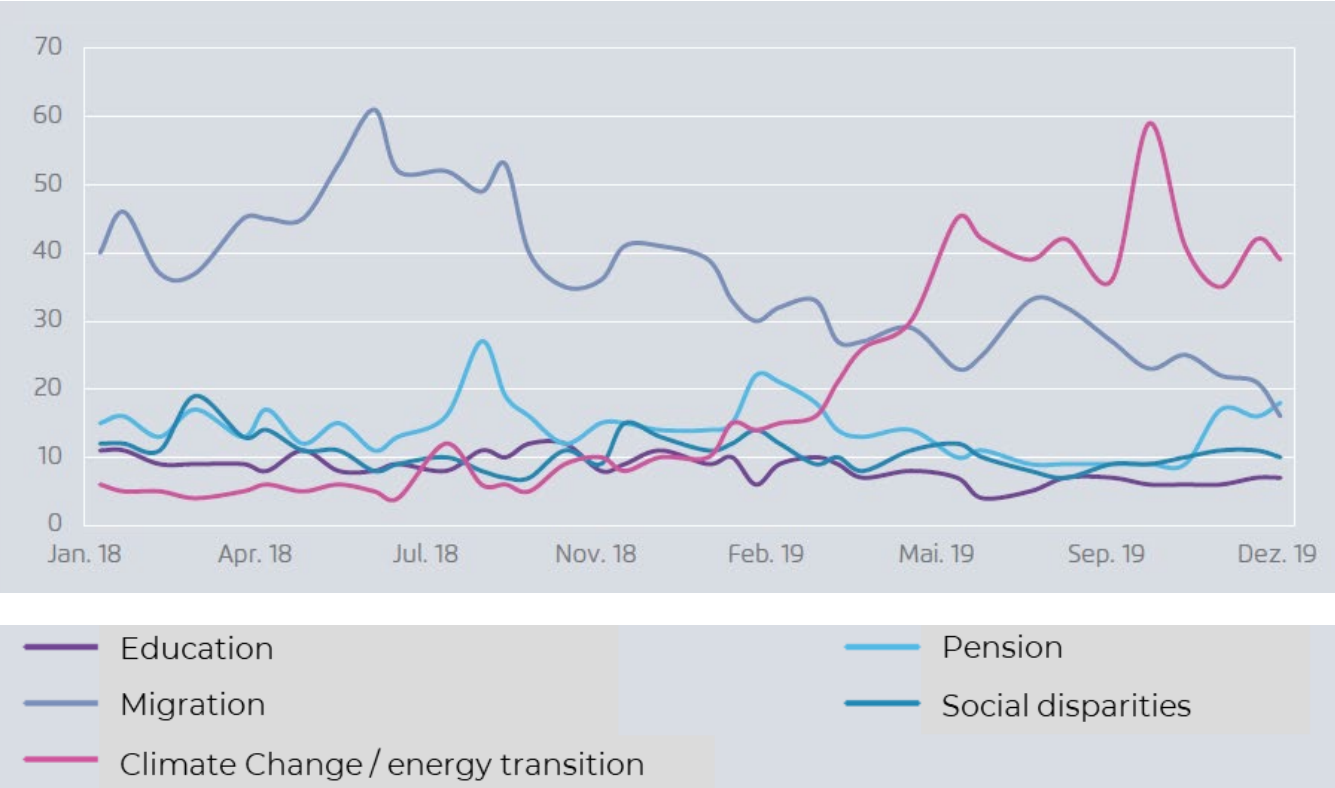


Figure 3: Top 5 political problems in Germany 2018-2019 according to 'Politbarometer'

Source: (Agora Energiewende 2020, p. 65)

This societal shift towards a broader engagement for climate protection and the transition towards a more sustainable energy system got picked up on the political level. In 2018, BMWi published its new strategy paper 'Reallabore' (BMWi 2018b). 'Reallabore' are thereby framed in the context of the increasing need of flexibility when experimenting with digital technologies and described as policy instrument for the fields of economy, innovation and digitalisation (BMWi 2018b). The 7th energy research programme from 2018 explicitly emphasised the role of 'Reallabore' which are here described as holistic approach with the intention to increase flexibility of energy research (BMWi

2018a, p. 18). Flexibility here refers to the regulatory conditions that can be adapted in the temporally and spatially limited setting of the 'Reallabore'. While also former programmes included 'Reallabor'-approaches, this was BMWi's first funding line that named research activities as 'Reallabore' (see Interview DE_PIE_8).

It is only in this phase of the SIE-field development that participatory multi-actor collaborative formats started to be more strongly institutionalised: First, through large scale funding lines such as the BMWi strategy for 'Reallabore' in the energy sectors. In parallel to institutional actors also network activities by single researchers and research institutes increased the institutionalisation of collaborative multi-actor formats for experimenting with new pathways to sustainability. Activities by researchers include joint conferences, discussion papers and the development of methodological guidelines and principles for transdisciplinary and transformative research for sustainability. Furthermore, one important aspect of institutional work conducted by researchers was the formulation of policy recommendations. Especially the BaWü-Labs were quite broadly evaluated and researched in accompanying research activities. This resulted in policy brief with recommendation for how to improve funding frames for transdisciplinary and transformative research activities (Defila and Di Giulio 2019). Among others, the short funding periods for transdisciplinary projects was identified as impeding factor for the development of the format, which might be in danger of being treated as short-term hype. Furthermore, the lack of funding for practitioners and citizens engaged in these projects is identified as problematic (Defila and Di Giulio 2019).

Meanwhile, as more and more actors are developing participatory formats for experimenting with sustainable energy solutions, the boundaries of the approaches are also starting to blur. In other words, the hype behind terms and 'labels' makes it increasingly difficult to distinguish between aims and interests behind the terms used. This stresses the importance to more clearly define concepts and methodological approaches for participatory multi-actor formats for experimenting with new energy pathways.

Reallabor Energieavantgarde Anhalt
Energieavantgarde Anhalt describes itself as a regional collaborative network consisting of citizens, municipalities, districts, businesses and further institutions. It aims is to push a regional transition towards a more sustainable energy system, where energy is produced and consumed in the region

Anhalt-Bitterfeld-Wittenberg. On its website, the association describes its mission as follows: „The association wants energy to be produced and consumed in an environment friendly manner in the region. [...] This contributes to protecting environment and climate and avoids unnecessary costs for consumers. [...] The necessary technical, economic and socio-cultural changes are jointly shaped by partners such as the region's municipal utilities, companies in the renewable energy sector and municipalities, including the city of Dessau-Roßlau and the Wittenberg district. We call this great experiment 'Reallabor Anhalt'

(see: https://www.energieavantgarde.de/verein/philosophie-ziele/, own translation).

The initiative is a registered association, founded in 2012, which is support by private business, foundations and state institutions on different levels, such as the government of Saxony-Anhalt or the Federal Ministry of Education and Research (BMBF). *The initiative participated in larger research projects such as the SINTEG projects*.

Activities carried out by the initiative include the development of mission statements, a regional network and competitions for start-ups for energy related innovations. A major focus lies on networking activities and bringing actors together to work on a regional energy transition, suggesting a regional 'Balancekreis' that allows a more integrated perspective on regional energy transitions. The initiatives tries to combine economic aspects of a regional energy system with political questions around participation and can therefore by seen as sitting in the middle between the two strands of development described in this innovation history. On one hand, it targets multi stakeholder formats to jointly work on the technical and administrative dimension of local energy supply. On the other hand, the initiative targets the socio-cultural dimension of a regional energy transition and aims for co-production and the inclusion of citizens in an open approach, e.g. in workshops formats, by information campaigns but also by activities in public space such as art installations (see image above).

According to the initiative, it is their specific way of producing and integrating different forms of knowledge in research processes, that makes up the initiatives character as 'Reallabor': "'Reallabore' *create a platform for new formats and new partnerships, thereby promoting networking and cooperation structures between science, business, politics, administration and civil society actors*"(see: https://www.energieavantgarde.de/reallabor-anhalt/, own translation).

Especially activities on the European level suggest that collaborative multi-actor formats during the next years will continue to play an increasingly important role in research for sustainability energy systems. The recent Horizon Europe draft work programme for the years 2021-2022 e.g. includes funding for research in transition super labs with a broad range of actors to be included in these

activities: "Transition Super Labs are real-life laboratories where rapid decarbonisation is conceptualised, implemented, monitored and revised in an integrated way. Similar to 'living labs' but operating at a much larger scale, they spur the transformation of whole entities – such as non-sustainable business complexes, mining regions and polluted metropolitan areas – in an economically, socially and environmentally sustainable manner. Designed as flagship demonstrators, Transition Super Labs involve a broad range of actors – businesses and industry, different levels of government, academia, civil society, citizens at large – working closely with communities and regions directly affected by climate change" (Horizon Europe 2020, p. 96).

Power and power relations (power to + power over + power with)
Shifting power relations is often considered as an important aspect, which defines social innovation processes (Wittmayer et al. 2020b, p. 47). The term 'power' thereby refers to actors capacities to mobilise resources and institutions (Avelino 2017). In the context of this case study, we aim for analysing which power relations are enabling or impeding SIEs and how they do so (Wittmayer et al. 2020b, p. 48). It is important to distinguish between different types of power. Actors might have power to. for example, to do certain things and push their interests (e.g. political power, economic power, innovative power), power over others or power with other to achieve collective goals (Wittmayer et al. 2020b, p. 48). **Power to:** Looking at the overall development of the SIE-field, we see that key changes are often encouraged through policy actors and relate to developments of a broader context. Especially funding lines which define the actors included in experimentation settings can be seen as a powerful tool to include or exclude actors from experimentation. E.g. in many cases, it might not be possible to provide funding for non-professionals engaged in experimental settings and limited time frames make it difficult to encourage long-term engagement (Defila and Di Giulio 2019). **Power with:** As the SIE under study focuses on multi-actor collaborative formats, power relations are quite strongly relating to activities that aim for joining forces of different actors. One important aspect thereby is how to join forces when the aims of actors involved might still largely differ. Bridging these differences requires good ways of communication. This means that actors are trying to convince each other for a certain standpoint and form alliances. One Interviewee describes the power in these settings as 'communicative' form of power: **'***Power not as something you hold but more like using the force of others, relational and communicative power' (see Interview DE_PIE_2*). Power in these activities is something that is situational enacted and builds on communication and

the building of alliances. Therefore, it is not something 'you hold' but something you have to repetitively enact.

Power over (shifting): One major aspect of change that is encouraged through the SIE under study, is a shift in power over the shaping of the energy system. This concerns the question_ who can contribute to shaping the energy system? One aim of the SIE-field is to frame energy not as a subject that requires expertise knowledge but establishing it as '*something that anyone could do*' (Interview DE_PIE_2)

6 Summary, synthesis and conclusions

6.1 How do SIEs and SIE-fields emerge, develop and institutionalise over time?

SONNET studies social innovation in energy (SIE). A SIE is 'a combination of ideas, objects and/ or actions that change social relations and involve new ways of doing, thinking and/ or organising energy'. In this case study, we analysed the development of one SIE - and its SIE-field - over time in the national context of Germany. The SIE under study in this report is referred to as 'participatory incubation and experimentation', i.e. multi-actor, collaborative formats that aim to experiment with and/or try out novel energy solutions in specific (local and temporal limited, project-like) settings. We traced back the development of these formats during the last 20 years and described the innovation history.

In the German context, we could identify different collaborative multi-actor experimentation formats that were referred to as 'living labs', 'urban labs', 'Reallabore', 'Showcases' or 'regulatory sandboxes'. However, the term most prominent in the German context to describe collaborative multi-actor for experimenting with new energy pathways is 'Reallabore'. This term was first used in a federal state level funding programme in 2015 and increasingly institutionalised in the last two years of the SIE-field development. The institutionalization of the approach especially builds on the establishment of funding lines that explicitly target 'Reallabor' approaches. Furthermore networks among researchers are formed to develop methodologies and establish 'Reallabor'-research in the academic field. The emergence of the SIE-field dates back much further. In Germany, there is a long history of participatory attempts that emerged in the SIE-field of urban development but also included bottom-up protests against nuclear energy in the 1970s and 1980s. These forms of bottom-up engagement encouraged socio-ecological research activities and inspired the national research programme for sustainable development, FONA (Forschung für nachhaltige Entwicklung (Research for sustainability).

Overall, the SIE-field development in the German context is characterised by two strands of development: On the one side, research activities inspired by citizens participation experimented with transdisciplinary formats in a broader context of problems related to sustainability questions. On the other hand, energy focused forms of experimentation build on a strong belief in progress through technological innovation. Here, within the last ten years high potentials were identified for the digitalisation of the energy systems. Through different developments such as protests against specific technologies (e.g. the implementation of smart meter technologies) or the increasing diversification of actors involved in the energy sector in the course the liberalisation of the energy

market these technological experimentation formats increasingly recognised the need to include the perspectives of citizens (especially addressed in their role as 'users') in these R&D activities. Therefore, especially in the last two years, the two strands of developing started to approach each other, using similar terms for their activities, even if the concepts and aims behind these terms might still heavily differ.

In this innovation history, we identified four phases that describe the emergence, development and institutionalisation of the SIE-field. The first phase that lasts until 2005 describes the early phase of SIE-field development. It laid the foundations for transdisciplinary formats. The FONA programme got established in this phase and also collaborative multi-actors' formats institutionalised in the SIE-field of urban development. One important milestone for the SIE-field development was the birth of the term 'living lab' in 2005, which marks the starting point for a second phase. In this second phase, however, budgets for energy research and experimentation activities were rather small and concentrated on single technologies, without being embedded in an overall concept. This changed around 2010. In the third phase of development, starting with this change in 2010, large scale energy research activities started that increasingly started to include experimentation formats in accompanying research activities. With the German energy concept in 2010 and the nuclear phase out decision after the Fukushima nuclear accident in 2011, the awareness for energy related activities raised on the political level. In this third phase of development, the term 'Reallabore' emerged and first appeared in German research programmes. The fourth phase of the development is characterised by an institutionalisation of multi-actor collaborative formats for experimenting with alternative energy pathways. This happened in parallel in both strands of developments: in technological cantered energy research with the BMWi-strategy for 'Reallabore der Energiewende' in 2018 and in 2019 with the foundation of the network of sustainability oriented 'Reallabore'.

However, parallel to the institutionalisation of multi-actor collaborative formats in energy related experimentation, the terms also started to diffuse and thereby blur the lines between different interests in changes the energy system. Especially, private businesses like energy providers or technology companies are increasingly also using 'lab' approaches to gain knowledge about user interests. In some cases, there are no academic research aspects integrated in these private lab settings, which is in contrast to the origins of these approaches. Overall, collaborations often happen in short-term project-like settings that make it difficult to integrate knowledge in experimentation processes on a constant and ongoing basis. So far, experimentation and learning starts to expand to including 'users' or sometimes more generally 'citizens'. Only recently first attempts emerge to develop formats and concepts for experimenting with energy related policy making in these.

For the future development of the SIE-field, activities on the European level might be crucial. New research programmes suggest activities around 'transition super labs' and fund projects on 'energy citizenship'. It seems quite likely, that these European activities encourage further activities on the national level.

6.2 How do SIE-field-actors and other field-actors interact with the 'outside' institutional environment and thereby co-shape the SIE-field over time?

In SONNET, a SIE-field is defined as an arena/space that includes a specific SIE as well as SIE-field-actors working on it and other field-actors enabling and/or impeding it. In this arena/ 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. They recognise (but not necessarily follow) shared norms, beliefs and rules. While the field is constituted by SIE-actors and other field-actor's activities, it is also influenced by the outside institutional environment, which can interact, shape, enable or impede the development of the SIE. This institutional environment is constituted by formal as well as informal institutions.

In this case study, we identified a number of different actors as important for the SIE-field development. As the SIE-field is quite closely linked to research and development activities, researchers play a crucial role in shaping the SIE-field as SIE-field actors. SIE-initiatives in many cases have a rather local focus. Networking activities are therefore rather conducted by researchers, who are involved in different formats. Furthermore, looking at the SIE-field development it also becomes clear, that the emergence and institutionalisation of the SIE in Germany is strongly linked to the institutional embeddedness in R&D funding activities of national and federal policy makers. Even if the SIE-field is based on bottom-up attempts, major shifts mainly occurred when large scale funding programmes picked up participatory multi-actors' formats in their research programmes and provided funding. This refers especially to the FONA programme and the new BMWi strategy for Reallabore. These large scale funding programs highlight their character as 'Reallabore' and can therefore be seen as important milestones for the field development.

In the case of the SIE-field 'participatory incubation and experimentation' a number of external shocks as well as societal trends influenced the development of the SIE-field over time. A major impact in the German context was the 2011 Fukushima nuclear catastrophe, as it led to the German nuclear phase out decision and started what is internationally recognised as 'German Energiewende'. Engagement in increasing investments in renewable energy technologies as well as in developing alternative energy pathways started to intensify after the years 2010 and 2011. Concerning societal

trends, the 2015 migration 'crisis' also impacted the field development, as citizen engagement and the awareness for the need as well as the strength participation increased after the summer of 2015. This quite likely also inspired activities in sustainability and energy related topics. In addition, already the liberalisation of the electricity market from 1998 onwards - a formal institutional change - supported the intensification of cooperation between companies and other stakeholders, thereby partly preparing the ground for later participatory developments in the sector.

6.3 What are the enabling and impeding factors for SIE-field-actors and other field-actors to conduct institutional work and change the 'outside' institutional environment?

The analysis in this case study has outlined key changes in the SIE-field over time and identified actors relevant for influencing and actively shaping the SIE-field. We described how the SIE-field increasingly institutionalised during the last year of its development with increasing activities during the last 2 – 10 years. Regarding the factors that influenced the development of the SIE-field over time, we thereby identified key enabling and impeding factors in the German context.

Concerning the enabling factors, especially the longer tradition of participation formats in Germany can be seen as an important component. While participation is more common in areas such as urban development, this tradition has helped to encourage engagements of different actors including collaborative experimentations with sustainable energy pathways. Different forms of societal engagement for example in the context of the migration 'crisis' in 2015 and the Fridays for Future movement starting in 2018 have demonstrated, that there is a strong basis for civil society engagement and bottom-up protests in Germany. While energy might still be considered an 'expert' topic, this broad basis allows to encourage participation of societal actors also in energy related project settings. In addition, the initial pick-up of renewables since 2000 and the first peak of solar installations in Germany was also driven by societal engagement in general and a clash between the old nuclear energy industry and an ecological movement in particular. Furthermore, policy makers in Germany as well as on the EU level seem to be increasingly aware of the potentials of including multiple actors in experimenting with alternative energy pathways. A second enabling factors therefore lies in the German funding structures that picked up the topic especially during the last two years and provide funding frames and programmes which supports the development of diverse multi-actor collaborative formats. Concerning the intuitional work carried out by SIE-actors and SIE-field actors, a key enabling factor is the strong 'lab' metaphor. It works as a boundary concepts that

very different stakeholder groups can easily refer to and therefore allows to build alliances and joint activities between these stakeholders.

On the other hand, funding frames might also impede the multi-actor nature of these formats, as they are traditionally rather technology centred and provide funding only for formalised institutions and actors. Therefore, only specific projects and actors have the possibility to benefit from these structures. A second aspect is the increasing 'projectification' of these formats with short term frames that impede long term learning and the integration of different types of knowledge in an overall strategy. On the level of SIE-initiative, the lack of clearly defined terms and concepts and the consistent use of terms for different formats makes it difficult to distinguish between 'the label' and 'the process'. This often blurs the lines between different approaches and their aims. Furthermore, due the local focus of the activities of many SIE-initiatives, institutional work gets more difficult and actors might more likely concertation on their own activities instead of developing shared standards and joint activities. Concerning the intuitional work carried out by SIE-actors and SIE-field actors, a key impeding factor is that participatory processes have to be seen as extremely time intensive. This aspect, together with the lack of long-term funding possibilities, limits the engagement of SIE-actors and SIE-field actors.

7 Recommendations for our city partners, national and EU policy makers and SIE practitioners

SONNET city partners

- How are energy related issues connected to other topics in participatory processes? Encourage participation in energy related topics and include energy in broader processes of citizen participation.
- Who is involved in experimentation with sustainable energy pathways? Think of experimentation not only as a way for including citizens but also experiment with your own government settings and administrative structures

National and EU policy makers

- Who can apply for funding? Multi-actors' collaborative formats need to involve funding opportunities for multiple actors, instead of being directed to some specific actors only (such as research institutes or businesses)
- How are multi-actor formats embedded in an overall strategy for energy transitions? Participatory multi-actor formats benefit from making their aims and their embeddedness in an overall strategy transparent
- How long does it take? Including multiple actors takes time. It might help to integrate different formats with different speed and provide the timeframes suitable for each format. This should include the possibility for long-term funding to build up good participatory processes.

SIE-field-actors

- What do you mean? Provide clear definitions of the participatory concepts you are working on and make the aims of participatory processes transparent
- Who are you collaborating with? It might help to collaborate with different actors from different fields (e.g. research, businesses) at different stages of the experimentation process

8 Recommendations for our city partners, national and EU policy makers and SIE practitioners

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9 Annex 1

Methodology

Starting point for investigating the SIE-field was contact to researchers, who were engaged in research activities with close relation to the SIE-field. Especially, interviewing researchers with long year experiences in energy related research activities allowed to gain a first overview over the SIE-field and deciding whom to contact for further in-depth interviews. Overall, we were able to conduct 8 in-depth interviews, half of them with researchers engaged in different activities related to the SIE-field under study. Two interviews were conducted with members of policy making institutions, one operating on the European level, one on the national level. Due to the COVID-19 pandemic, it was difficult to get closer contact to SIE-initiatives e.g. through visiting meetings. We conducted two interviews with members of SIE-initiatives. However, the case study would have further benefited from observing meetings of initiatives with the possibility to observe varying opinions within one initiative.

The sampling strategy followed a snowball approach. The first interview was conducted with a researcher working on the SIE-field under study. This was followed by an interview with a policy maker, who has long time experience with working in the SIE-field. These two initial interviews helped to explore the field and to identify relevant SIE-initiatives and SIE-field actors for further interviews. The interviews furthermore helped to identify important documents that were reviewed for this case study. Overall we reviewed about 6 policy documents more in-depth, most of them related to policy lines for funding (such as BMWi an BMBF funding programs for energy research). The search for academic literature that we reviewed for this report also started from the suggestion of researchers interviewed. Especially academic networks such as the network 'Reallabore der Nachhaltigkeit' (as mentioned above) provided literature suggestions on their websites. These suggestions were then the entry point to explore academic literature on the field development (see detailed list of reviewed documents below). Furthermore, the approaches is inspired by the fruitful exchange with the SONNET researchers working on the SIE-field in the Netherlands and Poland.

The SIE under study is increasingly researched in different research fields such as sustainability transitions research, urban development, innovation studies, energy research and policy studies. Taking into account the time constraints of this study (1,5 months), I had to focus on identifying overall changes and their interrelations. Due to the time restrictions, it was not possible to research all debates in the different research fields mentioned in-depth National funding programmes and policies therefore served as the baseline for identifying changes, which were then traced back to the

actors engaged and their aims. The timelines were developed in the process of conducting the research and served in the last three interviews as a starting point for discussing the SIE-field-development. Therefore, the interviews were shown the timeline and then asked about their opinions concerning changes in the SIE-field.

List of interviewees

Code interview	Empirical description of case	Type of actor according to SONNET	Date of interview	Duration of interview	Interviewer
DE_PIE_1	Researcher involved in projects on Living Labs in Germany	SIE-field actor, Researcher	22/10/2020	54 min	Maria Stadler
DE_PIE_2	Member of Programming Initiative (European level)	SIE-field actor	06/11/2020	89 min	Maria Stadler
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	Maria Stadler
DE_PIE_4	Researcher involved in energy related research projects, including 'Reallabor'-formats	SIE-field actor, Researcher	18/11/2020	32 min	Maria Stadler
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	Maria Stadler
DE_PIE_6	Researcher involved in transdisciplinary research related to sustainability	SIE-field actor, Researcher	02/12/2020	75 min	Maria Stadler
DE_PIE_7	Researcher involved in projects in projects on regulatory sandboxes	SIE-field actor, Researcher	03/12/2020	76 min	Maria Stadler
DE_PIE_8	Member of project management agency (National level)	SIE-field actor	04/12/2020	61 min	Maria Stadler

List of meetings and events attended

Due to the corona pandemic, it was not possible to attend meetings personally. However, two online events could be attended. One more event was an older recorded webinar that was available online.

Event name	Event organiser	Type of event	Date of event	Who attended
Wie kann ein digitales Web-Tool Sachsen helfen, nachhaltiger zu werden?	SEBIT, Zukunftsstadt Dresden	Online-Workshop	26/11/2020	Maria Stadler
post-projectification – new normal in urban experimentation	IST conference session	Conference	20/08/2020	Maria Stadler
urban lunch talks #7 – from Test to Success	JPI urban Europe	Webinar (recorded)	08/10/2ß2ß	Maria Stadler

List of Documents reviewed

Author name	Document name	Document type	Year
Ballon, Pieter; Schuurman, Dimitri	Living labs: concepts, tools and cases	conference contribution	2015
Bauknecht, Dierk; Bischoff, Thore Sören; Bizer, Kilian; Führ, Martin; Gailhofer, Peter; Heyen, Dirk Arne et al.	Exploring the pathways: Regulatory experiments for sustainable development – An interdisciplinary approach	Journal article	2020
Bischoff, Thore Sören; Leyen, Kaja von der; Winkler-Portmann, Simon; Bauknecht, Dierk	Regulatory experimentation as a tool to generate learning processes and govern innovation. An analysis of 26 international cases	Journal article	2020
BMBF	Zukunftsstadt. Strategische Forschungs- und Innovationsagenda	Policy document	2015
BMUB	LEIPZIG CHARTA. zur nachhaltigen europäischen Stadt.	Policy document	2007
BMWi	7. Energieforschungsprogramm der Bundesregierung	Policy document	2018
BMWi	Reallabore als Testräume für Innovation und Regulierung. Innovation ermöglichen und Regulierung weiterentwickeln.	Policy document	2018
BMWi	Freiräume für Innovationen. Das Handbuch für Reallabore	Policy document	2019

Bylund, Jonas	Joint programming for urban transformations: the making of the JPI Urban Europe Strategic Research and Innovation Agenda.	Journal article	2020
Defila, Rico; Di Giulio, Antonietta	Transdisziplinär und transformativ forschen. Eine Methodensammlung.	book	2018
Defila, Rico; Di Giulio, Antonietta	Wissenschaftspolitische Empfehlungen zum Forschungs-und Förderformat Reallabor	Policy brief	2019
Erdmann, Lorenz; von Geibler, Justus; Dönitz, Ewa; Stadler, Karin; Zern, Rubina	Living Labs für eine Green Economy 2030. Langfassung mit Roadmaps in den Konsumfeldern Wohnen, Einkaufen und Mobilität. Ergebnis des Arbeitspakets 7 (AP 7.4) im INNOLAB Projekt: „Living Labs in der Green Economy: Realweltliche Innovationsräume für Nutzerintegration und Nachhaltigkeit	Report	2018
Horizon Europe	Draft Work programme 2021-2022	Policy document	2020
JPI Urban Europe	The knowledge hub for urban transitions	Leaflet	(unknown)
McCrory, Gavin; Schäpke, Niko; Holmén, Johan; Holmberg, John	Sustainability-oriented labs in real-world contexts: An exploratory review	Journal article	2020
Parodi, Oliver; Beecroft, Richard; Albiez, Marius; Quint, Alexander; Seebacher, Andreas; Tamm, Kaidi; Waitz, Colette	Von „Aktionsforschung“ bis „Zielkonflikte“ – Schlüsselbegriffe der Reallaborforschung	Journal article	2016
Schneidewind, Uwe	Urbane Reallabore - ein Blick in die aktuelle Forschungswerkstatt	Article	2014
Scholl; Christian, Ablasser; Gerhard, Eriksen; Mette Agger, Baerten; Nik, Blok; Johanna, Clark et al.	Guidelines for Urban Labs	Report	2017
Schuurman, Dimitri; Marez, Lieven de; Ballon, Pieter	Living Labs: a systematic literature review	Journal article	2015
Wagner, Felix; Miller, Eric	The Background and History of Real-World Laboratory Funding in Baden-Württemberg	Journal article	2018
WBGU	Welt im Wandel. Gesellschaftsvertrag für eine Große Transformation	Report	2011

10 Annex 2

Detailed SIE-field timeline

Phases, Milestones in the development of research and innovation policy after 1945, identified by Polt et al. (in press)

1980s	Innovation - Policy Trend	Innovation policies focus on key technologies	(Polt et al. in press, p. 32)
1990s	Innovation -Policy Trend	territorial diffusion-oriented system approach in innovation policies	(Polt et al. in press, p. 32)
2000s	Innovation -Policy Trend	sectoral system approach	(Polt et al. in press, p. 32)
2010s	Innovation -Policy Trend	Mission oriented innovation policies, social innovation	(Polt et al. in press, p. 32)

Phases of the German electricity transition (1986 – 2016), identified by Geels (2020)

1986 -1998	Energy - Policy Trend (GER)	'Niche innovations were nurtured in the context of a stable regimes'; wine turbines and PV supported after the 1986 Chernobyl shock	(Geels 2020, pp. 14–15)
1998 - 2009	Energy - Policy Trend (GER)	Red-Green coalition government: decision to phase out nuclear energy, renewable energy act (EEG, 2000)	(Geels 2020, pp. 15–16)
2009 - 2016	Energy - Policy Trend (GER)	Diffusion of renewable energy (feed-in-tariffs, declining RET prices), Fukushima and financial crisis as further landscape shocks	(Geels 2020, pp. 17–18)
2017 on	Energy - Policy Trend (GER)	government efforts to slow RET expansion and support utilities	(Geels 2020, p. 18)

Energy- and climate related policy events (national)

1990	Policy event	Federal Cabinet adopts its first emissions reduction target: 25 to 30 percent fewer CO_2 emissions by 2005, compared to 1987 levels	(Wettengel 2020)
1991	Policy event	New legislation introduces feed-in tariffs for renewable power	(Wettengel 2020)
2000	Policy event	Renewable Energy Sources Act: generation of renewable electricity encouraged through feed-in-tariffs	(Agora Energiewende 2015)
2002	Policy event	Decision on nuclear phase out (nuclear consensus)	(Agora Energiewende 2015)

2007	Policy event	German climate and energy policy package (greenhouse gas reduction 40% compared to the levels of 1990)	(BMU 2007)
2010	Policy event	Energy concept of the German government (for an environmentally friendly, reliable and affordable energy supply)	(BMWi 2010)
2011	Policy event	Nuclear phase out Law and announcement to close all of German nuclear power plants by December 2022	(BGBl 2011 I 43 S. 1704-1705)
2014	Policy event	Renewable Energy Sources Act (EEG 2.0): from specified feed-in tariffs to system of tendering	(BGBl 2014 I 33 S. 1066–1147)
2016	Policy event	Smart metering and the Energy Transition Digitisation Act	(BGBl 2016 I 43 S. 2034-2064)
2017	Policy event	Renewables reform The switch from set feed-in tariffs to auctions for renewables enters into force	(BGBl 2017 I 49 S. 2532-2539)
2019	Policy event	Climate action law Germany's first climate law makes emissions reduction legally binding	(BGBl 2019 I 48 S. 2513-2521)

Energy- and climate related policy events (international)

1997	Policy event	Kyoto Protocol: requires to cut CO2 emissions	(Wettengel 2020)
2007	Policy event	Leipzig Charter (on sustainable urban development goals)	(BMUB 2007)
2015	Policy event	Paris Agreement - UN Framework Convention on Climate Change with long-term temperature goal	(United Nations 2015a)
2015	Policy event	Agenda 2030 - Sustainable Development Goals (SDGs)	(United Nations 2015b)
2020	Policy Event	EU funding initative on Energy citizenship and transition super labs	

Field events (mentioned by interviewees and identified via Desktop research)

2006	Field Event	Frist attempts on EU level: EU commission declares support of Living Labs, ENOLL was established (see: https://enoll.org/)	(Schuurman et al. 2015)
2008 / 2009	Field Event	Design study by the European Commission shaped the term Living Lab: Design Study for the LIVING LAB Research Infrastructure, to research human interaction with, and stimulate the adoption of, sustainable, smart and healthy innovations around the home (see: https://cordis.europa.eu/project/id/212498)	(Liedtke et al. 2012) Interview DE_PIE_1

2010	Field Event	joint programming initiative (JPI) Urban Europe was established, Nearly half of the 73 JPI Urban Europe funded projects apply urban living labs approaches (see: https://jpi-urbaneurope.eu/)	(JPI Urban Europe)
2013	Field Event	Baden-Württemberg Ministry of Science, Research and Arts announced a new funding line for real-world labs entitled BaWü Labs, the first worldwide of its kind and scale (see: https://mwk.baden-wuerttemberg.de/de/forschung/ forschungspolitik/wissenschaft-fuer-nachhaltigkeit/reallabore/)	(Wagner and Miller 2018)
2014	Field Event	ITA (innovation and technology analysis) research program, forum and congress (see: https://www.bmbf.de/de/innovations-und-technikanalysen-ita-937.html)	(BMBF 2017)
2015	Field Event	Initiative by the Federal Ministry of Education and Research (BMBF) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to establish the Innovation platform 'Zukunftsstadt' (future city). The initiative includees the 'experimental implementation of promising concepts in urban real world laboratories' (see: https://www.bmbf.de/de/zukunftsstadt-566.html)	(BMBF 2015)
2018	Field Event	BMWi Strategy and funding for real world laboratories, including (see: https://www.bmwi.de/Redaktion/DE/Dossier/reallabore-testraeume-fuer-innovation-und-regulierung.html)	(BMWi 2018b, 2019b)
2019	Field Event	The Karlsruhe Institute of Technology, Wuppertal Institute, Leuphana University Lüneburg and Ecornet have launch the "Network Real Laboratories for Sustainability" (see: https://www.reallabor-netzwerk.de/news/)	
2019	Field Event	Network 'Reallabore' by the federal Ministry for Economic Affairs and Energy established and first meeting in Berlin (see: https://www.bmwi.de/Redaktion/DE/Veranstaltungsarchiv/ 20190828-netzwerktreffen-reallabore.html)	

Projects and initiatives (identified via Desktop research)

2006-2013	Projekct / Initiative	IBA Hamburg puts a focus on participatory urban development processes and sustainabality (see: https://www.iba-hamburg.de/en/)	Interview DE_PIE_2
2008	Project / Initiative	Since acquiring the property in 2008, EUREF AG has been developing the city district around the “Gasometer” (Gasholder) into a real-life	

		laboratory for the shift to renewable energy. (Zukunftsorte Berlin – urban development projects, Gründung der EURF AG) (see: https://euref.de/en/euref-campus_en/)	
2009	Initiative	Nexthamburg (since 2012: non-profit recognized association); Pilot project of the national urban development policy funded by the Federal Ministry of Transport, Building and Urban Development from 2009 to the beginning of 2012. Aims for open Civic Innovation (see: https://nexthamburg.de/)	(McCrory et al. 2020)
2010	Project	InnovationCity Ruhr, Labor Bottrop: the "Labor Bottrop" demonstrates what a climate-friendly urban redevelopment can look like, taking into account the safeguarding of the industrial site (see: https://www.innovationcity-bottrop.de/index.php?id=3)	
2011	Project	Quartier Zukunft – Labor Stadt (see: https://www.itas.kit.edu/projekte_paro11_quazu.php)	Interview DE_PIE_1
2011	Project	Effizienzhaus Plus in Berlin, Fasanenstraße, (see: https://www.bmi.bund.de/DE/themen/bauen-wohnen/bauen/energieeffizientes-bauen-sanieren/effizienzhaus-plus/effizienzhaus-plus-node.html)	Interview DE_PIE_1
2015-2019	Project	Living Lab Walldorf: community of electricity producers and consumers who exchange experiences and energy with one another. (see: http://www.living-lab-walldorf.de/projekt/)	
2017 - 2020	Project	Start of the project SINTEG: "In the funding programme "Smart Energy Showcase - Digital Agenda for the Energy Transition" (SINTEG), transferable model solutions for a secure, economical and environmentally friendly energy supply with temporarily 100% electricity generation from renewable energies are developed and demonstrated in large-scale model regions" (zeitlich befristeten „Experimentieroptionen", SINTEG als Reallabor) (see: https://www.sinteg.de/en/)	Interview DE_PIE_4
2017	Initiative	dynamis was founded in 2017 by the innogy Foundation for Energy and Society, the Institute for Advanced Sustainability Studies (IASS) and the 100 percent renewable foundation.; dynamis deals in a transdisciplinary way with the social dimension of the energy transition and issues that have to be tested in labs	https://www.dynamis-online.de/ueber-uns/

2019-2021	Project	Project REraGI aims for testing and evaluating regulatory options in fields with high technological or social innovation dynamics. (see: https://reragi.wordpress.com/reragi-englisch/)	

Broader societal Trends

2000s	societal trend	In the end of the 00s, the term Living Lab first appeared; the term Reallabor developed later mainly in the German context	Interview DE_PIE_1
2019	societal trend	Climate change for the first time as number one political topic	(Agora Energiewende 2020)

Environmental or societal shocks

2008-2009	Shock	Financial-economic crisis.	
2011	Shock	Fukushima nuclear catastrophy	
2015-2016	Shock	European migrant crisis	
2020	shock	Corona Pandemic	