www.oeko.de

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Working Paper

Experimenting with policies: Regulatory Innovation Zones as a tool for sustainability transitions

Oeko-Institut Working Paper 4/2020

Prof. Dr. Dierk Bauknecht
Dirk Arne Heyen
Christoph Heinemann
Dr. Peter Gailhofer

Öko-Institut e.V. / Oeko-Institut e.V.
info@oeko.de
www.oeko.de

Geschäftsstelle Freiburg / Freiburg Head Office
Postfach / P.O. Box 17 71
79017 Freiburg. Deutschland / Germany
Phone: +49 761 45295-0
Fax: +49 761 45295-288

Büro Darmstadt / Darmstadt Office
Rheinstraße 95
64295 Darmstadt. Deutschland / Germany
Phone: +49 6151 8191-0
Fax: +49 6151 8191-133

Büro Berlin / Berlin Office
Borkumstraße 2
13189 Berlin. Deutschland / Germany
Phone: +49 30 405085-0
Fax: +49 30 405085-388

Working Paper

Experimenting with policies: Regulatory Innovation Zones as a tool for sustainability transitions

Prof. Dr. Dierk Bauknecht
Christoph Heinemann
Dirk Arne Heyen
Dr. Peter Gailhofer

Working Paper 4/2020 Öko-Institut e.V. / Oeko-Institut e.V.

September 2020

Download: www.oeko.de/fileadmin/oekodoc/WP-Regulatory-Innovation-Zones.pdf

Die Working Paper Series des Öko-Instituts ist eine Sammlung wissenschaftlicher Beiträge aus der Forschungsarbeit des Öko-Instituts e.V. Sie präsentieren und diskutieren innovative Ansätze und Positionen der aktuellen Nachhaltigkeitsforschung. Die Serie ist offen für Arbeiten von Wissenschaftlerinnen und Wissenschaftlern aus anderen Forschungseinrichtungen. Die einzelnen Working Paper entstehen in einem sorgfältigen wissenschaftlichen Prozess ohne externes Peer Review.

Oeko-Institut's Working Paper Series is a collection of research articles written within the scope of the institute's research activities. The articles present and discuss innovative approaches and positions of current sustainability research. The series is open to work from researchers of other institutions. The Working Papers are produced in a scrupulous scientific process without external peer reviews.

Zusammenfassung

Dieses Papier befasst sich mit Regulierungsexperimenten als einer Möglichkeit, neue Regulierungsoptionen als wichtigen Beitrag in Transformationen zu mehr Nachhaltigkeit zu entwickeln und in der Praxis zu testen. Dies geschieht vor dem Hintergrund der Rolle von Experimenten in Transformationsstudien, in der Politikwissenschaft sowie aus einer rechtlichen Perspektive von Rechtsinnovationen. Das Papier stellt eine Typologie von vier verschiedenen Arten von Experimenten mit unterschiedlichen Rollen für die Regulierung vor, einschließlich praktischer Beispiele. Eine Schlüsselfrage ist, ob die Regulierung nur den Hintergrund für technische Pilotprojekte bildet oder ob die Regulierung selbst zum Hauptgegenstand eines Experiments wird. Für letzteren, bisher wenig erforschten Typus stellt das Papier die Regulatorische Innovationszone (RIZ) als ein Konzept für das Experimentieren mit Regulierung vor. Es wurde ursprünglich im Kontext von Smart Grids entwickelt, ist aber auf andere Bereiche anwendbar. Das Konzept wird im Hinblick auf die konkreten Gestaltungsmöglichkeiten und Herausforderungen in der Umsetzung von Regulierungsexperimenten diskutiert.

Abstract

This paper deals with regulatory experiments as a way to develop and test in practice new regulatory options as an important contribution to sustainability transitions. This is set against the background of the role of experiments in transition studies, in political science as well as a legal perspective of innovations in law. The paper presents a typology of four different types of experiments with different roles for regulation, including practical examples. A key issue is whether regulation only provides the background for technical pilots or whether regulation itself becomes the main object of an experiment. For this latter type, which is under-researched so far, the paper introduces the Regulatory Innovation Zone (RIZ) as a concept for experimenting with regulation. Originally developed in the context of Smart Grids, it can be applied to other fields. The concept is discussed with regard to the concrete design options and implementation challenges of regulatory experiments.

Table of Contents

List of Tables

1 Introduction

The sustainable transition of socio-technical systems like energy or mobility is based on innovations. Developing these innovations requires new policy strategies (Köhler et al. 2019; Weber and Rohracher 2012).

Developing and testing innovative solutions on a small-scale in purpose-built experiments is a key feature of transition and innovation strategies. It complements other key strategies, such as the interactive development of joint societal visions (Kemp and Loorbach 2006). This important role of experiments is reflected in such concepts as strategic niche management (Hoogma 2002; Schot and Geels 2008) and transition labs or real-world laboratories (Caniglia et al. 2017; Nevens et al. 2013).

From a governance perspective experiments have been identified as a key strategy for reflexive governance, which in turn is important to address sustainability and sustainability transitions (Voß et al. 2006). Hildén et al. (2017) provide an overview of various pieces of research that motivate or investigate the role of experiments.

The very concept of socio-technical transitions indicates there is a need not just for technical innovations but also social innovations, including public policy (Geels 2002b; Kemp and Loorbach 2006; Voß and Kemp 2006). Taken together with the role of experiments for developing innovations, this means that experiments are not just a governance approach that becomes particularly relevant in the context of transitions. Public policy itself can and should become an object of experiment. The transition literature acknowledges that a broad range of policy instruments, including more traditional ones, are relevant for transitions (Köhler et al. 2019, p. 9). Consequently, experiments with the various elements of regulatory frameworks[1] and testing how these instruments need to evolve with regard to transitions can be an important element in the transition toolbox.

The above-mentioned approaches, however, tend to neglect the potential role of regulation as the object of experiment. It is standard in the case of technical innovations, and increasingly also in the case of social innovations, that new concepts are first developed, tested and modified on a small scale (e.g. pilot and demonstration projects) before being “rolled out” and applied more widely. This is typically not the case for innovations in the regulatory framework, especially not in the sense of tailor-made spaces for experimentation.

The focus of this contribution is on experiments for developing regulation. The paper discusses regulatory experimentation as a means to deliberately deviate from the regulatory framework in order to experiment with a new framework. This provides an opportunity for experimenting with regulation itself, i.e. various regulatory options can be tested, developed in practice and compared. In our definition of experiments, we do not refer to general mechanisms of policy learning or to an understanding whereby each new policy implemented can be interpreted as a regulatory hypothesis to be tested in practice and revised based on its effects.

We follow the understanding put forward by Heilmann (2008, p. 3): “Policy experimentation is not equivalent to freewheeling trial and error or spontaneous policy diffusion. It is a purposeful and coordinated activity geared to producing novel policy options that are injected into official policymaking and then replicated on a larger scale, or even formally incorporated into national law”. Similarly, McFadgen and Huitema (2016) define policy experimentation as “a temporary, controlled field-trial of a policy-relevant innovation that produces evidence for subsequent policy decisions”.

[1] “Regulatory” is used here in a broader sense, i.e. not just, for example, for economic regulation of natural monopolies, but regulation as governance by the state or public policy in a general sense. Regulatory experiments thus also refer to general policy experiments. This is also the meaning applied in Section 4 on the “Regulatory Innovation Zone”.

Experiments in this understanding are purpose-built, temporarily delimited and they address specific regulatory options. They are restricted to specific areas, such as a city or district or an electricity grid operator, and the results need to be upscaled. However, our focus is on top-down instruments, i.e. the experiment is initiated by central rather than local governments and the instruments are supposed to be introduced country-wide afterwards, but first tested locally. This is an important difference to the bottom-up local and regional experiments, which have been the focus of previous studies and reviews (Hildén et al. 2017).

Addressing the shortcomings of the debate so far, the objective of the paper is to explore such top-down regulatory experiments and their practical implementation, while differentiating them from other kinds of experiments. As Hildén et al. (2017, pp. 3-4) have emphasised, the design and governance of experiments are crucial for their success.

The paper introduces the Regulatory Innovation Zone (RIZ) as a concept for experimenting with regulation. Concrete design options and implementation challenges of regulatory experiments are discussed. The concept was first developed within the context of implementing Smart Grids in the energy sector (Bauknecht et al. 2015), specifically within the Smart Grids roadmap for the German federal state of Baden-Württemberg (Smart Grids-Plattform Baden-Württemberg 2013). The integration of renewable energies into electricity supply is a case requiring significant regulatory innovation, particularly with regard to the interaction between the power network and the power market. The considerations on design options and implementation challenges can also be applied to other sectors.

The contribution looks at regulatory experiments in three steps and from different perspectives.

Section 2 provides the conceptual background and explains how regulatory experiments can be positioned in the literature. It does so by drawing on three strands of literature from different backgrounds: transition research, political science, and law.

Section 3 presents a typology of experiments that differ according to the role of regulation. It shows that regulatory exemptions can enable technical pilots. There can also be regulatory experiments that make regulation itself the main object of the experiment. Based on the typology, the section presents practical examples.

Section 4 looks in more detail at those experiments where regulation is the main object. For this purpose, it introduces the RIZ concept as a practical and application-oriented instrument with which such regulatory experiments can be conducted. The section presents the background of the concept as well as its central elements and design options. It also addresses implementation challenges, including legal issues.

2 Background

This section starts by introducing important transition research perspectives on innovation (niches) and experiments from the multi-level perspective, strategic niche management and different transition lab concepts. While these perspectives deal in depth with innovations and experiments, they fall short when it comes to the role of regulation, particularly its potential role as an object of innovation processes and experiments. Therefore, the section also provides insights from political and legal sciences on regulatory innovations.

2.1 Socio-technical innovations, experiments and the role of regulation in transition research

The sustainable transition of socio-technical systems is characterised by the co-evolutionary change of various system elements (Geels 2005). In addition to technical innovation, the development of material infrastructure, values, guiding principles and social innovation, the development of regulations and institutions plays a central role in such transitions.

Transition processes are described in the MLP as interactions between landscape, regime and niche levels (Geels 2002a). While the structures are particularly well established on the regime level, niches are more flexible and play a critical role in social change. Niches should not be mistaken for individual innovation or experiment; rather, they are made up of actor networks and innovation activities. Innovations play a major role in the development of niches and niches are organised around particular ideas or solutions, for instance new technologies or services. Social or technical innovation can occur within niches relatively independently from existing regimes, potentially leading to a change in the regime (Smith and Raven 2012).

Niches can arise incidentally or they can be intentionally created and supported, such as when a niche innovation offers a solution to a local problem within the regime. Through a process of “niche cumulation” niches can form the core of a new regime. The strategic development of niches – and experimenting with socio-technical innovations within them – forms a central element of the governance of system transitions. Concepts such as transition experiments (Bosch 2010; Loorbach and Rotmans 2010) and strategic niche management can be utilised here (Hoogma 2002).

Similar concepts, often with a focus on social (and socio-technical) innovations, have emerged over the last few years in the realm of transdisciplinary and transformative “action research” (see Schäpke et al. 2017, for an overview): urban transition labs (Nevens et al. 2013), living labs (Liedtke et al. 2015; Voytenko et al. 2016), social innovation labs (Westley et al. 2014) and, with increasing popularity especially in Germany, real-world laboratories (*Reallabore*) (Schäpke et al. 2017; Schneidewind and Singer-Brodowski 2013; WBGU 2016). Schäpke et al. (2017) mention five characteristics of real-world labs: a) contribution to transition, b) experiments as central research method, c) transdisciplinarity as core mode of research, d) scalability and transferability of results as an aim, and finally e) places and spaces of scientific and societal learning.

Despite certain differences, for example with regard to researchers’ control of intervention (Caniglia et al. 2017), these approaches share a focus on using experiments in real-world settings so as to understand, facilitate and/or shape societal transitions towards sustainability (Schäpke et al. 2017; Schäpke et al. 2016). Reflexivity and mutual learning play a key role in creating positive outcomes that are replicable, transferable to other settings and up-scalable to society at large (Luederitz et al. 2016).

What is the role of regulation in such experiments? In societal discourses, innovation is often limited to technical innovation. Yet even in situations where a predominantly technical innovation is present,

niches and experiments within niches can go beyond offering simple technical improvements by allowing for a technology to develop that can function in the real world and will hold up to the demands of the social and institutional context, including the regulatory framework. These are "configurations that work" (Rip and Kemp 1998). Social and institutional aspects are addressed, as well as the necessary networks of actors developed through the niche and issues such as the interaction between a technical innovation and its specific users. These aspects are tested and constructed complementarily to technical developments, such that the innovation functions both technically and as a regime innovation. Thus, regulation can play a role even in rather technical experiments but does so typically not as the object of the experiment.

Moreover, while the literature does discuss the governance *of* (socio-technical) experiments, experiments *with* governance (distinction from Hildén et al. 2017) have been a largely neglected topic (Bos and Brown 2012; Kivimaa et al. 2017). While research on the role of regulation within transitions has generally proliferated in recent years (see Köhler et al. 2019), regulation is still mainly analysed as enabling or obstructing framework conditions for socio-technical innovations and experiments (Bosch 2010, p. 187). While some attention has been paid to how niche actors may be able to change existing regulations towards rules favouring their preferred niches (Köhler et al. 2019, referring to Smith and Raven 2012, and Raven et al. 2016), the idea of systematically testing regulatory innovations has not been established in the literature, let alone reflected in detail. Rare examples within the transition literature are Bos and Brown (2012), Kivimaa et al. (2017), Laakso et al. (2017), Matschoss and Repo (2018). While Kivimaa et al. (2017) provide a literature review on "experiments in climate governance", only a small number of cases (12) detected explicitly or implicitly deal with governance (instrument or process) innovations. At least, experimental governance approaches and how they support transitions have been identified as a relevant issue for future sustainability transition research (Köhler et al. 2019).

2.2 Experiments in a political science perspective

While the previous section has explored the role of experiments in transition research, this section goes on to further illuminate the issue of regulatory innovation and experiments from a political science perspective. Here experimentation is seen mainly as a research method and rarely as a governance approach (Huitema et al. 2018); and when it has it is often focused on incremental policy reforms (Hildén et al. 2017).

Relevant discussions include the role of experiments as a governance strategy in the context of reflexive governance and the development of regulation in an innovation process that can be based on experiments.

In the literature on reflexive governance, experiments are considered as a strategy to deal with uncertainty and unintended side-effects. Reflexive governance assesses the intended as well as unintended effects of regulation and integrates this knowledge into future regulation. Governance structures need to adapt to changing regulatory objectives and contexts. Reflexive governance is about enabling learning and adaptability, including regulatory learning and adaptability in the realm of regulation itself. This is reflected in many discourses, such as experimentalist governance (Sabel and Zeitlin 2012). The transition discourse refers to reflexive governance and reflexivity failure has been identified as one transformational system failure that needs to be addressed by appropriate innovation policy approaches, including experiments (Weber and Rohracher 2012). Experiments can be one way to deal with "the uncertainty and ignorance about transformation dynamics and effects of intervention" (Voß and Kemp 2006, p. 18). Experiments and experimental learning also play a role in the literature on laboratory federalism and democratic experimentalism (for an overview see Bauknecht et al. 2019), as well as evidence-based policy-making (Sanderson 2002). At the same

time, there is an argument that experiments cannot simply be seen as a way to find out “what works” in policymaking. Rather, the experiment itself influences governance and it is important to keep in mind the politics of the experiment (Voß and Simons 2018).

Another relevant perspective is to look at the development of regulatory instruments as an innovation process. In the previous section we have argued that various approaches to experiments focus on technical or socio-technical innovations and largely neglect regulatory innovation. In the case of new regulatory options it is often assumed these can be freely implemented, for example to shape technical innovation niches. It is then seen as unnecessary to develop them through an innovation process similar to that of technical innovations. However, the development of regulation should not be viewed simply as a framework for technical innovations, but rather, as an innovation process itself. If we take the multi-dimensional nature of regimes and the above-mentioned understanding of evolutionary innovation seriously, it becomes evident that non-technical regime elements and thus the regulatory framework arise from innovation processes.

An example of an innovation perspective on the development of regulation can be found in Voß (2007), who looks at the innovation processes through which emissions trading and grid regulation have emerged. These instruments are generated from niches, and then developed through various processes into generally recognised instrument options, to be implemented in governance regimes. This evolution is called the “policy innovation journey”. Experiments in which the instruments were tested also played a role in this process. The transition of regulatory regimes is an open innovation process, in which both the design and the practical implementation of regulation are developed, mutually influencing each other.

From a policy-making perspective, it is essential not to get caught up in the *description* of these innovation processes and the role of experiments. It is also important to draw conclusions for the *design* of the policy instruments and not to leave their development up to chance.

Purpose-built regulatory experiments can be one conclusion from both reflexive governance as well as the innovation perspective on the development of regulation. Regulatory experimentation offers one possibility for increasing reflexivity and for influencing the regulatory innovation process.

2.3 Innovation in law: drivers of change and the rationale for legal experimentation

In innovation theory law is often viewed as a driver or obstacle to social and technical innovations (Edgel and Vogl 2013; Eichelberger 2012; Moyse 2016). Accordingly, law can be seen as a precondition or a political instrument to promote goals (such as technological innovations) or prohibit unwanted behaviour. However, in line with the perspective introduced in the previous section, legal theorists and sociologists have long stressed that law is not only a tool to promote (or impede) change, but is also an object of dynamic and potentially innovative evolution processes itself (see Ehrlich 1913; Hoffmann-Riem 2016a; Jasanoff 2008; Bora 2017). Such innovations in the law originate from diverse actors and are driven forward by different factors. Legislators may pursue the solution of problems by changing existing legal rules or by passing new ones. Independently from these legislative processes, many of the innovative dynamics in the law take place in everyday legal practice: courts, legal science and practice (e.g. by law firms) participate in the interpretative innovation, invention and diffusion of legal ideas (cf. Kumm 2012; Hoffmann-Riem 2016b; Jasanoff 2008; Hornung 2015).

Apart from this professional innovation in the law, an important factor for the outcome of legal developments is to be found in social practices surrounding the law. The ways in which citizens, businesses or public actors understand and make use of legal obligations, rights and liberties in their interactions is important not only for the question if a legal norm or institution can be effective at all

(or, for example, is being evaded) (cf. Bilz and Nadler 2014), it is crucial for the practical meaning of legal provisions themselves. For example, citizens might interpret certain rules or regulations in accordance with social values or particular goals, which might differ from the objective the rule's legislator originally pursued. The substantial outcome of legal norms in everyday life may, in turn, make legislators or judges try to adapt the law to better fit practical needs and circumstances (Hoffmann-Riem 2016a, pp. 518-532). Such mechanisms have been observed, for example, in the context of the energy transition. Heldeweg describes a case in which the framing or the definition of provisions of a shared solar programme by large economic actors led to an unintended output of the programme. Contrary to the original goal, which aimed at expanding access to solar incentives to groups previously excluded, the scheme became a vehicle for the recruitment of corporate and other large-scale subscribers looking to find a hedge against future energy price increases (Heldeweg 2017, p. 21).

The practical outcome of regulative measures thus not only depends on the functioning of economic preconditions of these measures (e.g. incentives), but also on the disputed definition or framing of normative questions, prominently the correct definition of the objective of the regulation.[2] The factors that condition the practical outcome of legal interventions, as Carbonara et al. (2008, p. 839) assert, include individual values and social norms as aspects of the intrinsic motivation of behaviour. An accurate understanding of these normative conditions of the success of innovative regulations with respect to their intended objective is, of course, crucial for their adequate legal design.

The intention to promote innovations on the one hand and the difficulties to predict the practical effects of legal rules in certain social or economic surroundings on the other have led researchers to transfer methods of experimental methodology to the law (cf. Carbonara et al. 2008). "Experimentation clauses" integrated into laws or provisions provide a way to test new legislation in geographically and/or temporally delimited trials and to cope with the contingencies of legal and societal innovations.

While experimentation clauses primarily focus on the legal facilitation of technical or economic innovations, the instrument of the RIZ (Section 4) concentrates on the very evolution "in the law", i.e. on the adaptation of regulatory instruments in the course of their practical use in social and economic contexts. In addition to the opportunity to practically test the feasibility of governance procedures and economic mechanisms and the facilitation of technical and social innovations, RIZs can be seen as tools to assess the normative functionality of innovative regulation. The experiment can help to clarify, if a given regulation is normatively functional, i.e. sufficiently aligned to the values and norms in a given social or economic context and resilient against framings and/or definitions of its provisions by diverse actors which contradict the goal originally pursued (cf. Heldeweg 2017; Carbonara et al. 2008, p. 839; Waldron 2001). Practically, placing the focus on the "normative resilience" and alignment of a regulation may help to substantiate the legal definition of a regulatory objective.

[2] In Heldeweg's example, two conflicting teleological "master frames" were identified: Firstly, that of "expansion" measured by industry and energy indicators, secondly, "democratisation", i.e. economic democracy or participatory democracy, cf. Heldeweg (2017, p. 20).

3 Typology of experiments: roles of regulation

This section systematises the different roles of regulation in experiments by distinguishing four different types. The purpose is to better understand the role of regulation in actual experiments. Therefore, we provide a range of practical examples. This represents a useful clarification, scientific as well as political, given that different types and understandings are often mixed up in debates (see the SINTEG example below).

With the role of regulation as the main criterium, our typology differs from existing typologies: those of governance experiments (see Laakso et al. 2017, for an overview); the specific typology of climate governance experiments by Kivimaa et al. (2017)[3]; and that put forward by Caniglia et al. (2017)[4].

We introduce a typology that organises experiments in sustainability science according to type of control over interventions and subjects of experimentation

In Type I regulation is not specifically addressed but represents an unmodified framework condition for social and technical experiments. Most pilot projects across different sectors fall under this type. In Type II it is acknowledged that regulation – if it remains unchanged – can be a barrier for experiments. Regulation is therefore adapted to enable such experiments. Much is currently happening around this type of experiment, especially with regard to digitalisation, but also in the energy sector. However, regulation is still merely considered as a framework condition rather than the object of the experiment.

It is only in Type III that the key argument made in Section 2 is taken up, namely that regulation itself can be the object of the experiment. This type of experiment develops and tests future regulation. This kind of experiment has rarely been deliberately taken up in practice and has received little attention in transition research (see Section 2). We hence develop it further in Section 4.

While in Type III the focus is on experimenting with new regulatory options, Type IV goes one step further. It combines regulatory and broader socio-technical experiments. This type is included here as new regulation and socio-technical innovations often need to be jointly tested. Still, Section 4 focuses on Type III, as the focus is on the challenges associated with regulation as the main object of the experiment. Generally, from a regulatory perspective there is an increasing complexity from Type I to Type IV.

In practice there can be some overlap between the experiment types. Since Type III experiments, for instance, are implemented in the real world, other socio-technical elements are likely involved. However, the key object is the regulatory experiment. In the green arrow example below under Type III, the main point from our perspective is that a new rule is tested and not whether the green light as a material artefact works. Similarly, in Types I and II, government actors can be involved, yet this does not mean that new regulation is tested as the object of the experiment.

Table 3-1 gives an overview of the types of experiments; the following subsections explain the types of experiments and their differences in more detail and provide examples from the fields of energy and mobility.

[3] The typology by Kivimaaetal. (2017) mainly points to different objectives (desired impacts) of such experiments and distinguishes the following four types of (governance) experiments: niche creation; market creation; spatial development; and societal problem solving and change.

[4] This typology is based on the type of control over interventions and subjects of experimentation.

Table 3-1: Types of experiments with different roles of regulation

	I. Pilot project / innovation lab	II. Pilot project / innovation lab with regulatory support	III. Regulatory experiments	IV. System innovation lab
Goal / focus	Testing technical, social or socio-technical innovations	Testing technical, social or socio-technical innovations. Regulatory conditions for innovations may be included in legal experimentation clauses.	Testing regulatory innovations (new or modified policy instruments)	Testing system innovations (co-evolution of technical, social and regulatory change)
Role of regulation	Regulation is not an object of the experiment. Existing rules only as given framework conditions.	Regulation is not an object of the experiment. Enabling role through regulatory exemptions that remove regulatory barriers for socio-technical experiments or make the innovations tested economically viable.	New regulation and its impact as main object of experiment.	Interaction between socio-technical change and innovative regulation as research object.
Evaluation of regulation	No evaluation of regulation foreseen.	No evaluation of regulation foreseen. Evaluation may result in longer-term policy changes to support the innovation. If optimal regulation still unclear, switch to Type III or IV.	Evaluation of regulation necessary and key. Several parallel regulatory experiments possible to compare different policy options.	Evaluation of the regulation's interaction with socio-technical change as key.
Existing examples	Private car-sharing services introduced in a city as a pilot project German SINTEG programme: "Smart Energy Showcases - Digital Agenda for the Energy Transition"	Legal exemptions and support for autonomous driving tests and parcel delivery through robots and drones EcoMobility World Festival, e.g. 2013 in Suwong (South Korea) Experimentation Ordinance for the SINTEG programme: Smart energy showcases (Germany)	Emission trading experiments in the USA and China Pilot projects testing green arrow signs for cyclists	Real-world test field for interconnected and autonomous driving in Karlsruhe (Germany)

Source: Authors' own depiction

3.1 Type I: Pilot project / innovation lab

Type I is about testing technical, social or socio-technical innovations and the business models around them within the existing regulatory framework, which is taken for granted within the experiment.

This pilot-project type is the most common of the four types as the typical research, demonstration and development (RD&D) project belongs to this category. Governments use it as an instrument to promote technical innovations; companies – both established firms as well as start-ups – use it to test their innovations before introducing them on a large scale. The innovation labs, living labs and real-world laboratories that are more explicitly set up in a transition context also belong to this type (see Section 2.1). Their object is broader and not merely technical, but regulation is typically not included either.

In Type I, the regulatory framework remains unchanged. It does play a role in the experiment in that it may influence how the experiment can be designed and what prospects there are for using the innovative solution beyond the experiment. Type I is based on regulatory discussions on the topic of innovation that revolve around the ways in which regulations either support or impede technical innovation (Eifert and Hoffmann-Riem 2008).

This type of experiment can be combined with an analysis of existing regulation and alternative options, and how these affect the experiment and whether they may hamper or promote the more widespread application of the new solution beyond the experiment. Even in this type regulatory learning can take place. In a review study of 229 publications on sustainable energy demonstration projects (Bossink 2017, p. 1357), one finding is that “many outcomes of demonstration projects are used to learn to develop public policy that stimulates the use of sustainable energy forms”.

It may emerge that the innovation does not work well under existing rules. This may necessitate switching to Type II, III or IV, if possible. In the electricity sector, the SINTEG programme in Germany is a case in point. It was originally set up to demonstrate a power system with high shares of renewables, including technical elements such as power storage, actor coordination and business models. Thus it was programmed with typical Type I experiments. Only when it was realised that many of these solutions cannot actually be demonstrated under the current regulatory framework was an ordinance set up that enables Type II experiments to some extent (see next section)[5].

Examples for Type I from the field of mobility include the many pilot projects for car-sharing (also bike-sharing) systems in selected cities and city quarters (Shaheen et al. 2015; TCRP 2005), increasingly in the more innovative form of “free-floating systems” and with new electric vehicles (Shaheen and Chan 2015). Commercial providers such as Car2go usually start their operations in a few selected cities before expanding to others. In some pilot projects, research institutions and/or city administrations have been involved. In some cases operators decided to stop and not to export their business (e.g. Honda’s DIRACC system started in Singapore).[6] If the introduction and testing of car-sharing systems is publicly supported – for example by the conversion and exclusive dedication of (parking) space in their favour (Shaheen et al. 2010) – this corresponds with Type II (see next section).

[5] See https://www.bmwi.de/Redaktion/EN/Artikel/Energy/sinteg-funding-programme.html

[6] See http://carsharingus.blogspot.de/2008/03/innovative-carsharing-program-in.html

3.2 Type II: Pilot project / innovation lab with regulatory support

Like Type I, Type II is also about testing technical, social or socio-technical innovations. However, regulation moves more to the centre stage as the regulatory framework for the experiment is not just analysed but is amended to enable the experiment. Regulatory exemptions are put in place specifically for the experiment that remove legal (part of the experiment is simply not allowed) or economic barriers (the experiment is not economical under the current regulatory framework).

The starting point for this type of experiment is technical or social innovation. Regulatory exemptions are derived from an analysis of what changes in regulation is needed to test these innovations. Experimenting with new regulatory options is not the objective here, nor is the aim to provide a basis for the future regulatory framework. This may even be explicitly excluded as an objective[7]. However, as in Type I, an evaluation of the experiment may result in longer-term policy changes to support the innovation (e.g. if evaluations lead to the conclusion that long-term regulatory support is necessary). If optimal regulation for/of the innovation is still unclear, one might switch to Type III or IV.

So-called “experimentation clauses” or “flexibility clauses” (Maaß 2001) are one example of legal mechanisms to provide the space or financial support for socio-technical or administrative innovations and to cope with difficulties in predicting the outcome of regulating complex issues (Schwarting 2003). As a regulatory technique, the legislator authorises the executive in an experimentation clause to deviate from current laws. The clause enables the administration to carry out innovative projects, which may eventually be regulated permanently (Maaß 2001). In German law, examples for experimentation clauses can be found, inter alia, in municipal, childcare and traffic law and school legislation.[8]

More recent examples are often discussed under the label “regulatory sandboxes”. The term originates from financial sector regulation in the UK (Financial Conduct Authority 2015) and many recent examples in different countries can be found in the energy sector (IEA ISGAN 2019).

In Germany, the so-called SINTEG-V[9] is a statutory ordinance based on the energy law for the research and development programme “Showcase Intelligent Energy – Digital Agenda for the Energy Transition” (SINTEG) mentioned under Type I. It expands the Type I programme into Type II experiments. The German SINTEG ordinance is one of the first examples in the energy sector where regulatory exemptions are provided to test new technological solutions because the current regulatory framework prevents these solutions. In order to make it possible for the participants of the programme to test new technologies, procedures and business models in practice without facing financial disadvantages, the ordinance provides programme participants with room for conducting experiments. This means that participants are reimbursed ex-post for financial disadvantages they may face under current regulation as a result of their demonstration projects. The ordinance clearly defines the situations for which such a retrospective reimbursement can take place.

Similarly, in the UK the sandbox programme set up by the regulator Ofgem is supposed to allow “innovators to trial new products, services and business models in a real-world environment without some of the usual rules applying.” Yet Ofgem emphasises that “it is not a means to change regulation on a permanent basis.”[10]

7 See https://www.bmwi.de/Redaktion/EN/Artikel/Energy/sinteg-funding-programme.html

8 For example, § 2 para.7 of the German “Personenbeförderungsgesetz” (Passenger Transportation Act) contains an example of an experimentation clause. For further examples see DeutscherBundestag (2018) pp. 9-12.

9 For a description in English see IEA ISGAN (2019)

10 See https://www.ofgem.gov.uk/system/files/docs/2018/09/what_is_a_regulatory_sandbox.pdf

Besides the development of regulatory sandboxes, there is a development that refers to the concept of real-world laboratories (see Section 2.1) that provides legal exemptions to such laboratories. Similar to Finland and the UK before (Kivimaa et al. 2017), the German Federal Ministry for Economic Affairs is currently pursuing an agenda and specific programmes to legally support real-world laboratories, particularly in the field of digitalisation (BMWI 2019).

Examples from the field of mobility can be found around the many recent experimental projects with (semi-) autonomous driving and delivery. For tests in (geographically limited) real-world settings, legal exemptions and public support are granted. Examples in Germany include the A9 motorway for semi-autonomous cars, the city of Hamburg for parcel delivery robots and the Bavarian district Traunstein for flying parcel drones.

A perhaps more holistic example is the EcoMobility World Festival, a month-long experiment for car-free city districts supported by the organisation ICLEI and taken up by three willing city administrations so far (two in Southeast Asia and one in South Africa). While individually owned cars are banned from the neighbourhood during the project, opportunities for public transport, cycling, light electric vehicles and their sharing are improved.[11] The focus of the project is not on how to organise a car ban, which would make it a Type III or Type IV project. Rather, it is about testing and promoting alternative mobility options, which is facilitated by the car ban.

3.3 Type III: Regulatory experiments

While the focus of the first two types is on socio-technical innovations, Type III is about testing regulatory innovations, i.e. new or modified regulation. The starting point is societal goals and the question of which regulatory options can be used to achieve them. The evaluation of regulatory options is at the core of these projects, regarding such criteria as effectiveness, efficiency, justice implications, acceptance and unintended side-effects. Public authorities may set up several parallel regulatory innovation labs in different cities or city quarters to compare different policy options.

Examples of this range from local and locally initiated regulatory experiments to larger experiments initiated by higher governance levels. A typical small-scale example is the testing of a permanent “green arrow” traffic sign specifically for cyclists at city crossroads (so that cyclists can always turn right carefully) in various European municipalities including Paris, Basel and Berlin. In Germany, the Federal Transport Ministry has recently taken up the idea and is currently conducting pilot projects in nine cities. On the basis of the experiences gained, it plans to decide whether to adapt road traffic regulations so as to allow green arrows for cyclists permanently and across the country.[12]

China is known for using policy experiments quite systematically as a tool for national (economic) policy-making. Speaking of “experimentation under hierarchy”, Heilmann (2008) distinguishes between geographically delimited experimental points and zones (selected by central government), initially sector-delimited policy experiments, and general but temporally delimited interim regulations. In the case of carbon emissions trading, in 2011 China started by selecting two provinces and five cities as pilot regions. Given leeway to design their schemes, they varied with regard to, inter alia, sector coverage, allocation of allowances, price uncertainty, market stabilisation, and enforcement (Zhang 2015). Further experiments with emission trading schemes can be found, for example in the United States (Voß and Simons 2014). In Germany, a pilot approach was developed in the 1980s

11 See http://www.ecomobilityfestival.net/

12 See https://nationaler-radverkehrsplan.de/en/notices/news/green-arrow-cyclists-pilot-project-nine-german

where the “model project Kannenbäckerland” for compensation regulation was implemented based on the German Clean Air Act (Gawel and Ewringmann 1994).

Looking again at the SINTEG programme, the SINTEG ordinance explicitly has the objective “*to learn from practical tests so that the existing legal framework can be updated.*”[13] Should this example therefore be seen as a Type III experiment, as new regulation and its impact is the main object? The answer is no and this example nicely shows the difference between Type II and Type III experiments. If there are regulatory exemptions introduced in a Type II project, it is certainly advisable to learn from these exemptions and their effects for future regulation. Indeed, as we have seen, regulatory learning can take place even in Type I experiments. However, in order to enable such learning for future regulation in a structured way, the experiment needs to be set up accordingly. This means the regulatory question is the starting point and an evaluative process is set up to enable regulatory conclusions. In the SINTEG example, neither was the case. Instead, the exemptions have been defined in order to enable the testing of the technical solutions in the SINTEG programme, current regulation remains in place and there is only a retrospective reimbursement and the experiments have not been designed in order to draw general conclusions regarding regulation.

These issues are addressed in Section 4, which presents the Regulatory Innovation Zone as a specific concept for Type III experiments.

3.4 Type IV: System innovation lab

Type IV can be seen as the most comprehensive (and probably most ambitious) form of the four experiment types since it entails experimentation with system innovations. The main objective of such a project is to learn about the co-evolution and interactions between technical, social and regulatory innovations as well as their optimisation. It combines the other types of experiments, especially Types I and III. As in Type III, different regulations can be applied in different experiments to learn about their respective effects on socio-technical innovations and their adaptation. Regulatory actors and private actors are usually both involved in such experiments. Moreover, professional research support and an evaluation are advisable.

Existing ideal-type cases are hard to find, but a current example that comes close to Type IV is the test field for interconnected and autonomous driving in and around Karlsruhe/Germany, which started in 2018. The project is funded by the federal state of Baden-Württemberg and is carried out by several research institutions in collaboration with local administrations. While the focus is on socio-technical issues, including societal acceptance of autonomous driving, the project also looks at the necessary or appropriate advancement of the regulatory framework (FZI 07.07.2016).

[13] See https://www.bmwi.de/Redaktion/EN/Artikel/Energy/sinteg-funding-programme.html

4 Design and implementation of regulatory experiments: The concept of the Regulatory Innovation Zone

Building on the considerations in the previous sections, the Regulatory Innovation Zone (RIZ) is to be understood as a practical and implementation-oriented instrument. The concept is about experimenting with new regulation and is thus a Type III (see the typology in Section 3). As Type IV builds on Type III, the issues discussed here are also relevant for Type IV experiments.

The next section briefly explains the process through which the concept was developed. Section 4.2 presents the basic principles of the RIZ. Section 4.3 addresses various design questions and options.

4.1 How the concept was developed

The RIZ concept was developed in a stakeholder process, in which various stakeholders discussed the potential and the design challenges of the concept. This was done in an iterative way, i.e. based on the discussions within the stakeholder group, a draft paper with possible design options and challenges was written as an input for the next workshop and this was then further elaborated on with the stakeholder group.

The idea of the RIZ was originally developed in 2013 in a stakeholder process on Smart Grids in the electricity sector which was coordinated by the authors (Smart Grids-Plattform Baden-Württemberg 2013). The state of Baden-Württemberg funded this stakeholder process with the goal to set up a roadmap for the development of smart grids in Baden-Württemberg. About 80 stakeholders – actors from the state ministries, grid operators, energy retailers, smart home companies, law firms, researchers working on regulatory impact assessment and the regional regulator – discussed necessary regulatory changes needed for the development of Smart Grids. Through this they generated the idea that regulatory experiments are needed.

For the development of Smart Grids regulatory innovations are required, especially at the interface between electricity networks and markets. The concept can also be applied to other areas of the energy system transition, as well as other sectors. One challenge in the electricity sector is the fact that regulation to a large extent addresses companies that compete against each other, and RIZ should not distort that competition. This is less problematic for some other sectors, for instance the case of municipal traffic regulation.

On this basis, the ministry commissioned two studies on how this idea could be implemented: one on the general implementation issues (Bauknecht et al. 2015), one on legal questions (Missling et al., 2016). In the first study, two one-day stakeholder workshops with the same stakeholder types as in the process described above and 15 participants were chosen as a key methodology. The second study provides an analysis of the legal requirements of regulatory experiments.

The design options and challenges have not been derived from the observation of real experiments. Neither was the stakeholder process set up in a way to observe how different types of stakeholders react to the concept. The stakeholder process identifies design options and challenges which have been raised by the involved stakeholders and which have been discussed in the process. As the approach was rather exploratory, this should not be seen as a conclusive list of options and challenges.

4.2 Basic principles

In a RIZ new regulatory mechanisms are selectively introduced, then tested in practice and further developed by participating actors, including market actors and regulatory authorities.

The term “regulatory” does not mean that the experiments are limited to regulation in the stricter sense. In the electricity sector, for example, it can include rules affecting the regulated grid infrastructure, but also the legal framework in the competitive areas of generation and sales, including for example economic instruments, and the interface between the two. Innovative regulation is to be tested, as well as the resulting practical processes and incentive *effects*. The tests take place in a delimited area (“zone”), such as within a regionally delimited research project or within a network area and are clearly temporally delimited.

The main goal of a RIZ is to develop recommendations for action with regard to changes to the existing regulatory framework, in order to achieve societal goals in the most efficient manner. New business models will then be enabled, which can compete to offer the most efficient achievement of the desired output. However, it must be noted that the starting point of a RIZ is not the lack of economic efficiency of a certain business model. Rather, the starting point is the question of how we can better achieve societal goals and which legal framework conditions are necessary for this. Our stakeholder discussions have shown that the RIZ as a Type III regulatory experiment is often understood as a Type II experiment, especially by company representatives.

The RIZ supports the preparation of the comprehensive introduction of new regulations. Just as with technical innovation projects, a useful result of a RIZ can be the finding that a certain regulation option is unsuitable.

In sum, the following questions may be addressed in a RIZ:

- What effects does a new regulatory instrument have on political goals, in the energy sector for example on the energy policy target triangle of environmental effects, economy and the security of supply, potentially also with a fourth target of participation? The distribution effects and acceptance of various options can also be addressed.
- Which incentives are given to various actors through the instrument in practice and how might these actors react to them?
- Which processes between various actors become necessary due to the new instrument and how can these be designed and finely adjusted? This includes processes between regulating authorities and those being regulated. These actors should be involved in the RIZ accordingly.
- Which unintended and unexpected secondary effects arise from the instrument in practice, for example through its interaction with other instruments?

The regulatory body will have to play an active twofold role within the process of regulatory innovation. First and foremost, the regulator has to come up with the relevant research questions as to which kind of regulatory innovation is needed and decide which specific regulation(s) should be tested. The regulatory experiment needs to be designed on this basis. In addition, the evaluation of the regulatory innovation (by the regulatory body or external researchers) has to include the impact on the regulatory body itself. Issues like workload and data availability at the regulatory body might arise and should therefore be included in the evaluation.

RIZ should be considered not just as enablers of technical demonstration projects (like Type II experiments, see Section 3). Rather, they should be designed as demonstration projects themselves, for example with a design that includes the evaluation of the practical effects of the regulatory options and allows for the generalisation of results (Type III experiments).

4.3 Implementation challenges

In order to set up RIZ, a number of design and evaluation challenges need to be taken into account. Table 4-1 presents these challenges and possible solutions. They have been identified and discussed in the stakeholder workshops described above. The third column provides links to the relevant literature.

When the focus of regulatory experiments is on learning about regulation itself (Type III), it becomes highly relevant to design the experiment in such a way that it allows for drawing conclusions about future regulation. Moreover, legal feasibility is discussed in the following subsection.

Table 4-1: Policy experimentation: Potential implementation challenges and possible solutions

Implementation challenge	Possible solution	Link to the literature
Distortion of competition needs to be avoided if regulation is changed for some actors	Regulatory experiments should be treated as other RD&D projects within the energy sector; there should be non-discriminatory tenders so that all competitors have the same chance to contribute to possible solutions for the energy system regulation, see Section 4.3.2. Results should be used to improve the regulatory framework so that all actors can benefit.	See Section 4.3.1, especially the legal principle of equality, and Missling et al. (2016, p. 85)
The regulatory design in the experiment should not prejudge future regulation. This concern has mainly been raised by regulators.	RIZ is by definition set up as a fixed-term project. Alternative regulatory options can be tested in parallel. In Type III, the objective is to change regulation, but the regulatory option tested in the experiment should not necessarily be the one that is implemented afterwards. It should be an explicit option that the experiment can fail.	This implementation challenge has also been raised in the sandbox cases presented in Section 3.2. However, in these cases, the experiment was restricted to Type II.
It is unclear how investment incentives can be tested in fixed-term projects.	The new rules could be extended beyond the project period exclusively for the investments made under the project regime.	We have not found any discussion or examples of this issue in the literature.
Experiments always have to deal selection bias issues and the fact that a statistical analysis is not possible.	RIZ are not just about testing the effects of a specific regulatory option, but are also about designing regulation in practice and testing the mechanisms through which the regulation works, see Section 4.2. The regulatory experiment should be carried out as a complement to other approaches (e.g. models); different approaches should be combined.	In the literature, there is distinction between policy evaluations and mechanism experiments which is relevant here (Ludwig et al. 2011). Evaluation has been emphasised as a key requirement for experiments, including the comparison of multiple experiments (Hildén et al.

	There should be guidelines that help to decide in which cases experiments can be expected to be useful and where this is not the case. It can also be useful to compare different regulatory options in parallel RIZs. There should be a baseline and a reference group. An evaluation concept should be in place that allows for scaling up the results.	2017). How the evaluation needs to be designed for regulatory experiments requires more work.
One objective is to test the practical implementation of a new regulation, including unintended effects.	Regulators and a broad range of affected stakeholders should be involved.	The inclusion of a broad range of stakeholders in a transdisciplinary process has been discussed for example in the context of real-world laboratories (Schäpke et al. 2017).
Regulatory challenges and options in an innovation context cannot always be clearly defined upfront and may only become visible in the process.	Dynamic adaptation and learning within the regulatory experiment can be enabled.	This relates to the concept of reflexive governance and that it can and should be implemented on different levels. This means that the experiment as a reflexive governance tool itself needs to be designed in a reflexive way (Voß et al. 2006). The concept of real-world laboratories includes this kind of adaptation, similar to technical laboratory, where the experiment can be adapted and repeated. It can be based on “cyclical learning processes through reflection and adaption” (Wanner et al. 2018, p. 13). In the case of regulatory experiments, this can be difficult to implement in practice due to the legal issues discussed in Section 4.3.1.

Source: Authors‘ own depiction

4.3.1 Legal feasibility

The design of a RIZ has to take into account a range of legal questions. It has been argued that the flexible, temporarily and geographically confined adoption of rules can conflict with basic legal principles as well as with specific legal provisions. An important difference between regulatory experiments and other experiments such as technical ones is that the former can typically be put in place only based on specific regulation (which is the very point of establishing regulatory experiment). Constitutional, sectoral and European law may – to a different degree, depending on the legal field concerned – constrain options for a RIZ.[14] For example, Missling et al. (2016) assert that a variation of norms in the context of German energy law would infringe compulsory rules on the national and European level and is therefore not feasible under current legal conditions. Accordingly, the experimental adoption of innovative statutory orders by regulatory authorities would conflict with superior energy law, which does not permit temporal and geographical exceptions from general rules (Missling et al. 2016, pp. 22-24). Furthermore, a general clause in energy law according to which a regulatory body could adopt innovative statutory orders based on its own discretion would collide in different ways with the principle of the rule of law (most importantly with the principles of priority and reservation of law) (cf. Missling et al. 2016, pp. 25-28). Kahl et al. (2016) assume, however, that regulatory experiments in the energy sector could be performed in a general way by allowing variations of the given regulation by a legal permission to adopt statutory orders. This legal competence – in the case of German energy law, the Ministry of Economic Affairs – would be provided by a legal norm that establishes the power to enact secondary statutory instruments ("*Verordnungsermächtigung*").

The adoption of innovative rules may be less problematic if no divergent law exists, e.g. if the given sector to be experimented on is not yet regulated. However, regulatory experimentation will have to consider for each individual case if general legal principles stipulate that legal experimentation requires an alteration of the legal basis by the legislator. This will prominently depend on if the principle of the rule of law is affected and on the effects on basic rights:[15] Regulatory experimentation, as Huitema (2018) points out, may affect persons in different ways; it might lead to considerable benefits for some while others bear considerable costs. Such differences in regulatory treatment will have to consider the legal principle of equality. It seems unlikely, however, that regulatory experiments fail because of an unequal treatment (cf. Missling et. al. 2016). If, as in a RIZ, the legislator does not intend the unequal treatment of groups of persons (e.g. culturally or ethnically defined), but treats factual circumstances unequally, the legal requirements to justify a different treatment related to a RIZ are less strict.[16] A *reasonable* consideration then can constitute a permissible reason for differentiation. If it is justifiable, the legislature may in principle deviate from rules it itself has enacted (Kahl et. al. 2016). However, in concrete cases, if the unequal treatment affects the enjoyment of individual liberties protected by basic rights, such as the freedom of property and the freedom to pursue an occupation, the justification might be more demanding. In such cases, the legislator has to balance the impacts on these rights with the interests or objectives pursued with the experimentation. The requirement to balance the objective of the regulatory experiment and

[14] This section refers to German law and doctrine.

[15] E.g. according to the principle of reservation of the law (which is an element of the rule of law) and the doctrine of "legislative reservation" developed by the German Federal Constitutional Court, decisions with a substantial weight for the commonwealth require parliamentary approval (cf. BVerfGE 47, 46 (78f.). Essential questions regarding legal policy consequently have to be regulated in a formal statute. In cases of potential encroachments on basic rights, the principle of reservation to the law finally may also imply a "prohibition of delegation" regarding the authorisation of the administration to enact statutes or regulations (Hoffmann-Riem 2005, p. 52).

[16] Cf. BVerfG, NVwZ 2011, 1316 f.

potentially affected rights illustrates the practical need for a clear definition of the (sustainability) goals of a regulatory experiment.

4.3.2 Distortion of competition and call for tenders

A transparent and non-discriminatory call for tenders can be necessary in order to prevent potential competition distortions that might arise during the RIZ implementation, especially in cases where regulation directly addresses companies and these companies operate in a competitive market, as in the electricity sector. Table 4-2 presents various options.

Table 4-2: Options for a call for tender for a RIZ

	How is RIZ defined?	Comments
Variation 1:	Call for tender for one (or more) RIZ is publicised, the definition of the object of investigation is part of the tender.	One advantage is that potential issues for the RIZ are already generated directly from the market during the bidding phase. Individual market actors are challenged with translating these issues into system-relevant RIZ questions, based on their respective business perspectives.
Variation 2:	Call for tender for one (or more) RIZ, specific issues based on a system perspective are put out for tender.	In a two-step process, in preparation for the tender, relevant issues can first be identified together with the market actors, and these issues can then be included in the call for tender.
Variation 3: Open RIZ	As an alternative to awarding a RIZ to a certain consortium, the RIZ could be set up, for example, with a network operator in which all market actors with different business models can actively participate. This requires addressing one or several specific regulatory issues.	Although the organisation of such a RIZ is more complicated, the knowledge gained would be potentially more substantial.

Source: Authors' own depiction

5 Conclusions

The development of new regulation is an on-going process and can be understood as an innovation process. Regulatory innovations hold great significance and are an important element of sustainability transitions. At the same time, the practical effects of new regulatory options are subject to considerable uncertainty, especially in the context of socio-technical transitions.

We argue that the development of the regulatory framework should not be left to chance but should happen in a reflexive way and should include a comprehensive impact assessment. Regulatory experiments can be a tool for such a reflexive development of regulatory innovations.

This builds on the broad debate on niches as an incubator for innovations and the purpose-built design of such niches with the help of strategic niche management in real-world laboratories etc.

Just as these concepts extend the concept of small-scale experiments from the testing of merely technical solutions to socio-technical arrangements, regulatory experiments broaden the scope further to also include the regulatory framework into the experiment. Opportunities for the small-scale testing and development of regulatory innovation should thus be provided just as with other socio-technical innovations. This requires a corresponding framework, as legal experiments are particularly demanding.

We have presented a typology of four different types of experiments with different roles of regulation, including practical examples. The starting point are typical pilot projects (Type I) that focus on technical innovations, where existing regulation is taken as a given framework condition. A key issue is whether regulation only provides regulatory exemptions for technical pilots (Type II) or whether regulation itself becomes the main object of the experiment (Type III). These should and will often not be stand-alone innovations but are combined with other socio-technical innovations into system-innovation labs (Type IV), especially in the context of socio-technical transitions. Nevertheless, as a first step towards these integrated system innovation labs, we see a need to address the specific challenges of Type III regulatory experiments, where new regulation is developed and tested.

There are examples for all types, but what is most wide-spread besides the standard Type I pilots are regulatory exemptions where regulation is not at the core of the experiment (Type II).

We have presented the concept of Regulatory Innovation Zones (RIZ) that has been developed in the context of smart grids in order to enable Type III, i.e. regulatory experiments. In this context, various design requirements, options and challenges of regulatory experiments have been explored. These show that regulatory experiments are characterised by some specific challenges. These options and challenges need to be discussed further and it needs to be analysed in more detail how knowledge about experimenting in general can be applied to regulatory experiments.

List of References

Bauknecht, D., Bischoff, T., Bizer, K., Heyen, D.A., Führ, M., Gailhofer, P., Proeger, T., Leyen, K. von der, 2019. Exploring the pathways: Regulatory experiments for Sustainable Development – an interdisciplinary approach. ifh Working Paper 22, 18 pp. https://www.econstor.eu/bitstream/10419/208382/1/1683885708.pdf. Accessed 6 March 2020.

Bauknecht, D., Heinemann, C., Stronzik, M., Schmitt, S., 2015. Austesten von regulatorischen Innovationen – das Instrument der Regulatorischen Innovationszone. Energiewirtschaftliche Tagesfragen 65, 61–64.

Bilz, K., Nadler, J. Law, Moral Attitudes and Behavioral Change, in: The Oxford Handbook of Behavioral Economics and the Law, pp. 241–267.

BMWI, 2019. Reallabore: Testräume für Innovation und Regulierung. Bundesministerium für Wirtschaft und Energie. https://www.bmwi.de/Redaktion/DE/Dossier/reallabore-testraeume-fuer-innovation-und-regulierung.html.

Bora, A. Semantics of ruling: reflective Semantics of ruling: theories of regulation, governance and law, in: Society, Regulation and Governance. New Modes of Shaping Social Change?, pp. 15–37.

Bos, J.J., Brown, R.R., 2012. Governance experimentation and factors of success in socio-technical transitions in the urban water sector. Technological Forecasting and Social Change 79, 1340–1353. 10.1016/j.techfore.2012.04.006.

Bosch, S. van den, 2010. Transition experiments: Exploring societal changes towards sustainability. PhD, Rotterdam.

Bossink, B.A.G., 2017. Demonstrating sustainable energy: A review based model of sustainable energy demonstration projects. Renewable and Sustainable Energy Reviews 77, 1349–1362. 10.1016/j.rser.2017.02.002.

Caniglia, G., Schäpke, N., Lang, D.J., Abson, D.J., Luederitz, C., Wiek, A., Laubichler, M.D., Gralla, F., Wehrden, H. von, 2017. Experiments and evidence in sustainability science: A typology. Journal of Cleaner Production. 10.1016/j.jclepro.2017.05.164.

Carbonara, E., Parisi, F., Wangenheim, G.v., 2008. Legal Innovation and the Compliance Paradox. Minnesota Journal of Law, Science & Technology 9, 837–860.

Deutscher Bundestag, 2018. Experimentierklauseln in der grenzüberschreitenden kommunalen Zusammenarbeit, 12 pp. https://www.bundestag.de/resource/blob/573014/a6bfa652bd1d6b81e8f431e7c358a753/wd-3-259-18-pdf-data.pdf. Accessed 30 August 2019.

Edgel, R.A., Vogl, R., 2013. A Theory of Innovation: Benefit, Harm, and Legal Regimes. Law, Innovation and Technology, 21–53.

Ehrlich, E., 1913. Grundlagen der Soziologie des Rechts, 4th ed. Manfred Rehbinder 1989, Berlin.

Eichelberger, J. Innovationsrelevante Regeln des allgemeinen Zivilrechts und ihre Innovationswirkung, in: Herausforderung Innovation: Eine interdisziplinäre Debatte, pp. 45–64.

Eifert, M., Hoffmann-Riem, W., 2008. Innovationsfördernde Regulierung: Innovation und Recht II, 1st ed. Duncker & Humblot, Berlin, 341 pp.

Financial Conduct Authority, 2015. Regulatory sandbox, London. https://www.fca.org.uk/publication/research/regulatory-sandbox.pdf. Accessed 2 August 2019.

FZI, 2016. Testfeld für automatisiertes Fahren: Karlsruhe wird Pionier-Region, Karlsruhe.

Gawel, E., Ewringmann, D., 1994. Die Kompensationsregel der TA Luft. Erfahrungen aus dem Modellvorhaben "Kannenbäckerland". Natur und Recht (NuR) 16, 120–125.

Geels, F.W., 2002a. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31, 1257–1274.

Geels, F.W., 2002b. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31, 1257–1274.
Geels, F.W., 2005. Technological Transitions and System Innovations. A Co-Evolutionary and Socio-Technical Analysis. Edward Elgar, Cheltenham.
Heilmann, S., 2008. Policy Experimentation in China's Economic Rise. St Comp Int Dev 43, 1–26. 10.1007/s12116-007-9014-4.
Heldeweg, M.A., 2017. Normative Alignment, Institutional Resilience and Shifts in Legal Governance of the Energy Transition. Sustainability. 10.3390/su9071273.
Hildén, M., Jordan, A., Huitema, D., 2017. Special issue on experimentation for climate change solutions editorial: The search for climate change and sustainability solutions - The promise and the pitfalls of experimentation. Journal of Cleaner Production 169, 1–7. 10.1016/j.jclepro.2017.09.019.
Hoffmann-Riem, W. Gesetz und Gesetzesvorbehalt im Umbruch: Zur Qualitäts-Gewährleistung durch Normen. Archiv des öffentlichen RechtsArchiv des öffentlichen Rechts 2005, 5–70.
Hoffmann-Riem, W., 2016a. Innovation und Recht - Recht und Innovation: Recht im Ensemble seiner Kontexte. Mohr-Siebeck.
Hoffmann-Riem, W., 2016b. Innovationen im Recht: Zur Einführung, in: Hoffmann-Riem, W. (Ed.), Innovationen im Recht, 1st ed. Nomos, Baden-Baden, pp. 11–32.
Hoogma, R., 2002. Experimenting for sustainable transport: the approach of strategic niche management. Routledge.
Hornung, G., 2015. Grundrechtsinnovationen. Moihr-Siebeck.
Huitema, D., Jordan, A., Munaretto, S., Hildén, M., 2018. Policy experimentation: Core concepts, political dynamics, governance and impacts. Policy Sciences 51, 143–159. 10.1007/s11077-018-9321-9.
IEA ISGAN, 2019. Innovative Regulatory Approaches with Focus on Experimental Sandboxes: Casebook. http://www.iea-isgan.org/wp-content/uploads/2019/05/ISGAN_Casebook-on-Regulatory-Sandbox-A2-1.pdf. Accessed 2 August 2019.
Jasanoff, S. Making Order: Law and Science in Action, in: The Handbook of Science and Technology, pp. 761–786.
Kemp, R., Loorbach, D., 2006. Transition management: a reflexive governance approach, in: Voß, J.-P., Bauknecht, D., Kemp, R. (Eds.), Reflexive governance for sustainable development. Edward Elgar, Cheltenham, UK, pp. 103–130.
Kivimaa, P., Hilden, M., Huitema, D., Jordan, A., Newig, J., 2017. Experiments in climate governance: A systematic review of research on energy and built environment transitions. Journal of Cleaner Production 169, 17–29. 10.1016/j.jclepro.2017.01.027.
Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sanden, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D., Wells, P., 2019. An agenda for sustainability transitions research: State of the art and future directions. Environmental Innovation and Societal Transitions 31, 1–32. 10.1016/j.eist.2019.01.004.
Kumm, M., 2012. Constitutionalism and experimentalist governance. Regulation & Governance 6, 401–409.
Laakso, S., Berg, A., Annala, M., 2017. Dynamics of experimental governance: A meta-study of functions and uses of climate governance experiments. Journal of Cleaner Production 169, 8–16. 10.1016/j.jclepro.2017.04.140.
Liedtke, C., Baedeker, C., Hasselkuß, M., Rohn, H., Grinewitschus, V., 2015. User-integrated innovation in Sustainable LivingLabs: An experimental infrastructure for researching and developing sustainable product service systems. Journal of Cleaner Production 97, 106–116. 10.1016/j.jclepro.2014.04.070.

Loorbach, D., Rotmans, J., 2010. The practice of transition management: Examples and lessons from four distinct cases. Futures 42, 237–246. 10.1016/j.futures.2009.11.009.

Ludwig, J., Kling, J.R., Mullainathan, S., 2011. Mechanism Experiments and Policy Evaluations. Journal of Economic Perspectives 25, 17–38. 10.1257/jep.25.3.17.

Luederitz, C., Schäpke, N., Wiek, A., Lang, D.J., Bergmann, M., Bos, J.J., Burch, S., Davies, A., Evans, J., König, A., Farrelly, M.a., Forrest, N., Frantzeskaki, N., Gibson, R.B., Kay, B., Loorbach, D., McCormick, K., Parodi, O., Rauschmayer, F., Schneidewind, U., Stauffacher, M., Stelzer, F., Trencher, G., Venjakob, J., Vergragt, P.J., Wehrden, H. von, Westley, F.R., 2016. Learning through evaluation: A tentative evaluative scheme for sustainability transition experiments. Journal of Cleaner Production. 10.1016/j.jclepro.2016.09.005.

Maaß, V., 2001. Experimentierklauseln für die Verwaltung und ihre verfassungsrechtlichen Grenzen: Zugleich ein Beitrag zu § 7a BerlHG. Duncker & Humblot, Berlin, 6 pp.

Matschoss, K., Repo, P., 2018. Governance experiments in climate action: Empirical findings from the 28 European Union countries. Environmental Politics 27, 598–620. 10.1080/09644016.2018.1443743.

McFadgen, B., Huitema, D., 2016. Are all experiments created equal?: A framework for analysis of the learning potential of policy experiments in environmental governance. Journal of Environmental Planning and Management 60, 1765–1784. 10.1080/09640568.2016.1256808.

Missling, S., Lange, H., Michaels, S., Weise, M., 2016. Gutachterliche Stellungnahme zum Instrument einer Regulatorischen Innovationszone. Becker Büttner Held, Berlin, 90 pp.

Moyse, P.-E., 2016. Innovation: In the Shadow of Law. https://www.wipo.int/edocs/mdocs/mdocs/en/wipo_ipl_ge_16/wipo_ipl_ge_16_t8.pdf.

Nevens, F., Frantzeskaki, N., Gorissen, L., Loorbach, D., 2013. Urban Transition Labs: Co-creating transformative action for sustainable cities. Journal of Cleaner Production 50, 111–122. 10.1016/j.jclepro.2012.12.001.

Raven, R., Kern, F., Verhees, B., Smith, A., 2016. Niche construction and empowerment through socio-political work: A meta-analysis of six low-carbon technology cases. Environmental Innovation and Societal Transitions 18, 164–180. 10.1016/j.eist.2015.02.002.

Rip, A., Kemp, R., 1998. Technological change, in: Rayner, S., Malone, E.L. (Eds.), Human Choice and Climate Change: Resources and Technology. Batelle Press, Columbus, OH, pp. 327–399.

Sabel, C.F., Zeitlin, J., 2012. Experimentalist Governance, in: Levi-Faur, D. (Ed.), The Oxford Handbook of Governance. Oxford University Press, pp. 169–183.

Sanderson, I., 2002. Evaluation, Policy Learning and Evidence-Based Policy Making. Public Administration 80, 1–22. 10.1111/1467-9299.00292.

Schäpke, N., Stelzer, F., Bergmann, M., Lang, D.J., 2016. Tentative Theses on Transformative Research in Real-World Laboratories: First Insights from the Accompanying Research ForReal. Technikfolgenabschätzung - Theorie und Praxis 25, 45–51.

Schäpke, N., Stelzer, F., Bergmann, M., Singer-Brodowski, M., Wanner, M., Caniglia, G., Lang, D.J., 2017. Reallabore im Kontext transformativer Forschung: Ansatzpunkte zur Konzeption und Einbettung in den internationalen Forschungsstand. IETSR Discussion Papers in Transdisciplinary Sustainability Research 1.

Schneidewind, U., Singer-Brodowski, M., 2013. Transformative Wissenschaft: Klimawandel im deutschen Wissenschafts-und Hochschulsystem. Metropolis Verlag, Marburg.

Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technology Analysis & Strategic Management 20, 537–554. 10.1080/09537320802292651.

Schwarting, G., 2003. Von der Experimentierklausel zur Standardöffnung – ein neuer Weg der Vorbereitung von Rechtsvorschriften? Vortrag anlässlich des 10. deutsch-französischen Verwaltungskolloquiums am 16./17.6.2003 an der Ecole Nationale d'Administration Strasbourg, 2003, Strasbourg.

Shaheen, S., Cohen, A., Martin, E., 2010. Carsharing Parking Policy: Review of North American Practices and San Francisco, California, Bay Area Case Study. Transportation Research Record: Journal of the Transportation Research Board 2187, 146–156. 10.3141/2187-19.

Shaheen, S.A., Chan, N.D., 2015. Evolution of E-Mobility in Carsharing Business Models, in: Beeton, D., Meyer, G. (Eds.), Electric vehicle business models. Global perspectives. Springer, Cham [Switzerland], pp. 169–178.

Shaheen, S.A., Chan, N.D., Micheaux, H., 2015. One-way carsharing's evolution and operator perspectives from the Americas. Transportation 42, 519–536. 10.1007/s11116-015-9607-0.

Smart Grids-Plattform Baden-Württemberg, 2013. Roadmap der Smart-Grids Plattform Baden-Würtemberg, Stuttgart.

Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Research Policy 41, 1025–1036. 10.1016/j.respol.2011.12.012.

TCRP, 2005. Car-Sharing: Where and How It Succeeds. Transportation Research Board, Washington, D.C.

Voß, J.-P., 2007. Designs on governance. Development of policy instruments and dynamics in governance. PhD thesis. Twente University, School of Management and Governance, Enschede.

Voß, J.-P., Kemp, R., 2006. Sustainability and reflexive governance: introduction, in: Voß, J.-P., Bauknecht, D., Kemp, R. (Eds.), Reflexive governance for sustainable development. Edward Elgar, Cheltenham, UK, pp. 3–28.

Voß, J.-P., Kemp, R., Bauknecht, D., 2006. Reflexive governance: a view on an emerging path, in: Voß, J.-P., Bauknecht, D., Kemp, R. (Eds.), Reflexive governance for sustainable development. Edward Elgar, Cheltenham, UK, pp. 419–437.

Voß, J.-P., Simons, A., 2014. Instrument constituencies and the supply side of policy innovation: the social life of emissions trading. Environmental Politics Vol. 23, 735–754. 10.1080/09644016.2014.923625.

Voß, J.-P., Simons, A., 2018. A novel understanding of experimentation in governance: Co-producing innovations between "lab" and "field". Policy Sciences 51, 213–229. 10.1007/s11077-018-9313-9.

Voytenko, Y., McCormick, K., Evans, J., Schliwa, G., 2016. Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda. Journal of Cleaner Production 123, 45–54. 10.1016/j.jclepro.2015.08.053.

Waldron, J. Property, Honesty, and Normative Resilience, in: New Essays in the Legal and Political Theory of Property, pp. 10–35.

Wanner, M., Hilger, A., Westerkowski, J., Rose, M., Stelzer, F., Schäpke, N., 2018. Towards a Cyclical Concept of Real-World Laboratories. disP - The Planning Review 54, 94–114. 10.1080/02513625.2018.1487651.

WBGU, 2016. Humanity on the move: Unlocking the transformative power of cities. Flagship Report 2016. German Advisory Council on Global Change.

Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. Research Policy, 1037–1047.

Westley, F., Antadze, N., Riddell, D.J., Robinson, K., Geobey, S., 2014. Five Configurations for Scaling Up Social Innovation. The Journal of Applied Behavioral Science 50, 234–260. 10.1177/0021886314532945.

Zhang, Z., 2015. Carbon emissions trading in China: The evolution from pilots to a nationwide scheme. Climate Policy 15, S104-S126. 10.1080/14693062.2015.1096231.