SPRU

Science Policy Research Unit

BRIEFING NOTE

Designing Innovation Policy for Transformative Change

UNIVERSITY OF SUSSEX

About this briefing note

This note has been prepared by academics in the Science Policy Research Unit (SPRU) at the University of Sussex to support their in person contributions to OECD discussions on systems innovation and experimentation taking place in June and July 2016 in Paris and Seoul[1]. It draws on a body of work in progress within SPRU on innovation policy for transformative change and applies this through specific examples of 'innovation policy mixes' and transition experiments as a complement to classic technology demonstration projects. We very much welcome further discussion and interactions with the OECD and will be pursuing the ideas presented in this note and others in future years as we pass our 50th year as an organisation contributing to research on innovation, inequality and the environment. We argue that today's grand societal challenges mean that we need to work on the integration of social and environmental concerns into the traditional aims of innovation policy such as competitiveness, economic development and industry building, rather than seeing them as separate policy issues. Precisely how to do this, is an important topic for future research but also further engagement between academics and policy makers.

About SPRU

With 50 years of experience, SPRU is internationally recognised as a leading centre of research on science, technology and innovation policy. We are driven by a desire to tackle real-world questions, whilst also contributing to a deeper theoretical understanding of how innovation is shaping today's world. Founded in 1966 by Christopher Freeman, a pioneer of what is now known as innovation studies, SPRU was one of the first interdisciplinary research centres in the field of science and technology policy and management. Drawing on insights from across the social and natural sciences, engineering and humanities our research addresses pressing global policy agendas, including the future of industrial policy, inclusive economic growth, and the politics of scientific expertise, energy policy, security issues, entrepreneurship, and pathways to a more sustainable future. We work across a broad range of sectors including food, energy, healthcare, biotechnology and ICT.

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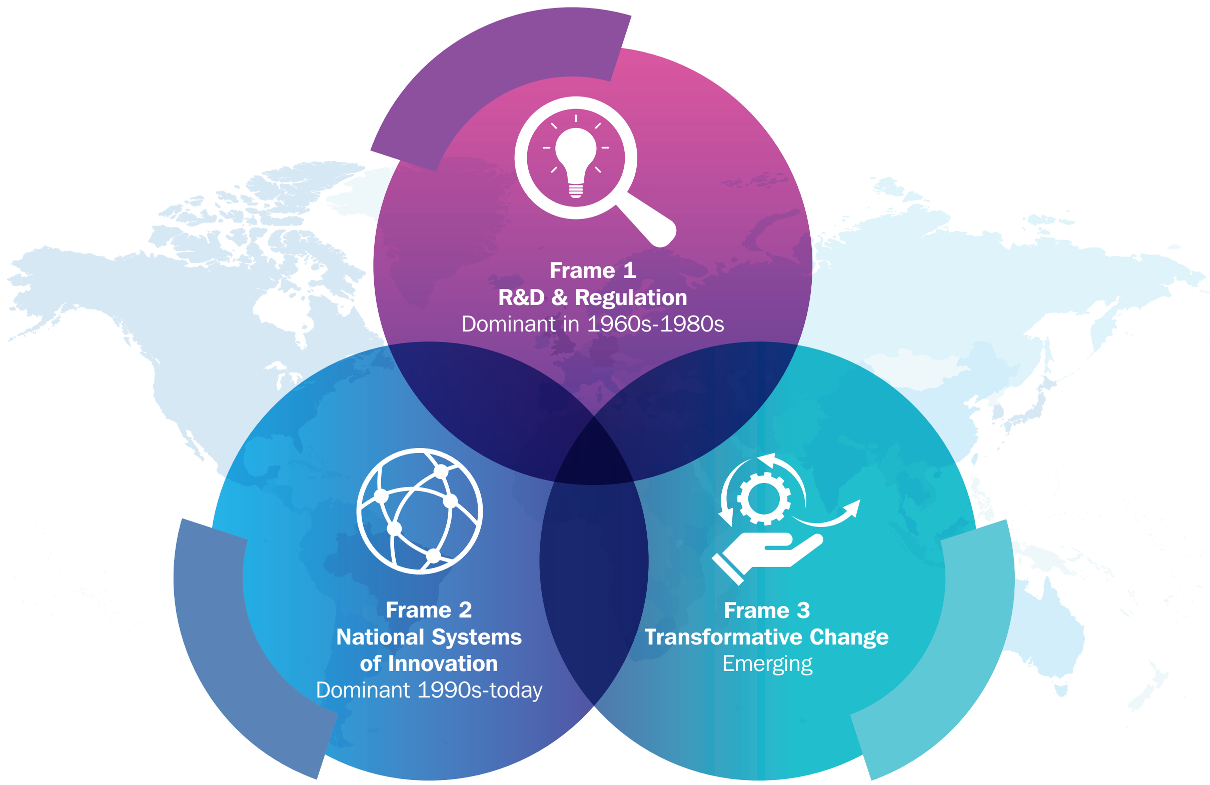
CELEBRATING SPRU 1966–2016

[1] The workshop on 'Technology Development and Demonstration for System Transformation' is organised by the OECD Directorate of Science, Technology and Industry and the Korean Ministry of Science, ICT and Future Planning and will be held in Seoul on 7-8th of July 2016. 47th Meeting of the Working Party on Innovation and Technology Policy will take place in Paris 20-22 June 2016.

1. Three Frames of Innovation Policy

Based on: Johan Schot and Ed Steinmueller, Framing Innovation Policy for Transformative Change – Innovation Policy 3.0. SPRU working paper series, forthcoming.



The world is facing a series of crises and persistent problems. The modern way of provisioning basic needs is not sustainable in the long run, and is causing climate and environmental change on an unprecedented scale. It is clear that we cannot globalise our current ways of providing food, energy, mobility, healthcare, and water. These problems will stay with us regardless of the future growth path of the global economy or individual nations, and they will likely worsen as time progresses – with a risk of increased climate change and profound societal turmoil, tensions and war. These issues cannot be solved by optimising current scientific and technological solutions, burning more fossil fuels, investing more money in high-tech medicine, nor by globalising value chains and continuing to promote automobile-based mobility patterns. We need to move away from a costly "business as usual approach" to an approach addressing these persistent global problems.

SPRU work on innovation policy for transformative change takes as a starting point that science and technology are hugely implicated in these problems. And because our modern society and available frames for innovation policy are built upon the idea that innovation is necessarily beneficial, we are not in the position to mobilise the power of innovation to face them. Too often policy seeks to stimulate entrepreneurial activities and solve its negative impacts retrospectively through regulation and compensatory measures. This is embedded in what we might call the social contract of modernity: the market is responsible for innovation and generating economic growth while the state manages public goods. It intervenes in the distribution of costs and benefits only when a shared perception emerges that market mechanisms generate excessive social disparities or environmental harm.

Over the last decades **two main innovation policy frames have been developed**. As described below, we believe a new third frame is needed that focuses on transformative change.

FRAME 1: R&D

This frame portrayed innovation policy as providing incentives for the market to produce socially and economically desired levels of science knowledge.

This is mainly implemented by subsidies and measures to enhance the capture of economic returns from innovation such as IPR. To identify which areas need support, countries have developed an array of foresight institutions and processes. When innovation proves to have negative impacts, regulations may be enacted. This framing identifies the most important element of innovation as the discovery process (invention) and this gives rise to the linear model in which technology is the application of scientific knowledge. The linear model privileges discovery over application in part because the rewards of application are assumed to be carried out through an adequate functioning of the market system. Only in the case of market failure is government action required.

FRAME 2: NATIONAL SYSTEMS OF INNOVATION

This frame aims to make better use of knowledge production, inducing commercialisation and bridging the gap between discovery and application.

It puts various forms of learning at the centre, including learning by using, producing and interacting, linkages between various actors, absorptive capacity and capability formation of firms, and finally entrepreneurship. The rationale for policy intervention is system failure: the inability to make the most out of what is available due to missing links in the innovation system. Innovation policy focuses for example on technology transfer, building technology platforms and technology clusters to stimulate interaction, and human capital formation. Foresight, technology assessment and regulation are add-ons to the core activity which is the promotion of innovation assuming any innovation is good since this is the motor for producing economic growth and competiveness.

FRAME 3: TRANSFORMATIVE CHANGE

This frame takes as a starting point that benefits of innovation are not necessarily certain. The negative impacts of innovation can overtake the benefits.

Creative destruction can become destructive creation, and begin to threaten the foundations of economic growth and competiveness. **This frame focuses on mobilising the power of innovation for addressing a wide range of societal challenges** including poverty reduction, climate change, and inequality. Innovation policy is aiming for socio-technical systems change and trying not only to influence the rate, but the direction of innovation. This will require a new structural transformation in governance arrangements between the state, the market, civil society and science, more space for experimentation and societal learning, a more constructive role for foresight helping to shape innovation processes earlier on and on a continuous basis, and the development of new types of knowledge fusing social science, humanities, engineering and sciences.

The emergence of a new frame does not necessarily replace or displace Frames 1 and 2. However, they all compete for the imagination of policymakers and ultimately citizens. Rationales and arguments for particular policies and the actions that follow from them is influenced by the prevalence and understanding of the framings.

TYPICAL POLICY ACTIVITIES

FRAME 1

R&D stimulation in various forms (subsidies, tax credits, procurement, mission-oriented programmes) and establishing a healthy business climate which stimulates investment in R&D. Both developed and developing countries need to invest in R&D. Emergence of 3% norm and ambition in EU.

Building IPR regime providing appropriate mix of protection and option for diffusion and larger spread of benefits

Education policy, with emphasis on Science, Technology, Engineering and Math (STEM subjects).

Science Communication to explain importance of STEM to wider public, needed to legitimize larger investment funded through taxation.

Foresight to select focus areas.

Regulation and technology assessment to manage negative impacts. Technology assessment efforts mainly focus on informing parliaments and wider public debate.

Regulation efforts lead to debates about best policy mixes of economic, command and control and social and informational instruments in case of environmental impacts. In the case of social benefits debate it is about levels of benefits, policies for reskilling etc.

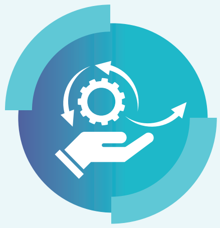
Regulation is not integrated in Science and Technology Policy.

FRAME 2

Constructing links between the actors (building platforms, networks, databases) and organizing technology transfer; stimulate learning by doing, using and interacting, stimulate Entrepreneurship; incubators.

In general focus on capability development, enhancing absorptive capacity, ability of State to stimulate development and deliver positive contributions to innovation and help direct innovation.

For example, there is a stronger belief in importance of building government programmes which stimulate development of cleaner technologies instead of end-of-pipe technologies. The latter are add-on solutions that simply capture a pollutant while not solving the problem at source. Cleaner technologies seek to prevent pollution at source.



FRAME 3

Stimulate opening up, debate between promotion of various options, generation of more options and diversity, for example through experimentation (niche construction) & open innovation; organize and stimulate destabilization of dominant societal-technical systems and regimes; stimulate institutional entrepreneurship & work of intermediaries; organize closing down of less desirable directions; organize participatory anticipation; exploring new modes of governance; introduce responsible research and innovation & constructive technology assessment; building interface competences between the social and the technical, for example through higher education policy which should aim for bridging the gap between the STEM domain and the social sciences and humanities.

To engage in these transformative innovation policy activities we also need to re- frame and reinterpret policy analysis. SPRU researchers are working in this area – two examples being innovation policy mixes for transformative change and the importance of experimentation. These will be discussed in more detail below to show some of the implications of the transformative change frame and how it might be implemented within innovation policy.

2. Application 1. Innovation policy mixes for creative destruction

Based on Paula Kivimaa & Florian Kern (2016)'Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions'. *Research Policy*

Public policies can be influential drivers of innovations in multiple sectors ranging from manufacturing to transport. However, transformative change towards sustainability originating from technological innovation often take decades, time that we do not have. At present, innovation policy mixes – the variety of incentivising, regulatory and promotional policies aimed at science, technology and innovation - typically cover many of the functions needed to support the creation of new technologies. There is, however, much less focus on dismantling standards, rules and actor-networks that preserve non-sustainable practices and technologies in innovation, production and consumption processes – measures that can be labelled destructive (of current practices).

Schumpeter's term of 'winds of creative destruction' describes a process that revolutionises the economic structure, making certain skills and capabilities redundant and creating new ones at the same time. By adopting the idea of creative destruction, we outline a new conceptualisation of innovation policy mixes.

To stimulate the rapid uptake of innovations contributing to transformative change the design of new innovation policy mixes as well as their assessment and evaluation need to include both creative and destructive measures:

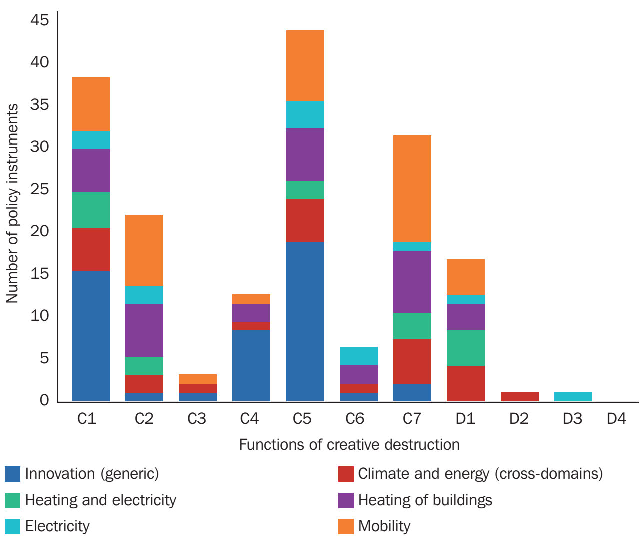
- Creative innovation policies support research and development, experimentation and market entry as well as guide innovation towards societally important thematic areas (such as energy demand reduction)
- Destructive innovation policies are **broader and often sectoral, and "destabilise" non-sustainable institutional structures and practices**. They reduce barriers for the broader diffusion of more sustainable technologies, services and practices and better enable systemic innovation for sustainability transitions.

CASE EXAMPLE: POLICY MIX FOR LOW ENERGY INNOVATION

In recent work we have illustrated this argument by building on the functions of technological innovation systems literature[2], adding four new destruction functions that address the need to significantly reformulate rules (adding control policies and making structural reforms in legislation and institutions), change the technological basis of systems (reducing support for dominant regime technologies) and alter the composition of actors and networks (changing social networks and replace key actors (Kivimaa and Kern, 2016).

We analysed all national-level policies potentially reducing energy demand in two European countries – the UK and Finland and assessed to what extent the objectives of the policy measures can be expected to support innovation or contribute to the 'creative destruction' of high energy use practices. We found that there are dozens of policies focused on creating low energy innovations (innovation which reduce energy demand or increase energy efficiency) but that there is much less attention on the destructive side of creative destruction.

UK POLICY MIX FOR LOW ENERGY INNOVATION IN 2014 SHOWS THAT HARDLY ANY INSTRUMENTS ADDRESS THE DESTABILISATION OF HIGH ENERGY SYSTEMS.



Key: C = creative measure D = destructive measure

[2] This literature describes technological innovation systems to form in interaction between different functions comprising knowledge creation and diffusion, formation of new markets, entrepreneurial experimentation, resource mobilisation, creation of legitimacy, guidance of search, and positive externalities (e.g. Bergek et al., 2008; Suurs and Hekkert, 2009; Wieczorek et al., 2013).

INNOVATION POLICY MIXES FOR TRANSFORMATIVE CHANGE: TWO TYPES OF FUNCTIONS AND POLICY MEASURES

DESTRUCTION FUNCTIONS (REGIME DESTABILISATION)	TYPES OF POLICY MEASURES ADDRESSING THE FUNCTION
Control policies (D1)	Emission regulations, carbon taxes, technology bans, etc.
Significant changes in regime rules (D2)	E.g. structural reforms in legislation, significant new overarching laws.
Reduced support for dominant regime technologies (D3)	Removal/reduction of subsidies and R&D funding, technology bans, etc.
Changes in social networks, replacement of key actors (D4)	E.g. creation of new powerful committees with involvement of niche actors
CREATION FUNCTIONS (NICHE CREATION)	**TYPES OF POLICY MEASURES ADDRESSING THE FUNCTION**
Knowledge creation, development and diffusion (C1)	R&D funding schemes, innovation platforms, demonstration subsidies, etc.
Establishing market niches/ market formation (C2)	Regulation, tax exemptions, public procurement, deployment subsidies
Price performance improvements (C3)	Deployment and demonstration subsidies enabling learning-by-doing
Entrepreneurial experimentation (C4)	Advice systems for SMEs, incubators, low-interest company loans, venture capital, etc.
Resource mobilisation (C5)	R&D and deployment subsidies, venture capital, educational policies, etc.
Support from powerful groups / legitimisation (C6)	Innovation platforms, foresight exercises, labelling etc.
Influence on the direction of search (C7)	Targeted R&D funding, regulations, tax incentives, voluntary agreements, etc.

Key: C = creative measure   D = destructive measure

An example of destructive policy is the UK Climate Change Act with potential to start a destabilisation process. The Act introduced a longer term policy framework than is typical for election-cycle based policies, set up targets for binding carbon cuts, and created new organisations around it. Other disruptive policies include the ban of incandescent light bulbs by the EU, new organisations changing established policy networks (such as the Committee on Climate Change) and policies changing crucial rules or significantly controlling the environmental impacts of activities (such as energy efficiency requirements of building codes or car fuel standards). The origin of many of these measures lie in the European Union. The share of more generic innovation policy measures has been negligible in destabilising the socio-technical system, whereas both cross-domain climate and energy policies as well as building energy efficiency and mobility specific policies were found to have the potential to destabilise unsustainable systems. Further considerations relate to how the different goals and instruments in the mix actually interact with each other to influence innovation – both over time and at a given moment (Huttunen et al., 2014; Rogge and Reichardt, 2016; Kern et al. 2016)

MESSAGES FOR POLICYMAKERS

Important considerations for innovation policy mixes from the perspective of transformative change are that: (1) Control policy instruments matter for wider transformative change. For example, in Germany nuclear phase out has been seen as a key instrument in the mix supporting the creation and diffusion of renewable energy technologies (Rogge et al. 2015). (2) Sectoral policies, such as energy, health, employment, and transport are significant parts of 'real world' policy mixes influencing the direction and speed in which transformative change occurs.

3. Application 2: From technology demonstration to transition experiments

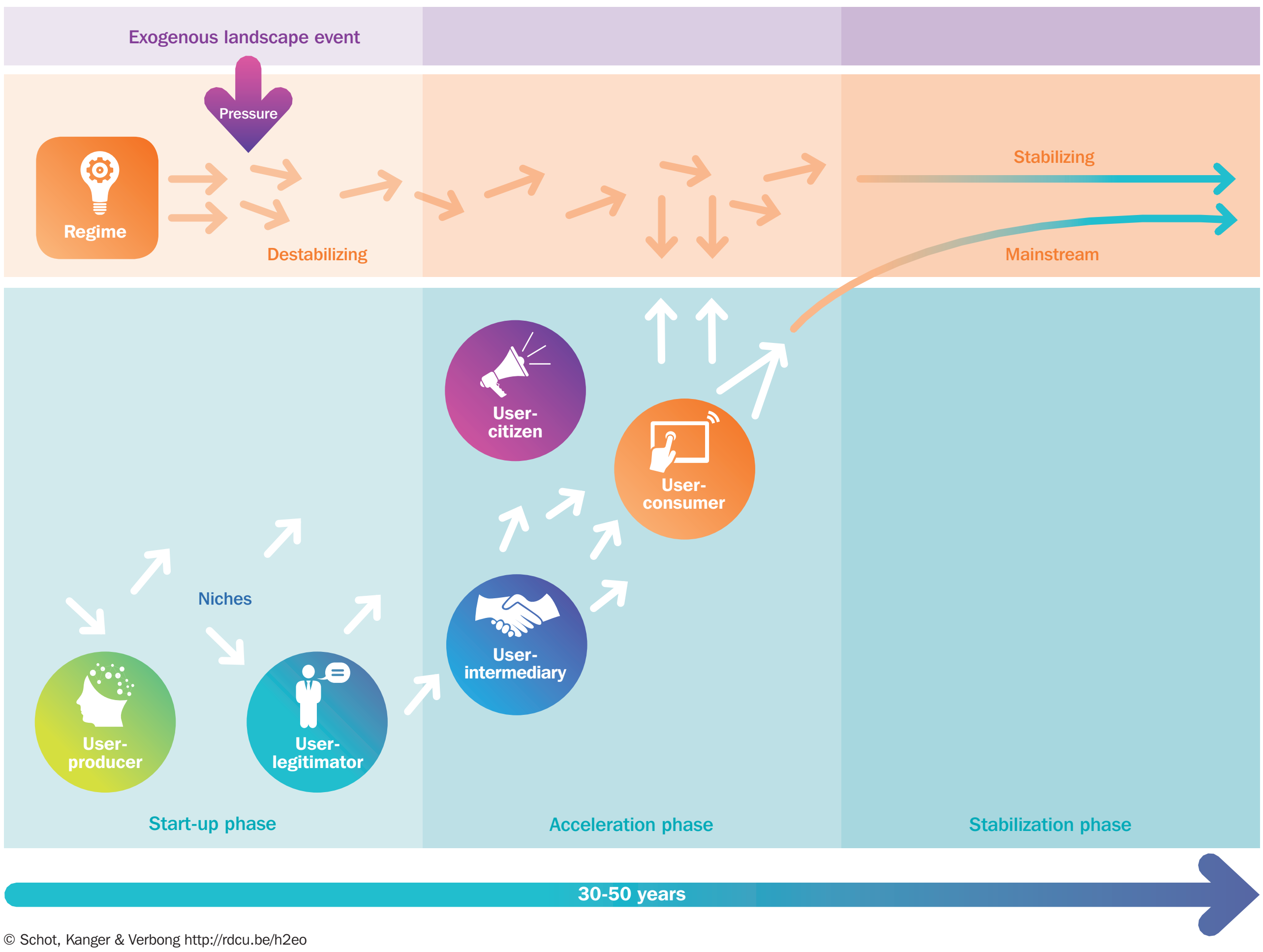
As argued above, transformative change or transitions (we use both terms interchangeably here) need to be supported through an appropriate mix of policy instruments. Although there is a need for new types of policy instruments and governance processes, some classic innovation policy instruments can also play an important role if they are adjusted in ways that make them suitable for fostering transformative change. We argue that **demonstration projects need to be designed and organised as a form of transition *experiment* in order to foster learning about potential alternative development pathways.** Innovation policy should engage in strategic niche management (Schot and Geels 2008) which explores alternative socio-technical configurations.

WHAT ARE TRANSITION EXPERIMENTS?

Experimenting with new socio-technical configurations is a key tool for promoting transformative change towards sustainability. Scholars have proposed to use the notion of experiment rather than demonstration in order to stress that learning is central (Hoogma et al 2002). The learning from experiments should go beyond first order learning (technical learning) and involve learning about user needs, societal benefits and potential negative effects, regulations as well as questioning existing preferences and collectively building new ones. Recent research has shown that the role of users is crucial in transitions. They can enact social learning, boost scaling up and help to create favourable regulatory environments (Schot et al. 2016).

Experiments are understood as initiatives which develop highly novel socio-technical configurations which are potentially able to lead to substantial sustainability gains, have a high level of ambition and therefore risk, and bring together new networks of actors to cooperate in a learning process (Berkhout et al. 2010). The literature on strategic niche management shows that technology policy can contribute to the creation and development of promising sustainable socio-technical configurations through experimentation (Schot and Geels 2008).

FROM NICHE TO MAINSTREAM: WHY PEOPLE POWER IS KEY TO CHANGING OUR SYSTEM



HOW DO TRANSITION EXPERIMENTS DIFFER FROM DEMONSTRATION PROJECTS?

Table 1 lists some of the key differences between classic demonstration projects and transition experiments. There are significant dissimilarities in the starting points, objectives and methods of the two types of projects and this has important implications for the way in which such programmes need to be designed. The main aim of a transition experiment is not to solve a given (technical or cost) problem but to help create a social learning process across a range of different actors to explore novel socio-technical configurations; this makes it difficult to measure the outcomes of experiments.

TABLE 1: KEY DIFFERENCES BETWEEN DEMONSTRATION PROJECTS AND TRANSITION EXPERIMENTS

	DEMONSTRATION PROJECT	TRANSITION EXPERIMENT
Starting point	Possible solution (to make innovation market ready)	Societal challenge (to solve persistent societal problem)
Nature of problem	A priori defined and well-structured	Uncertain and complex
Objective	Identifying satisfactory solution (innovation)	Contributing to a transition (fundamental change in system)
Perspective	Short- and medium-term	Medium- and long-term
Method	Testing and demonstration	Exploring, searching and learning
Learning	1st order, single domain and individual	2nd order (reflexive), multiple domains and collective (social learning)
Actors	Specialised staff (researchers, engineers, professionals, etc)	Multi-actor alliance (across society)
Experiment context	(partly) controlled context	Real-life societal context
Management context	Classic project management	Transition management (focussed on societal transition goals)

Source: van den Bosch 2010: 63

EXPERIENCE WITH TRANSITION EXPERIMENTS

There is some academic literature which reflects on the practical experience with real-world transition experiments. A review of recent literature found that most commonly reported outcomes of transition experiments are changed discourse and learning (deepening) as well as replication of technologies (broadening), whereas altered governance structures, new markets and changed consumption practices occur much more rarely (Kivimaa et al. 2015). One of the shortcomings of many experiments is that they are too focussed on technology development and neglect broader co-evolutionary dynamics, that there is too little follow up to generate enough momentum for the new socio-technical configuration to develop further and that often regime actors are too dominant in such programmes. This limits the space to develop radical alternatives (Schot and Geels 2008; Kern and Smith 2008; Raven et al 2016). Intermediary actors can play a key role in aggregating lessons from individual experiments (Kivimaa 2014). The literature also clearly points to the importance of going beyond experimenting with alternative socio-technical configurations in that pressure on existing regimes are also crucial for transitions (Kivimaa and Kern 2016). The box below reflects on a specific transition experiment programme in the Netherlands. While the programme had many novel features, we argue that its selection criteria were too narrow to be able to contribute to transformative change.

THE EXPERIENCE WITH TRANSITION EXPERIMENTS IN THE DUTCH ENERGY TRANSITION PROGRAMME

In 2001 the Dutch government set up a dedicated funding scheme to support experiments to contribute to an energy transition. The Ministry of Economic Affairs felt that existing funding schemes were not well aligned with the aims of transition experiments which is why a dedicated subsidy scheme was put in place (UKR). The UKR provided subsidies of €118 million between 2004 and 2007. Projects had to involve at least two different partners, at least one of which had to be a business. One example of an experiment was a project by the Dutch paper industry which aimed to save 50% energy use along the production chain of paper by 2020. The association cooperated with actors from the entire production chain – from raw materials and machine suppliers to end users and waste processors – to fulfil this ambition.

However, one of the challenges of designing such a programme is to develop appropriate selection criteria for the projects. In the UKR the selection criteria were: effectiveness (potential emission reductions, new business opportunities, or contributing to greater independence of imports), feasibility (technological feasibility and cost effectiveness), strength of demand (is there a sufficiently strong market demand if the project is successful?) and pace (can the project be achieved quickly?). While all of these criteria are legitimate, they unduly limit the scope for novelties to emerge. If technologies are feasible and cost effective already, then the added value of funding experiments is limited. Markets for radically new socio-technical configurations are not easily formed which is why 'strength of demand' is a challenging and potentially misleading criterion. Innovations may be ill-adapted to the existing system and often have cost disadvantages over incumbent technologies for the individual investor (whilst offering societal benefits such as emission reductions) which makes cost effectiveness a problematic criterion. The chosen criteria therefore unduly reduce the space to experiment and favour options which are already technically feasible, economically viable or close to market which resulted in limited variation with concomitant implications for the potential for transformative change (Kern and Smith 2008).

MESSAGES FOR POLICY MAKERS

While classic demonstration projects remain an important instrument of innovation policy, it can be argued that in the context of transformative change, the use of these projects needs to be changed. They should be used as platforms for enabling transformative change, focus on learning, networking, and eventually the creation of a broader market niche which provides an alternative socio-technical configuration to fulfil social needs such as nutrition, shelter, mobility or energy. This includes building a set of connections between a wide range of transition experiments. It is therefore important to develop mechanisms which help with the aggregation of lessons learned from a variety of experiments, for example through the establishment of government-affiliated intermediaries. Transition experiments also need careful design with regard to the selection and evaluation criteria which is important in order for such programmes to have the potential to stimulate transformative change. Lastly, policy makers also need to ensure that the design of the programme is not unduly influenced by incumbent interests which may limit the scope for transformative change.

Further engagement with SPRU

The ideas shared in this briefing paper form part of a much wider body of work in progress within SPRU. To mark our 50th anniversary, SPRU has embarked on an ambitious new strategy focused on long-term transformative change and innovation across different sectors, societies and structures. We hope this paper has provided a useful point of entry from which we would value continued engagement and discussion. We are currently exploring a range of new research avenues under the banner of 'Transforming Innovation' and our Anniversary Conference 7-9 September 2016 will bring together leading thinkers from business, academia and civil society to explore the future of innovation policy. This offers a space for academics and policy shapers to engage more deeply on this agenda.

For further information on the SPRU research strategy 'Transforming Innovation' visit:

www.sussex.ac.uk/spru/research/strategy

For Further information and to register for the SPRU 50th Anniversary Conference visit:

www.sussex.ac.uk/spru/about/50years

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SECTION 2

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Professor Schot's research is wide ranging but has always focused on integrating social science and historical perspectives for a better understanding of the nature and governance of radical socio-technical change. Under Johan's directorship, SPRU is embarking on an ambitious, new strategy as part of the 50th anniversary in 2016 which will draw on SPRU's extensive activities and capture the best thinking within and beyond SPRU. As part of this new strategy, Johan and SPRU colleagues aim to develop a new innovation theory which will address the current crisis of capitalism and a number of key challenges our world is facing: inequality, climate change, the democratic deficit, and the need to develop new systems of provision for security, food, water, energy, healthcare and mobility. Necessarily the program will theorize the nature, scale and scope of long-term transformative change, and ways of providing directionality to economic growth. The new theory will synthesise insights from economics of innovation, science & technology studies, history of technology, and other relevant fields.

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Professor Steinmueller has been Professorial fellow at SPRU since 1997. He has published widely in the field of the industrial economics of information and communication technology industries including integrated circuits, computers, telecommunications, software and the economic, social policy issues of the Information Society. He has also contributed to research in science policy and the economics of basic research. Professor Steinmueller has been an advisor to several Directorates at the European Commission, the National Academies of Science and Engineering (US), and the Department of Trade and Industry and Office of Telecommunications (UK).

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Dr Kern has more than ten years of experience in research, consulting and teaching in the area of energy, climate and innovation policy as well as socio-technical transitions. In his work for the Centre on Innovation and Energy Demand, based in SPRU he leads on a project 'Policy Mixes for Low Energy Innovation.' His research combines ideas and approaches from innovation studies and policy studies/political science to investigate the politics and governance of innovation for low carbon energy systems and sustainability transitions more generally. He has engaged with policy makers in the Netherlands, the UK, and Austria as well as the European Commission and the WTO on these issues.

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Dr. Kivimaa is based in the Centre on Innovation and Energy Demand (CIED) within SPRU. Her previous research ranges from climate, energy and environmental policy analysis from the perspective of innovation to examining change and stability in energy and transport systems. Current research interests include policy analysis from low-carbon innovation and transition perspectives as well as policy complementing approaches to support low-carbon innovation, such as intermediation. Prior to joining SPRU she has worked for 12 years as a researcher in the Finnish Environment Institute (SYKE).

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Dr Rogge joined SPRU as Lecturer in Energy Policy and Sustainability in November 2013 from the Fraunhofer Institute for Systems and Innovation Research, Germany. Dr Rogge's interdisciplinary research combines insights from environmental economics, innovation studies and policy analysis to study the link between policy and innovation in the energy sector. She has led the GRETCHEN project (2012-15) investigating the influence of the policy mix for renewables on technological and structural change in Germany and is also Fraunhofer ISI's principal investigator of the European project PATHWAYS, in which she performs a multi-level analysis for the electricity sector in Germany. She also contributes her policy mix expertise to the Centre on Innovation and Energy Demand (CIED). Karoline has been involved in advising the German government since 2004, including as a member of the scientific secretariat of the German Emissions Trading Stakeholder Group, and prior to that has acted as a consultant to the OECD and World Bank. Since 2016 she is a Fellow of the Higher Education Academy.

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