Policy for system innovation

the case of Strategic Innovation Programs in Sweden

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JEL: O30; O33; O38

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Summary

System innovation policy refers to a horizontal policy approach that mobilises technology, market mechanisms, regulations and social innovations to solve complex societal problems in a set of interacting or interdependent components that form a whole socio-technical system. Even if policies start to be aimed at addressing these complex societal challenges, as many governments are presently doing, system innovation framing is still under-developed and it is unclear how to implement such policies. In this report we seek to contribute to both gaps. Firstly, we develop an analytical framework that allows to specify the conditions that enable and constrain system innovation. Secondly, we apply this framework on two Strategic Innovation Programs, a policy initiative by Vinnova, Sweden's Innovation Agency, targeting system innovation. Correspondingly, the objective of this report is to explore how system innovation policy is implemented and to analyze how system innovation policy practice corresponds to the challenges set out by the transformative change implied by system innovation.

As an overall framework, the analysis makes use of the literature on socio-technical transitions. While this literature provides relevant and useful concepts to understand (conditions for) system innovation, it remains a challenge to apply the socio-technical transitions literature for policy studies. We therefore develop an analytical framework for system innovation policy by integrating concepts from socio-technical transitions into an innovation system approach. A starting point for developing such a analytical framework is to focus on the essence of societal challenge driven system innovation policy, which is primarily related to the question of directionality. Whereas innovation policy traditionally has been directed to improving the generic capacity of countries, regions and/or industries for innovation and, ultimately, economic growth, system innovation policy is closely linked to setting of collective priorities. **Directionality** can be defined as the ability not just to generate innovations as effectively and efficiently as possible, but also to contribute to a particular direction of transformative change. To diversify into different pathways experimentation plays an important role (Boschma et al., 2016). **Experimentation** is at the core of innovation activities carried out in niches and foregrounds its agentic qualities. It refers to processes that enable the alignment of a heterogeneous set of actors, institutions and technologies in order to establish socio-technical "configurations that work" through processes of interactive learning. Here experimentation is understood as an iterative construction process where networks of distributed actors jointly create new market segments and user profiles, adapt regulations, lobby for subsidies, or define new technical standards and thereby ultimately create the conducive environment that helps a new industry develop and mature (Garud and Karnøe 2003; Garud et al. 2010). The third building block captures the system effects of experimentation, i.e. to what extent it gives rise to transformative change, understood as a change of directionality in systemic patterns of consumption and production. Here we distinguish between two system effects. On the one hand, through experimentation feedback (both positive and negative) is generated about existing and prospective institutional arrangements for innovation thus giving rise to **policy learning and coordination**. Three levels of policy learning are distinghuished. Government learning relates to learning and coordination within and across public government organisations, network learning to the support structure of an innovation system including stakeholders such as firms, universities and NGOs whereas governance learning encompasses state-economy-civil society relations broadly understood. On the other hand, experimentation also affords for **demand articulation**, i.e. anticipating and learning about user needs to enable the uptake of innovations by users. Again, different degrees user involvement can be

distinguished ranging from raising awareness about novel technological and social innovations based on user feedback, to close integration and co-creation by users and consumers in more open innovation models.

To provide for greater analytical precision in analysing the conditions for and processes of system innovation policy, we suggest a return to some of the basic categories from innovation systems, namely actor interests and capabilities, networks and institutions. This will allow us to unpack and specify when and how policy measures are able to influence processes of directionality, experimentation, demand articulation and policy learning & coordination.

The aims and objectives of the SIP program – to create preconditions for sustainable solutions to global societal challenges and to increase competitiveness in areas of high relevance to the Swedish economy – are broadly formulated, allowing for fairly open-ended interpretation and adaptation by the participating actors. The SIP program is organized with a profound bottom-up ambition in which design as well as implementation is decentralized to the participants of respective consortia with as little involvement of Vinnova as possible. Below we summarize the main findings from our case studies on two specific SIP programs: Bioinnovation and Re:source.

	Directionality	**Demand articulation**	**Experimentation**	**Policy learning and coordination**
Actor interests and capabilities	*Broad, catch-all agenda-setting* > **more fine-grained operationalization & agenda-setting along the way**	*Lack of innovation procurement capabilities* > **explicit call for projects on public procurement and innovation**	*Lack of involvement by small firms* > **active management of project consortia by expert teams & focus on small-scale projects** *Co-funding remains difficult for small firms* > unresolved	*Mismatch between the interests, routines and professional cultures of industry and academia* > **greater attention and focus on industry engagement**
Networks	*Unresolved conflicts of interest within and across value chain due to power and knowledge assymetries* > **active search and enrolment of new actors by program managers**	*Insufficient user-producer interaction* > **active and prominent involvement of users as necessary condition for innovation project proposals**	*Closed collaboration networks* > **active management of project consortia by expert teams & focus on small-scale projects**	
Institutions	*Little evidence of institutional change in the form of aligned values, norms and strategic objectives* > unresolved.	*Little attention for changing consumer attitudes and practices* > unresolved		Institutional mismatch in terms of incentives and regulations between industry and academia > **explicit attention for learning about need for**

				changes in regulation and policy

1. Introduction

Grand societal challenges such as climate change, ageing population and food security feature increasingly on the agenda of policymakers at all scales. Innovation policies that directly target these challenges are in particular advocated by supranational organisations such as the OECD and the European Union (EU), but are gradually also taken on board by local, regional and national authorities (Cagnin et al. 2012; Coenen et al., 2015). This orientation towards grand societal challenges can be seen as a new wave or paradigm for innovation policy.

Against this context Schot and Steinmuller (2016) suggest three historical framings of innovation policies. *Innovation policy 1.0* has been primarily directed to R&D-based innovation, drawing on a linear model of innovation that priviliges the technological discovery process. *Innovation policy 2.0* aims to make better use of knowledge production, support commercialisation and bridge the gap between discovery and application, drawing on the concept of systems of innovation. *Innovation policy 3.0* involves the explicit mobilisation of science, technology and innovation for meeting social needs. It addresses the issues of sustainable and inclusive societies at a more fundamental level than previous framings or their associated ideologies and practices. Drawing on socio-technical transition theory it implies a more capacious understanding of innovation including technological, social and grassroot innovations and calls attention for the directionality of innovation.

In light of the above grand societal challenges, Schot and Steinmuller (2016) argue strongly for the importance of innovation policy 3.0 – innovation policy for transformative change - as ”innovation policy should focus much less on products, processes, firms, and R&D, but on the achievement of systems wide transformations, since optimization of existing systems will not be a sufficient answer” (p. 17). Similarly, the OECD (2015) observes that “by and large, most innovation policies aim to foster incremental change; fostering wider system change is a new challenge for innovation policy makers, especially as many of the actions will fall in areas outside the direct remit of research ministries or innovation agencies but where their input, coordination and implementation actions will remain critical” (p. 9). This challenge, in turn, requires so-called *system innovation policy* understood as “a horizontal policy approach that mobilises technology, market mechanisms, regulations and social innovations to solve complex societal problems in a set of interacting or interdependent components that form a whole socio-technical system” (OECD 2015, p. 7).

Even if policies start to be aimed at addressing these challenges, as many governments are presently doing, this third framing is currently under-developed and it is unclear how to implement such policies (Kuhlmann and Rip, 2014; Schot and Steinmuller, 2016). In this report we seek to contribute to both gaps. Firstly, we develop an analytical framework that allows to specify the conditions that enable and constrain system innovation. Secondly, we apply this framework on two Strategic Innovation Programs, a policy initiative by Vinnova, Sweden’s Innovation Agency, targeting system innovation. Correspondingly, the objective of this report is to explore how system innovation policy is implemented and to analyze how system innovation policy practice corresponds to the challenges set out by the transformative change implied by system innovation.

The remainder of the report is structured as follows. Section two provides an introduction to Vinnova’s Strategic Innovation Program and the two sub-program that have been analyzed, namely Bioinnovation and Re-source. Section three presents our analytical framework drawing on innovation system and socio-technical transition theory. Section four gives a description of the actual system innovation that these two sub-programs are addressing, namely the transition to a biobased circular economy. In section five we apply our analytical framework on the policy practice of Bioinnovation and Resource. Section six provides the conclusions.

2. Strategic Innovation Programs in Sweden

The Strategic Innovation Programs (SIP) are part of a wider initiative called the Strategic Innovation Areas, a policy initiative which explicitly targets system innovation. It was launched by the Swedish Government in 2012 as a mission to Sweden's Innovation Agency (Vinnova), the Swedish Energy Agency (Energimyndigheten) and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas). The initiative has a twofold objective, (1) to improve international competitiveness and (2) to address global societal challenges. It consists of two sets of interrelated activities (explained below): the Strategic Innovation Agendas and the Strategic Innovation Programs (SIP). While previous innovation policy initiatives in Sweden have largely focused on exploiting and furthering specialization in established or emerging strengths in Sweden's innovation system (in terms of sectors, technologies and/or regions), the initiative explicitly sets out to enhance interaction between different actors in the innovation system by transcending sectors and territorial boundaries. The rationale for this has been the recognition that interaction and collaboration between diverse and sometimes unrelated sets of actors is increasingly important for innovation in modern economies (Boschma et al., 2016). Such interaction needs to be enhanced by policy because it did not seem to take off despite big investments in research and innovation (OECD, 2016).

The first set of activities in the initiative, Strategic Innovation Agendas, provided seed funding to stimulate formulation of agendas and alignment of expectations on how to address certain global societal challenge related thematic areas with ambitions to generate industrial and technological renewal. Funding was distributed in small amounts to initiatives shaped and implemented by actors from academia, business and society, much in line with the triple helix strategy already established in Vinnova's historical policy portfolio (Cooke, 2005). Between the start of the SIO initiative and fall 2016, more than 150 agendas have been supported, which indicates that this program could be seen as experimental rather than truly strategic: priorities between potential strength areas were made ex-post based on evaluation rather than based on an ex-ante strategic orientation. The second set of activities, which is the main focus of this report, was named Strategic Innovation Programs (SIP). Drawing on the inputs and insights generated through strategic innovation agendas, Vinnova opened a call for large scale strategic investment into some of the agendas with highest potential, based on the roadmaps formulated in the agendas and the constellations of actors composing them. The SIP program is organized with a profound bottom-up ambition in which design as well as implementation is decentralized to the participants of respective consortia with as little involvement of the agency as possible (OECD, 2016). The involved actors thus have significant opportunity and autonomy to decide on strategic as well as operational actitvities. While such a bottom-up approach opens possibilities to address needs and demands identified by the actors themselves, it also creates challenges connected to path-dependency, vested interests and power assymetries among the participating actors. This challenge may have been further accentuated as a result of mergers of different independent innovation agenda as a way of mobilizing greater interest and more resources when applying for SIP. Several of the SIP initiatives draw on combinations of different agendas; in some cases up to ten agendas generated through SIA have been merged into one SIP.

The overall SIP program is currently distributed across and implemented through 16 strategic innovation programs launched in three generations (2013, 2014, 2015). Each SIP has recieved initial funding for three years with the possibility for extension up to nine additional years if they meet the review criteria specified by Vinnova in collaboration with the participating actors as an integral part of the program itself. Due to the nature of the initiative and the program, it is not entirely straightforward to evaluate its long-term effect already three years into the program. The first evaluation should probably be seen primarily as a milestone assessment aiming for improvement in the continuation of the program, although failure might lead to termination, or at least reduction or reorientation of activities. This also indicates that policy learning, based on openness and adaptability, is given priority in the SIP program (c.f. Borrás, 2011).

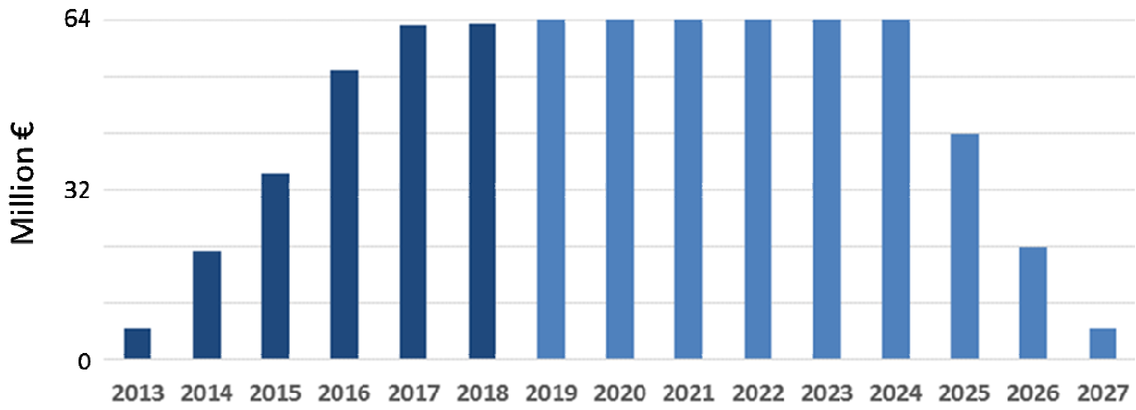
The aims and objectives of the SIP program – to create preconditions for sustainable solutions to global societal challenges and to increase competitiveness in areas of high relevance to the Swedish economy – are broadly formulated, allowing for fairly open-ended interpretation and adaptation by the participating actors. In addition to stressing the need for interaction and broad participation of actors of different types, Vinnova highlights the ambition to draw on pre-existing strengths in the innovation system (in terms of industries, competences, profiles, scientific themes etc) and at the same time stimulate industrial and technological renewal. During the course of the programme, the initial focus on international competitiveness in areas of high importance for the Swedish economy has, according to the programn representratives interviewed in this study, been increasingly combined with a focus on addressing global challenges, in particular challenges connected to sustainability. In the most recent descriptions of the SIP program (Vinnova, 2016) the main aim has even shifted and forefronts now the focus on sustainable solutions to global societal challenges. This change of priorities can also, according to the OECD (2016) review of Swedish Innovation Policy, be traced in the selection of SIPs from agendas. The first generation of SIP was dominated by traditional Swedish strengths in the innovation system (resource based industries and production) while the second and third generation almost entirely focus on areas directly related to challenges for sustainability (bio-innovation, waste management, transport systems, heath-technologiues and sustainable built environments).

Due to the complexity of global challenges for sustainability, the broad range of actors representing academia, business and other private and public sector organisations is one of the key characteristics of the inititiative. While this opens for potential cross fertilization across previously separated domains and knowledge bases, it also raises challenges with regard to coordination and alignment of interests and expectations. One challenge which came across clearly in the interviews on which this study is based, is the assymetric engagement by different actors. In the initial phase of the program, the initiative was clearly led by actors from academia, while companies kept a significantly lower profile. During the course of the program, however, business engagement had strengthened. Furthermore, the complexity of problems set out to deal with emphasises the need for both technological and non-technological innovations as well as institutional change, and spans severeal technological and sectoral domains. To handle this wide span from a policy point of view, the SIP program is organized as a joint initiative between three agencies; Vinnova, the Swedish Energy Agency and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas).

Chart 1 provides the budget figures for the overall initiative, allocated by the Swedish Government, which will reach approximately €64 million in 2017. To this should be added at least the same amount in matching funds by participating actors (from both the private and public sector). Combined with the related initiative "Challenged Driven Innovation" (UDI), the SIO program represent 30% of Vinnova's total innovation support, and is thus a significant part of the public sector's investment in the Swedish innovation system. According to Vinnova's own analysis the program is dominated by four research areas (all primarily related to technical disciplines) and around 30 organisations, among those several research institutes and universities (OECD, 2016). The concentrated pattern into technology/engineering is an assumed effect of the early focus on Swedish strength areas.

At an operational level, the SIP program is focused on different types of measures such as financial support to research, development and innovation projects and demonstration sites. Other activities are facilitation of knowledge creation and diffusion through conferences, business advice and incubation activities, and commission of various outlook and evaluation reports. The most common way of organizing financial support for research, development and innovation projects and demonstration sites is through open calls for proposals which are assessed by panels of expert reviewers. Some programs also work with more targeted projects defined and assessed by the program committees. Examples of the latter are market analyses and capacity building projects.

Figure 2.1: Government funds allocated each year to the Strategic Innovation Programs



This report focuses particularly on two Strategic Innovation Programs from the second and third generation of SIP, specifically targeting global challenges related to sustainability. *BioInnovation* gathers actors with an interest in the bioeconomy and is based on a combination of nine different innovation agendas in the SIA program. Spanning over at least a handful of different sectors and a wide group of actors from the public as well as private sector, Bioinnovation is a good illustration of the broad range of stakeholders the SIP initiative targets, and the nature of the initiative also implies the broadness of scope with regard to research base as well as market. *RE:Source* gathers actors with an interest in the circular economy, spanning a somewhat more narrow scope in terms of industries but still broad enough to represent the intended shift from specialization towards platform technologies and solutions to more generic challenges. The SIP is based on a combination of five different agendas. Sectorwise Re:Source is partly overlapping with Bioinnovation, although looking at involved actors the two programs are differently organized. These similarities and differences make these initiatives a suitable pair for assessing SIP as a policy for system innovation, with specific attention to system transformation challenges on the level of actors, networks and institutions.

BioInnovation

The guiding vision underpinning the SIP BioInnovation is that Sweden should make the transition to a bio-based economy in the first half of the 21st century. The mission of the initiative is to create conditions to increase the added value in the Swedish bio-based sector. Expected effects are new innovations leading to bio-based materials, products and services that give increased international competitiveness for Swedish enterprises and increased export value for Sweden. The BioInnovation consortium is currently composed by more than 60 organisations from different sectors, representing industry, academia and the public sector. The explicit ambition with BioInnovation is to promote cross-fertilization of competences and experiences by stimulating interaction and collaboration across sectoral boundaries. A percieved precondition for achieving such cross-fertilization, is to work towards bridging the gaps between the sectors by way of coordinating and, when possible, integrating standards, norms, traditions and business cultures. The total annual budget for the initiative is €10 million of which at least 50 percent comes from contributions by the participating organizations.

The initiative is operationally organzed around four areas of priority, each of which is governed by a so called Expert Team. These expert teams are coordinated by a chairman appointed by the general assembly of BioInnovation. Within each area of priority the expert team coordinates support to a number of innovation projects which are supposed to run for 3 years with a total budget of 45 MSEK (equivalent to approximately €5 million). Thus, even at the project level within the respective areas of priority the volumes of investments are relatively big.

Criterias for evaluation of project support are derived from the general guidelines for the SIP program defined by the funding agencies. However, due to the decentralized model of SIP, each consortia is responsible for its own evaluation. BioInnovation stresses the combined relevance of projects departing from well defined societal challenges and at the same time targeting and shaping sustainable markets. It also stresses the need for transcending traditional boundaries through stimulating new forms of collaboration, and it presupposes long-term perspectives on renewal. With these guiding principles BioInnovation, within each of the four areas of priority, offers two forms of project support: activity projects supporting among other things the formation of new meeting platforms and investigation of potential new markets, and open calls supporting new innovation projects of various kind.

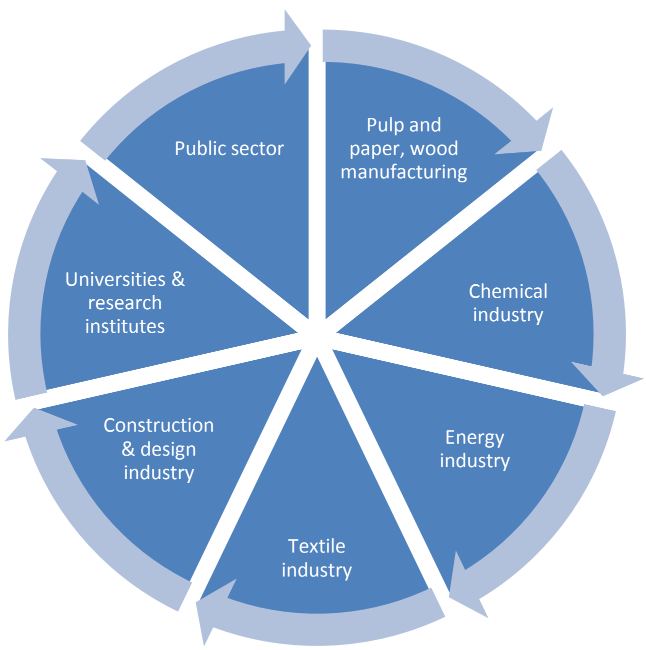
The four areas of priority are currently *chemicals and energy, construction and design, materials, and new utilization*. In line with the ambition to stimulate boundary-spanning and cross-fertilization BioInnovation explicitly encourages participation by actors in more than one area of priority. These respective areas of priority share the common challenge of making the transition to a bio-economy, but they also face some specific challenges.

The main challenge for the chemicals and energy area is the transition from a fossil to a non-fossil resource base. This implies a need for developing and implementing new production processes, but also to stimulate a change in consumer preferences and market logics. A big niche in this area of priority is biorefinery technology, and applications are platform- as well as specialty chemicals.

Integrated processes through biorefineries would utilize the natural resource base more efficiently, yet there are still both technological and societal challenges that must be addressed. One main technological challenge is related to separation and transformation of biomass, and to streamlining the production process making it energy efficient enough to compete with traditional fossil based processes. There are also societal challenges related to policy (e.g. regulations and incentives) and market (e.g. consumer preferences and legitimacy).

The construction and design area is partly sharing the same challenges as the chemicals and energy area in the sense that there is an urgent need to increase value and cater for environmental sustainability in the production process through more efficient use of raw materials. Addressing this challenge Bioinnovation supports innovation projects aiming to develop new construction materials and processes based on biomaterials, as well as innovations that can increase the sustainability of existing materials. There is thus an overlap between the area of construction and design with both the chemicals and energy area related to process development, and to the area of materials related to defining new materials with sustainable features and potential. In addition to this challenge the materials area also supports project for innovations in the packaging and logistics as well as the health care industries. Such industry-transcending scope of activities makes this area a good case for analysing institutional challenges for transitions, in particular since some sectors (e.g. health care) are defined by fairly strict regulation and control. The area of new utilization is described as the most experimental of the four areas of priority. In principle it cuts across the other three areas by focusing on new experimental ways of utilizing biomaterials, both in terms of products and processes and in terms of markets and business models.

Figure 2.2: provides an overview of the actors involved in BioInnovation and which sectors they represent.



RE:Source

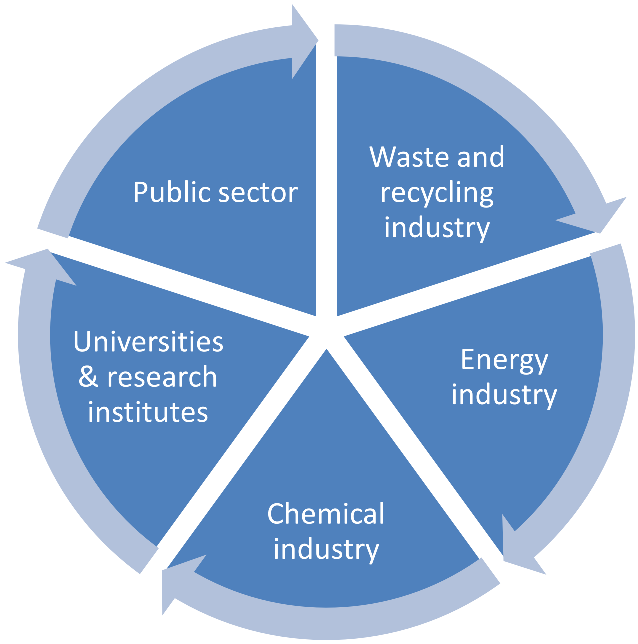
The guiding vision for Re:Source is that Sweden by 2030 should be the world-leading country in minimizing and utilizing waste. With this vision comes an ambition to contribute with innovative solutions to face the grand societal challenges of resource demand, material supply, and a sustainable energy system. The initiative sets out a number of strategies to achieve these aims. The overarching strategy is to establish Re:Source as a central platform and arena for interaction among actors from industry, academia and the public sector involved in resource- and waste management. Similar to the BioInnovation initiative the complexity of challenges for Re:Source presupposes that such interaction and collaboration takes place across sectoral and territorial boundares. Some of the immediately involved sectors (e.g. chemicals and energy) are the same as in the BioInnovation program. However, due to the generic nature of resource- and waste management, one could argue that all parts of the Swedish economy (both on the production and consumption side) are involved in one way or another. While this underscores the relevance and potential impact of the program, it also underscores the complexity of challenges it faces, not least with regard to coordination and alignment of expectations and interests. Being recently initiated, the scope and scale of Re:Source is not yet as large as BioInnovation, but there is an expectation that this will develop during the course of the project. The first phase (three years) was initiated 2016, but already from the start the consortium plans for twelve years duration of the program.

The program is coordinated by SP, the Technical Research Institute of Sweden, at which also the programme management office is hosted. While BioInnovation is operationally organized into expert groups defined by thematic areas of priority and application, Re:Source does not have such sub-structure but is organized around an independent programme management group composed by one coordinator, one innovation leader and one team leader for each of the three specified main challenges (resource demand, material supply, and sustainable energy system). Each team leader has in turn a reference group with representatives from both the private and public sector. When assessing the Re:Source program in comparison with the BioInnovation initiative, the more generic nature of Re:Source is clearly apparent. Not only is the program organized in a more integrated manner, it is also quite hard to distinguish which concrete activities are devoted to each one of these three societal challenges.

In the first phase Re:Source gives priority to what can be defined as large volume waste streams such as food waste, electronics, vehicles, textiles, packaging, construction waste, rest products, but also other industry waste and residuals. On the input side (efficient and sustainable use of resources) is both the challenge of reducing input resources in general by optimizing production processes, and the challenge of increasing the use of non-hazard resources. Both these challenges indicate potential synergies with the BioInnovation initiative. Also from a downstream perspective there are common challenges such as better utilization of circular material flows. Re:Source highlights the following areas of priority for the first generation of the program (among a range of others): innovative business and governance models for transition to a circular economy, promting expanded lifespan of producs, efficient logistics for materials feeding into the circular economy, waste prevention strategies for production and reuse of products and components, improved awareness and attitudes among consumers, improved markets for reuse of products, depoisoned circular material flows, efficient and economically sustainable energy production based on biological processes, improved work environment, health and security. This non-exclusive list of priorities underscores the generic nature of the initiative, and the potential conflict of interest that may arise within the consortia and in relation to other initiatives. An obvious challenge connected to this is the potential contradiction between sustainability and economic growth.

By way of implementing its strategy, Re:Source is organised around six measures, or fields of activities. In addition to research- and innovation projects, which in similarity with BioInnovation consumes a fairly large share of the program budget, resources are allocated to commercialization and business development, policy analysis, coordination of education, international collaboration on research and innovation, and knowledge dialogue. The aim with the support to research and innovation projects is to promote new knowledge generation not only aiming for developing new technologies and innovative solutions, but also studies and evaluations, data collection and other investigations that strengthen the national knowledge base in the area of resource- and waste management. Commercialization and business development activities aims to support implementation of new business ideas and promote export of Swedish innovations in the field of resource- and waste management. In this aim lies efforts to identify markets, support to entrepreneurs, infrastructure investments and support to communication between SMEs, agencies and other organisations to help companies navigate in a complicated policy landscape. Also support to demonstration projects and their upscaling belong to this category of measures. Policy analysis aims to provide policy makers with sound basis for decision making and to facilitate a dialogue between policy makers, researchers and business actors. Much attention is geared towards laws, regulations and different types of standards. This measure resembles many shared characteristics with the measures on coordination of education and knowledge dialogue, although the latter implies a broader focus than policy analysis.

Figure 2.3: provides an overview of the actors involved in Re:Source and which sectors they represent.



3. Towards an analytical framework for system innovation policy

In the following section, we briefly outline the conceptual framework that our study draws upon as point of departure. As an overall framework, the analysis makes use of the literature on socio-technical transitions. While this literature provides relevant and useful concepts to understand (conditions for) system innovation, it remains a challenge to apply the socio-technical transitions literature for policy studies. We therefore develop an analytical framework for system innovation policy by integrating concepts from socio-technical transitions into an innovation system approach.

Socio-technical transitions

The literature on socio-technological transitions is primarily concerned with specifying the conditions for transformative shifts in systems of production and consumption that unfold as disruptive technological change co-evolves with changes in markets, user practices, policy, discourses and governing institutions (Geels 2002; Kemp et al. 1998; Markard et al. 2012; Smith et al. 2010). This literature calls attention for the co-evolution of a broad range of innovations which highlights technological, social, organisational, institutional, and business model novelty. It shares many theoretical roots with innovation studies, most notably a system perspective on innovation and a neo-Schumpeterian evolutionary understanding of change and industrial dynamics (Coenen and López 2010). However, compared to innovation system approaches, it claims to comprise a wider set of institutions and networks of heterogeneous actors including firms, user groups, scientific communities, policy makers, social movements and special interest groups. As a result, it stresses the importance of directionality, resistance and contestation in innovation processes. The most well-known examples of such socio-technological transitions concern low-carbon transition in fields of energy and transport. However the conceptual model can be applied to any field subject to broad system transformation.

Drawing on the Schumpeterian notion of creative destruction, research on socio-technological transitions has emphasized the role that technological niches play in radical change in the face of relatively stable regimes (Schot and Geels 2008). A regime refers to an entrenched socio-technical system whose institutional logic structures perception and behavior of actors, thus favoring incremental change and innovation. A central and recurrent proposition in socio-technical transition research is that system transition requires the destabilisation of an existing regime. A niche is defined as an 'incubation space' for radically new technologies characterized by high technological, institutional and market uncertainty. Niches protect radical innovations against market selection and institutional pressures from a regime and allow actors to learn about novel technologies and their uses through experimentation (Coenen et al. 2010; Geels 2002). System transition can occur when niches gather sufficient momentum so that these relatively loose configurations become institutionalized and create capacity for emergent technologies and radical innovations to challenge and substitute a regime. The distinction between niches and regimes has been proven to be a useful heuristic to capture processes of new path creation in the emergence of radically new sustainable technologies while at the same time accounting for processes of path-dependence and resistance when such technologies start to substitute and dislodge existing socio-technical systems (Smith et al. 2010).

However, a number of shortcomings can be identified. First of all, various scholars have pointed out that there is a need for greater rigor in the operationalization of niches and regimes (Berkhout et al. 2004; Fuenfschilling and Truffer 2014; Markard and Truffer 2008). Numerous empirical studies have for example conflated niches with new entrants and regimes with incumbent actors. As a result, there has been a relative neglect of the role of incumbents in driving radical transformation processes in sustainability transitions (Smith et al. 2005; Hockerts and Wüstenhagen 2010). In light of the specific transitions that this study is addressing (i.e. bio-based economy and circular economy) and the supposedly important role of incumbent actors in these transitions, a careful empirical analysis of regime-level and niche-level conditions is therefore warranted.

Secondly, it has proven challenging to use the socio-technical transition literature for policy-making, at least compared to the innovation systems approach (Turnheim et al., 2015). Quite recently, however, some scholars have started to develop frameworks that help study the ways in which policy influence (both enable and constrain) system transition (e.g. Weber and Rohracher 2012; Kivimaa and Kern, 2015). These studies typically combine or integrate a transitions framework with an innovation systems framework. However, these tend to be primarily conceptual and lack serious and systematic empirical investigation.

Systemic approaches to innovation policy

The rationale for policy support in systemic approaches to innovation is to address system failures (Laranja, Uyarra, and Flanagan 2008). A system perspective on innovation (innovation policy 2.0) goes beyond the neoclassical economic rationale that policy intervention is only legitimate and needed due to market failure because of sub-optimal resource allocation by firms (innovation policy 1.0). Rather, it builds on the notion that innovation processes are social learning processes that take place in a context of actors' capabilities and interests, networks and institutions, and which can pro-actively influence the innovation capacity of firms, regions and nations. This implies that public intervention is legitimate and needed not only if the complex interactions that take place among the different organisations and institutions involved in innovation do not function effectively. Various authors (Klein Woolthuis, Lankhuizen, and Gilsing 2005; Smith 1998) have identified a number of structural system failures which inform and shape system-oriented public policy support for innovation.

- Capabilities' failures: The lack of appropriate competencies and resources at the firm and organisational level may limit and/or prevent the generation of, access to, and exploitation of knowledge.
- Network failures: Intensive cooperation in closely tied networks leads to myopia and lack of infusion of new ideas or too limited interaction and knowledge exchange with other actors inhibits exploitation of complementary sources of knowledge and processes of interactive learning.
- Institutional failures: Absence, excess or shortcomings of formal institutions such as laws, regulations, and standards, in particular with regard to IPR and investment and lack of informal institutions such as social norms and values, culture, entrepreneurial spirit, trust and risk-taking that impede collaboration for innovation.

While the relevance of these types of failures is generally accepted, this framework has been criticised for being geared primarily to system optimization while challenges of system transition have been relatively neglected (Alkemade et al. 2011). Drawing on insights from socio-technical transitions literature, table x outlines the differences between system improvement and system transformation.

Policy goal	System improvement	System transformation
	Structural system failures	
Actors	• Capability deficiencies (type of actors, level of capabilities, incompatible knowledge profiles) • Lack of capital (physical, financial)	• Capability mismatch (knowledge in "wrong" areas) • Reactive innovation strategies • Vested interests (profit opportunities, sunk investments)
Networks	• Fragmentation • Low level of interaction	• Strong ties between incumbents (network rigidity, exclusion of new actors) • Lack of boundary spanners / unrelated variety in networks
Institutions	• Disincentives to engage in learning and innovation • Lack of trust • Lack of institutional adaptation (for economic / technological specializations)	• Normative, regulative and cognitive institutions favor lock-in to existing development paths • Institutional uncertainty and mismatch for emerging technological and industrial paths • Disincentives for experimentation

Table 3.1: system improvement versus system transformation (source, the authors)

Various advances have been made that suggest how the above innovation system failure framework can be extended to address not only system improvement but also system transformation (Weber and Rohracher, 2012; Kivimaa and Kern, 2016). Weber and Rohracher (2012) provide a comprehensive framework that informs policies for transformative change drawing on a combination of market failures, structural system failures and transformational system failures. The four transformational system failures can be regarded as a direct extension of the structural system framework outlined above. These include: directionality failure, demand articulation failure, policy coordinate failure and reflexivity failure. There is a risk, however, that the suggested transformational system failures remain schematic and, in doing so, remain mute concerning several important questions. By simply categorizing systemic failures along different dimensions, there is a lack of understanding how these failures are interconnected and whether they all are of equal importance. Moreover, cause-effect relationships remain black-boxed. Finally, even though this critique is also acknowledged by Weber and Rohracher (2012) the semantics of 'failures' may follow too closely the neo-classical market-failure framing and legitimizing of policy intervention, thus discounting for more pro-active and developmental approaches to innovation policies (Asheim et al., 2011; Mazzucato, 2016). To address the latter critique we substitute a concern with system failures with system challenges while solving questions related to the interconnections between the different transformation challenges requires better embedding in a theoretical framework.

A starting point for developing such a theoretical framework is to focus on the essence of societal challenge driven system innovation policy, which is primarily related to the question of directionality (Schot and Steinmuller, 2016). Whereas innovation policy 2.0 has been directed to improving the generic capacity of countries, regions and/or industries for innovation and, ultimately, economic growth, innovation policy 3.0 is closely linked to setting of collective priorities (Steward, 2012). One important building block of the theoretical framework relates thus to the conditions and mechanisms through which directionality is provided. Directionality can be defined as the ability not just to generate innovations as effectively and efficiently as possible, but also to contribute to a particular direction of transformative change (Weber and Rohracher, 2012). In transition terminology, this refers to a regime-shift of socio-technical system, incorporating co-evolving structural changes in production and consumption patterns. To diversify into different pathways experimentation plays an important role (Boschma et al., 2016).

Experimentation is particularly emphasized in the MLP framework. Experimentation is at the core of innovation activities carried out in niches and foregrounds its agentic qualities. It refers to processes that enable the alignment of a heterogeneous set of actors, institutions and technologies in order to establish socio-technical "configurations that work" through processes of interactive learning (Callon 1998; Rip and Kemp 1998; Raven, 2008). Here experimentation is understood as an iterative construction process where networks of distributed actors jointly create new market segments and user profiles, adapt regulations, lobby for subsidies, or define new technical standards and thereby ultimately create the conducive environment that helps a new industry develop and mature (Garud and Karnøe 2003; Garud et al. 2010).

The third building block captures the system effects of experimentation, i.e. to what extent it gives rise to transformative change, understood as a change of directionality in systemic patterns of consumption and production. Here we distinguish between two system effects, closely related to the Weber and Rohracher (2012) framework. On the one hand, through experimentation feedback (both positive and negative) is generated about existing and prospective institutional arrangements for innovation thus giving rise to policy learning and coordination. Borrás (2011) suggests three levels of policy learning. Government learning relates to learning and coordination within and across public government organisations, network learning to the support structure of an innovation system including stakeholders such as firms, universities and NGOs whereas governance learning encompasses state-economy-civil society relations broadly understood. In terms of organisational capacity, government learning reflects administive capacity, network learning reflects analytical capacity through broadening the competence base, while governance learning reflects major reflexive and institutional capacity going beyond actor networks or groups of actors. On the other hand, experimentation also affords for demand articulation, i.e. anticipating and learning about user needs to enable the uptake of innovations by users. Again, different degrees user involvement can be distinguished ranging from raising awareness about novel technological and social innovations based on user feedback, to close integration and co-creation by users and consumers in more open innovation models (von Hippel, 2005).

These building blocks are interrelated. Through experimentation, novel pathways in production and consumption are explored, trialled and tested. This leads to opportunities for demand articulation as well as policy learning and coordination, which, in turn, feed-back on the direction of chosen pathways and opportunities for future waves of experimentation. To provide for greater analytical precision in analysing the conditions for and processes of system innovation policy, we suggest a return to some of the basic categories from innovation systems, namely actor interests and capabilities, networks and institutions. This will allow us to unpack and specify when and how policy measures are able to influence processes of directionality, experimentation, demand articulation and policy learning & coordination. The following matrix provides the backbone for our analytical framework:

	Directionality	**Experimentation**	**Demand articulation**	**Policy learning and coordination**
Actor interests and capabilities				
Networks				
Institutions				

Table 3.2: analytical framework to study system innovation policy (source: the authors)

4. System innovation in focus – a circular bio-based economy[1]

The transition to a circular bio-based economy has within the last 10-15 years emerged as an important policy priority in many countries, and is also identified as one of the EU's Horizon 2020 societal challenges. Consequently, policies at multiple scales have been introduced to address multiple issues including collection, production and processing of raw materials, research and innovation efforts targeting products and processes, and market-side interventions (Staffas et al. 2013). The development towards a circular bioeconomy can be characterised as a system innovation as it requires fundamental changes in both production and consumption. To replace incumbent fossil fuel-based socio-technical systems, actors are considered to change direction when innovating, producing and consuming products; formal and informal institutions ought to change; and new infrastructures should be established. To exemplify, a transition from fossil fuel-based chemicals to bio-based chemicals requires new competencies and collaborations within and between firms and sectors; customers who value and trust bio-based chemicals; the development of new standards and other forms of supporting regulations; and the creation of new infrastructures to handle different forms of feedstock. In summary, the scale of required changes and their systemic character imply that a system innovation is needed. This system innovation pertains to the two SIPs analysed in this chapter, Bioinnovation and Resource.

The circular bio-based economy intertwines with many of the grand challenges faced by modern society. Evidently, a circular bio-based economy is particularly important in a climate change perspective, but it is expected that this transition will also address issues in relation to food security, health, industrial restructuring and energy security (Richardson 2012; Ollikainen 2014; Pülzl et al. 2014).

Still, while the circular bio-based economy is considered highly important in addressing these grand challenges, it is often not clear what a bioeconomy implies in greater detail. As described by Pülzl et al. (2014, p. 386), *"its meaning still seems in a flux"* and Levidow et al. (2013, p. 95) characterise the bioeconomy as a *"master narrative"*, which is open for a number of different interpretations. Circularity is the context of the bioeconomy can be understood as the principle of maintaining biological resources in use as long as possible, extracting the most value from them at any stage, by reusing and recycling them and thereby closing the loop.

Based on a review of academic bioeconomy literature, Bugge et al. (2016) identify three ideal type visions of what a bioeconomy constitutes (see also Levidow et al. 2013; Staffas et al. 2013). They distinguish between:

1. *A bio-technology vision.* In this vision bio-technology research and application and commercialisation of bio-technology in different sectors play a key role. Circularity plays a minor role in this vision.

2. *A bio-resource vision*. This vision focuses on the role of research, development and demonstration (RD&D) related to biological raw materials in bio-based sectors such as agriculture, marine, forestry and bioenergy. A second important focus is the establishment of new value chains. Thus, in contrast to the bio-technology vision, which takes a point of

[1] This first part of this section draws on Bugge, M., Hansen, T. and Klitkou, A. (2016) What Is the Bioeconomy? A Review of the Literature. *Sustainability,* **8**: 691..

departure in the potential applicability of science, the bio-resource vision stresses the possibilities for upgrading and conversion of the biological raw materials. Circularity is of some, though not central, importance in this vision.

3. *A bio-ecology vision*. The third vision emphasises the importance of ecological processes that optimise the use of energy and nutrients, promote biodiversity and avoids monocultures and soil degradation. In contrast to the two previous visions, which are technology-focused and give a central role to RD&D in globalised systems, this vision emphasises the potential for regionally concentrated circular and integrated processes and systems. Consequently, circularity plays a central role in this vision.

As all ideal type categorisations, real world understandings of what the bioeconomy entails will often be less clear-cut. Still, key features of the three bioeconomy visions relating to overall aims and objectives, value creation, drivers and mediators of innovation, the role of circularity and spatial focus can be entangled. Table X summarises the main differences (see Bugge et al. 2016 for elaborate descriptions).

Table 4.1. Key characteristics of the bioeconomy visions

	The bio-technology vision	**The bio-resource vision**	**The bio-ecology vision**
Aims & objectives	Economic growth & job creation	Economic growth & sustainability	Sustainability, biodiversity, conservation of ecosystems, avoiding soil degradation
Value creation	Application of biotechnology, commercialisation of research & technology	Conversion and upgrading of bio-resources (process oriented)	Development of integrated production systems and high-quality products with territorial identity
Drivers & mediators of innovation	R&D, patents, TTO's, Research councils and funders (Science push, linear model)	Interdisciplinary, optimisation of land use, include degraded land in the production of biofuels, use and availability of bio-resources, waste management, engineering, science & market (Interactive & networked production mode)	Identification of favourable organic agro-ecological practices, ethics, risk, transdisciplinary sustainability, ecological interactions, re-use & recycling of waste, land use, (Circular and self-sustained production mode)
Importance	Low – processes designed	Intermediate – cascading	High – central importance

of circularity	to minimise waste	use of biomass and processing of waste important to optimise efficiency of biomass use	of cascading use of biomass and circular and self-sustained production modes
Spatial focus	Global clusters / Central regions	Rural / Peripheral regions	Rural / Peripheral regions

Source: Elaboration of Bugge et al. (2016, p. 10)

The key policy document in relation to the transition to a circular bio-based economy in Sweden is the "Swedish Research and Innovation Strategy for a Bio-based Economy" published in 2012 by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning in collaboration with the Swedish Energy Agency and Vinnova – the Swedish Innovation Agency. This document is the key national-level strategic document on the bioeconomy in Sweden, and it also to some extent covers issues of circularity. The used definition of a bioeconomy takes a starting point in the use of bio resources and emphasises that economic development and sustainability are equally important policy priorities (FORMAS 2012, p. 9):

"We have defined a bio-based economy (bioeconomy) as an economy based on:

- *A sustainable production of biomass to enable increased use within a number of different sectors of society. The objective is to reduce climate effects and the use of fossil-based raw materials.*
- *An increased added value for biomass materials, concomitant with a reduction in energy consumption and recovery of nutrients and energy as additional end products. The objective is to optimize the value and contribution of ecosystem services to the economy."*

Thus, the case of the envisioned transition to a circular bio-based economy in Sweden mostly resembles a bio-resource vision.

As the character of the document is a research and innovation strategy, aspects related to this topic naturally take an important role. However, this does not imply that the strategy takes a narrow research-push approach to the development of the Swedish bioeconomy. As noted by Staffas et al. (2013, p. 2762), *"[t]he document clearly has a broad approach to the BBE [bio-based economy] and addresses numerous aspects of both the BBE itself and the ways to reach it."* Thus, in addition to issues related to knowledge production in a systemic context and other aspects related to the *Innovation policy 2.0* framing, the strategy also highlights a number of important challenges which are closely related to transformative change, as understood in an *Innovation policy 3.0* framing. Below we elaborate on these challenges in relation to the previously introduced headings of directionality, experimentation, demand articulation, and policy learning and coordination.

In terms of **directionality**, the report specifically highlights the importance of continuously focusing on issues related to prioritisation. Since increasing or changing use of bio-resources may have unforeseen environmental or social consequences, the strategy highlights the importance of analysing such effects. This highlights the importance of ensuring that the development of the bioeconomy is not compromising other public policy priorities, i.e. that the development direction is desirable. Thus, *"[t]he collective environmental effects of the systems, both positive and negative, must form the starting point for sustainable production and use"* (FORMAS 2012, p. 28). The development towards a bioeconomy should in other words not be at the expense of e.g. biodiversity, use and leakage of nutrients, pesticides and antibiotics, or negative social implications for vulnerable groups. Rather the strategy underlines the need for improving the ability to including such aspects (e.g. biodiversity), which are inherently difficult to price, into business models and policymaking processes. Furthermore, the strategy also stresses the importance of research, which can solve potential conflicts of objectives concerning, for instance, land use. In summary, the strategy goes far beyond the understanding of the bioeconomy as desirable *per se*, and underlines the need for ensuring that the development towards the bioeconomy is in line with other public policy priorities, by continuously paying attention to directionality.

Regarding **experimentation**, the strategy repeatedly highlights the importance of involving many types of actors in development and innovation activities. Thus, it is argued that the challenges of a bioeconomy *"necessitate widespread collaboration between companies, sectors, universities, colleges, research institutes and public sector organisations. New technologies and knowledge requires multiple disciplines, subject areas and sectors to work together to be able to deal with the complex issues and demands for solutions that the challenges give rise to"* (FORMAS 2012, p. 31).This resembles calls for broad actor networks in experimentation activities in the transitions literature (Kemp et al. 1998). The strategy also underlines the role of small and medium-sized enterprises on a number of occasions, in particular in relation to commercialisation of new technologies. Specifically regarding development of biorefineries[2], which is arguably a key enabling factor for the transition to a bioeconomy that requires experimentation with new technologies, business models and organisational structures (OECD 2009; Bauer et al. 2016; Hansen and Coenen 2016), the strategy also calls for a close integration of up- and downstream aspects in development activities, preferably including user stages as well.

Aspects related to **demand articulation** are discussed extensively in the strategy and changes in consumption habits and attitudes are designated as one of four key challenges in transitioning to a bioeconomy. The advocated approach to this challenge is not merely to develop increasingly attractive and competitive bio-based products, but also to influence and give attention to consumer awareness and purchasing habits. This also includes an increased focus on circularity: *"To be able to achieve a recycling-adapted society based on biological raw materials requires changing attitudes towards consumption and changing the consumption patterns of both producers and consumers"* (FORMAS 2012, p. 27). The strategy also specifically stipulates that efforts to change consumption and use patterns should be seen in relation to the current situation where the existing fossil-based socio-technical regime continues to dominate. One specifically outlined policy initiative in the strategy to address aspects of demand articulation, is the establishment of a *User Forum* consisting of representatives from multiple types of user groups, including agencies, companies and members of the community, which are to provide recommendations for prioritising knowledge gaps and new problem areas, as well as giving advice for Swedish research funding organisations.

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[2] A biorefinery can be understood as *"an integrated system of bio-based firms, able to produce a wide range of goods from biomass raw materials (chemicals, bio-fuels, food and feed ingredients, biomaterials, including fibres and power) using a variety of technologies, maximising the value of the biomass"* Lopolito, A., Morone, P. and Sisto, R. (2011) Innovation niches and socio-technical transition: A case study of bio-refinery production. *Futures,* **43**: 27-38.

Finally, concerning **policy learning and coordination**, an important identified challenge is the lack of knowledge about the interrelation between policies: *"To date much of the research and development in the area of governance and policy has not taken a lifecycle perspective into account and has instead primarily examined individual policy measures, individual sectors or individual links in the production chain, instead of the entire system"* (FORMAS 2012, p. 29). This is particularly problematic in relation to the topic of system innovation, which is in particular characterised by a need for policy coordination across multiple policy spheres. While the strategy notes that policy coordination specifically related to research funding in the Swedish context is well functioning, it still suggests that *"more developed forms of collaboration between the agencies"* (FORMAS 2012, p. 33) could be beneficial in the future. The strategy also outlines that further knowledge is needed concerning obstacles of various types (including administrative and regulatory obstacles), which hampers the opportunities for developing and commercialising bio-based products.

In conclusion, despite having the character of a research and innovation strategy, FORMAS (2012) does indeed outline an number of important challenges related to transformative change towards the bioeconomy in Sweden. In addition, it should be mentioned that the Swedish Government has recently (June 2016) established five Strategic Collaboration Programs, including one focused on the circular bio-based economy, with the aim to strengthen collaboration between the public sector, business, universities and colleges, and thereby improve the innovativeness and competitiveness of Sweden. While most of the activities under this program are still to be established, and it is thus still unclear to what extent the program activities will address challenges closely related to transformative change, it is however worth noticing that most of the Strategic Collaboration Programs are not organised around traditional industry classifications (life science is the exception), but rather around topics and challenges that cut across multiple industries: smart cities; travel and transport for the next generation; connected industry and new materials; and circular bio-based economy. Thus, in summary, it appears that the *Innovation policy 3.0* framing is indeed evident in Swedish high-level policymaking around the topic of a circular bio-based economy, and the subsequent section analyses the extent to which specific system innovation policy initiatives and practices reflect the introduced transformative change agenda.

5. The cases of Bioinnovation and Resource

In this section, we will present the result of our empirical analysis. The empirical data has been collected through an extensive desk-based document analysis combined with nine semi-structured interviews. The document analysis has covered policy reports and other policy documents, newspaper articles and documents guiding the operative work within the programs. The latter were provided by the interview partners. The interviews were taken during spring 2016 and included program managers, chairmen and other board members, and members of the so called 'strategic committees' or 'expert teams' of both programs. In addition, respondents were selected to cover not only the different functions within the program, but as representatives of different stakeholder groups. By using a snowball sampling method, combined with insights gained from the document analysis, we have strived for a balanced selection of interview partners. Each interview lasted approximately one hour.

The interviews followed an interview guide based on the analytical categories derived from the theoretical discussion (table 3.2). We asked respondents about activities targeting different types of transformational failures, but did also allow for broader discussion about the operational design of the strategic innovation programs. By doing so, we gained both deeper and broader insights about the subject of matter. Consequently, the collected data was coded and analyzed using the previously identified categories. However, this process was complemented by the use of an 'in vivo' coding method, which guided minor adaptations of the categories.

The result from the analysis will be presented throughout the following four sub-sections, each based on one of the potential failures in the theoretical framework; directionality, policy learning and coordination, demand articulation and experimentation.

Directionality

Directionality in the SIPs has been provided primarily through the vision-development and agenda-setting exercise conducted through the SIA. As mentioned in section 2, one measure to ensure broad interest by and engagement of a variety of stakeholders was to combine a number of different and relative narrow innovation agendas into broader more encompassing programs. The formulation of the agendas as well as the strategic innovation programmes was mainly driven by individuals from research organisations and associations of public organisations and private industry who had experience in drafting proposals for funding. Acting as "boundary spanners", they used their network and interpretative power in order to mediate between different interests, synthesize the individual agendas, and formulate embracing visions. In the case of BioInnovation, nine Strategic Innovation Agendas, all related to specific aspects of the bioeconomy, were combined into one Strategic Innovation Program. RE:Source is the result of integrating agendas related to waste minimization and utilization.

The challenges in this regard are twofold:

- Firstly, on the actor side, the agendas have been criticized for being very broad thus weakening their power of providing direction in a concrete and actionable way for the involved stakeholders. It remains questionable whether and to what extent the SIPs have achieved an institutional change in the form of aligned values, norms and strategic objectives. This may have to do with a lack of experience with and understanding of actor driven innovation programs targeting societal challenges. Some stakeholders held the expectation that the SIPs would fund traditional innovation projects addressing individual actors' needs as opposed to the more comprehensive and collective activities required to target a societal challenge. Consequently, the investigated SIPs were designed rather as umbrella of several agendas, representing different actor interests rather than as a collectively forged, well-aligned and integrated program.

- Secondly, from a network perspective, industry representatives have pointed to unresolved conflicts within and across value-chains, which may not always receive sufficient attention from program managers and which have not been articulated in the strategic agendas. Actors from different parts of the value chain, of different size and financial power, might lack an understanding of their counterparts' specific challenges. Even though these asymmetries may be of a more structural and fundamental nature and beyond the scope of program managers to solve, they are perceived not to be sufficiently acknowledged with within the program.

To illustrate the latter challenge, in the case of Re:Source the waste recycling industry and the municipality-owned waste-handling companies compete for the same waste. The public waste-handling companies use waste for energy production that could also be used by the private industry for recycling. Currently, the public waste-handling companies are in a favourable position as they enjoy by law a monopoly on handling waste produced by households in Sweden. In BioInnovation, potential conflicts between different parts of the value chains of cross-sectoral innovation efforts have been highlighted by representatives of the large, incumbent industry actors. For example, one interview partners highlighted the asymmetry between smaller firms in the textile industry, entering collaborations with the intention of 'simply' gaining market access to new materials, while larger material suppliers are supposed to invest large sums in the innovation project to research and develop new material. Furthermore, incumbent actors of the industry have raised concerns regarding the need for active participation in the innovation projects, limiting the possibility of participation with the intention of exploring new technologies or learning about new business opportunities. This reflects an inherent conflict between the industry and innovation projects as a model for collaboration, as the industry is more short-term oriented and less prone to make large investments of exploratory nature.

The first problem – broad, catch-all agenda-setting - has been dealt with by breaking down the strategic goals and vision into a detailed set of objectives on different levels, which have been described in a document called "effektlogik". This is a living document that is adapted over time as response to changes in the environment and the perception of new or better ways of reaching the strategic goals. In other words, the strategic goals are set in the agenda while the roadmap for achieving these strategic goals is laid out in the effektlogik. This process of operationalisation is necessary in the course of program implementation and resonates with what Raskin et al. (2002, p. 32-33) describe as follows: "The broad goals express a powerful ethos for a sustainable world. This is the stirring but intangible music of sustainability. Also needed are the lyrics and the dance—specific targets to concretize the goals and policy actions to achieve them."

The second problem - unresolved conflicts of interest - has more important consequences and emerges also in the process of translating strategic goals into more concrete objectives and actions.

It has turned out in our case studies that a range of concrete objectives and actions were not feasible due to conflicting interests between key stakeholders. In such a situation, program managers are tempted to diverge from the strategic goals in order to formulate objectives and actions that receive sufficient buy-in and are achievable. This is because the performance of program managers relates to the success of the strategic innovation program. Rather than not absorbing funds and implementing fewer activities, from a program manager's perspective it may be the better option to promote collaborative activities that only weakly contribute to the strategic goals. Therefore, it is important to promote incentive mechanisms that promote addressing the root of the problem (i.e. in this case the unresolved conflicts) and an open discussion about how to address it.

As regards networks, measures have been taken to extend the reach of the programmes to new and potentially relevant actors. To this end, the programme managers of the two SIPs engage in networking and communication like a cluster organization that aims to increase the awareness and perceived benefits of the cluster. In addition, BioInnovation has established a formalized process for the development of innovation projects that facilitates the embedding of new actors into existing networks. In a first step, everyone is invited to submit ideas. The barrier of entry is low as this step only requires the formulation of the idea on one page. The expert teams of BioInnovation group the ideas, thereby linking the respective actors. Each group is invited to further elaborate the idea. Based on the extended elaborations, some groups are selected to create consortiums and include more actors. The most promising groups in terms of expected effect on structural change are invited to prepare a full project description.

Demand articulation

In relation to demand articulation, two main challenges have been identified:

- On the actor side, *lack of innovation procurement capabilities* in relevant public sector actors was identified as a barrier in relation to both BioInnovation and RE:Source. Public procurement for innovation is important since is stimulates the development of new, large scale markets and improves the likelihood of developing new products that answer to existing needs. Thus, public procurement for innovation may support the transition to a circular bio-based economy, however, managing such processes also requires new capabilities in the procurement divisions of public sector actors, who have traditionally been procuring almost exclusively based on price criteria.

- On the network side, *insufficient user-producer interaction* in innovation projects was highlighted as a problem in the case of BioInnovation. It is stressed that even though the attitude towards bio-based products generally is positive, the knowledge about such products is lacking among users. This is especially true for firms downstream in the value chain. It has practical implications for innovation projects, as it is hard for project leaders and experts to find collaboration partners understanding the value of bio-based innovation. Furthermore, insufficient user-producer interaction has apparent implications for ensuring the market relevance (and market creation when applicable) of innovation projects.

BioInnovation has addressed the first of these problems by launching an open call for projects specifically focused on public procurement and biobased innovation. The open call is a result of studies investigating the market- and political conditions for bio-based innovation, showing that there is a need to highlight alternative bio-based products in public procurement. In other words, BioInnovation identified public procurement as an important factor that could be used to increase demand. Thus, BioInnovation is investing directly in building innovation procurement capacity in the public sector. As a result of the open call, seven projects have been funded so far. One example is a project focusing on bio-based products in the health care sector, in particular replacements for fossil-based textiles and plastics. The project is led by one of the Swedish counties, which are responsible for public procurement in this field, and, thus, brings together producers and procurers in product development processes.

RE:Source has taken a more traditional approach by establishing a platform where policymakers, industry actors and academia can interact around the topic of innovation procurement. The assumption is that this will lead to a greater understanding of the needs and requirements of the different types actors involved in public procurement for innovation. At the time of field work, these activities were still in preparation, thus, their more detailed character was still unclear.

Finally, the challenge of insufficient user-producer interaction is a highly prioritised area in BioInnovation – awareness about the importance of inclusion of users and market creation is high on the program level. BioInnovation targets this by, firstly, stipulating that the inclusion of users – preferably as work package leaders – is a key criterion when deciding on funding for innovation projects. It has also been brought forward that in cases where the role of lead users is less pronounced, the model applied when creating project consortiums creates incentives for identifying and involving these actors. Thus, innovation projects, which are assessed to give insufficient attention to user involvement, are unlikely to receive funding through BioInnovation. Interviewees highlight that this works well when lead users with specified demands exist and can be identified on the market. However, interviewees also underline, that this is not always the case and, consequently, this criteria may discriminate against more radical innovation projects for which not even lead users have a specified demand. Secondly, collaboration between actors from different parts of the value chain, and between value chains of different industries, has been a central focus area. This allows e.g. forest industry actors to learn from actors in consumer-focused industries, e.g. the textile industry, who know how to meet the user involvement criteria.

Experimentation

The third system innovation building block is concerned with experimentation activities. In both cases, a lack of small firms focused on experimenting with new technologies and closed collaboration networks are considered the main challenges slowing down experimentation activities. There are simply too few experimentally focused firms, and it is difficult for such new actors, especially for SMEs, to enter the collaboration networks. Thus, barriers relate to both the actor-side and the network-side.

BioInnovation seeks to address this issue in a novel way by introducing expert teams who play an active role in facilitating and brokering in the formation of project consortia. The expert teams are made up of representatives from industry, research institutes, universities and industry organisations, typically with a background in R&D. Expert teams have been formed in relation to four key thematic areas:

- Chemicals and energy
- Construction and design
- Materials
- New Utilisation

When project proposals come in, the relevant expert teams assist in guiding the combination of project ideas and suggesting inclusion of additional actors in the projects, in order to ensure that projects are not simply reproducing existing collaboration patterns between incumbent actors. Thus, while funding decisions are not taken by the program office, BioInnovation takes an active brokering role in ensuring that actor constellations in projects are not hindering experimentation activities. As actors are lacking the experience of collaborating in such settings, BioInnovation provide training to members on how to work in innovation projects. For example, one project within the program targeted the need to provide learning opportunities with regards to useful and functional support for systemic collaboration between the different actors of the program, as this has been identified as a key challenge when working in innovation projects. Furthermore, BioInnovation has developed "template agreements" which are intended to overcome difficulties previously experienced by participating actors in the process of creating consortiums to apply for innovation projects. The template agreements have been developed in order to facilitate close collaboration between actors, but also to encourage commercialisation, and market creation, related to new bio-based products and services.

In the case of RE:Source, this issue is dealt with only through the decisionmaking structure, in which all funding decisions are taken not by the program office, but by the Swedish Energy Agency, one of the funding organisations for the whole SIP program. While this does not ensure an inclusion of outsiders and heterogeneity per se, the rationale is to separate the formal decision process from the interests of established actors who take part in the program, even though the program office naturally has a strong say during the process leading up to a decision. Thus, the assumption here is that the program office is not sufficiently isolated from the interests of participating incumbent actors in the SIP, which may subsequently lead to reproduction of collaboration networks through funding decisions.

Another aspect of importance for experimentation activities is the character of calls for innovation projects. In the case of RE:Source, the first call for projects was very broad with few restrictions, which resulted in a large number of applications covering a variety of topics. Most of them were small pre-projects intended to investigate the scope for larger applications at a later stage. Only a third of the applications were larger innovation projects. The average size of the projects being fairly small, this meant that a large number of projects could be funded. However, according to our interviews, future calls for innovation projects will be narrower, more focused and reflect the results of the pre-projects. While this may enhance the possibilities for steering development in a given direction, it may however also limit the scope for experimental activities.

Irrespectively of the approach taken to addressing the system innovation challenges by the two SIPs, one important remaining issue is, however, that all industry actors have to contribute with 50% co-funding. As expressed by an interviewee: *"There is money that SMEs can apply for to 'verify' or* *‘explore’ new ideas. But in the end, there’s always a problem of co-funding.”* Our interviews highlight that in practice formal co-funding rules may create barriers for particularly SMEs from participating in the consortia, and arguably, it is an issue if small firms do not find it feasible to participate in these projects, since it is a central activity of entrepreneurs to experiment with technologies, markets and organisational forms (Stern 2006). Thus, it may have negative consequences for experimentation activities if young, small firms find it difficult to participate in SIP-funded projects. This is not to criticize the co-funding requirement yet to raise awareness that this requirement may affect large or small firms in different ways.

Policy learning and coordination

Turning towards policy learning and coordination, the programs are concerned with two main underlying challenges: (1) a mismatch between the interests, routines and professional cultures of industry and academia and (2) an institutional mismatch in terms of incentives and regulations between industry and academia as well as between the different industries and scientific areas that are to be integrated when addressing the grand societal challenges. Recognition of these underlying problems could in a sense be described as a fundamental rationale for innovation systems policy in general, and to system innovation policy in particular. Despite awareness and recognition, innovation systems policy has had severe difficulties dealing with these challenges. The mismatch between industry and academia in terms of divergent planning horizons and career paths/merit systems have for decades been described as major obstacles to mobility between these sectors, despite ambitious agendas promoting such mobility. Incompatible incentives and regulations, and the vested interests stemming from those, are also well known barriers for change and renewal.

The initiation of SIO as such can be seen as recognition of these challenges, and as an example of government learning in the sense that the Swedish government, by lessons learned from previous experiences and policy experimentation, adapted its policy seeking more effective means addressing those challenges. Following almost two decades in which sectoral and territorially focused innovation policy programs had been gradually refined (e.g. Competence Centres, Vinn Excellence, VINNVÄXT) Vinnova, through SIO and UID, turned attention towards sector- and geography-transcending programs unified by thematic focus, spanning sectoral and territorial domains, with an explicit challenge-based rationale for policy intervention. This shift was justified by the acknowledgement of the multi-faceted nature of the grand societal challenges in combination with the identified difficulties to achieving the integration and coordination which is necessary for addressing such complexity.

Poliy network learning and coordination was thus one of the underlying aims of the SIO initiative, and it is clearly traceable also on the program level in SIP. Although broadening of networks and the formation of entirely new constellations of actors with more or less coordinated agendas were used as criteria from the agencies evaluating applications for SIA and SIP, both BioInnovation and Re:Source experienced problems of low commitment from industry representatives in the early stages of implementation. It was, according to the interviewees of this study, mainly representatives from academia that shaped the agendas preceding the SIPs and also laid the foundations to their strategic orientation. In terms of financial commitment in the first phase, both SIPs faced challenges of convincing industry representatives about the usefulness of the program. During the course of the program they managed to encourage more commitment from industry representatives, traceable not only by increased financial investments but also by more active involvement in program committee work and actual implementation of the strategies. This was achieved by systematic work to increase professionalization in the program administration, and by adapting the orientation of the programs, thereby making them more appealing to and relevant for industry.

The government learning of Vinnova, the Energy Foundation and Formas – most clearly visible by the implementation of SIO and its profound decentralized structure – was thus combined with network and governance learning in industry and academia in general, as well as at the concrete program level of BioInnivation and Re:Source. This report mainly focuses on the more concrete program level, although it is not always possible to distinguish from the society wide changes in reflexive and institutional capacity. As new innovation policy programs like SIP coexist in parallel with old ones, lessons could be transferred from one program to another, and new elements could be added to the programs over time as stakeholders in the network gain new insights. The merger and coordination of several agendas into one SIP – which was the case in both BioInnovation and Re:Source – by necessity implies such network learning, and possibly also governance learning.

Yet, despite progress with regard to reflexivity and institutional capacity, stemming from fruitful combinations of different competences and experiences, challenges in terms of mismatch between the interests, routines and professional cultures of industry and academia, as touched upon above, persist. These challenges – and some degree of learning – can be traced in both BioInnovation and Re:Source. While the first round of activities within BioInnovation were largely about financing research designed and implemented by academic actors, with little involvement by industry, the second round evolved towards better defined problem oriented projects clearly targeting solutions and with broader involvement from industry. Part of the explanation to this development was the coordination efforts carried out in the project consortium, not least through a process of reducing the scope of activities by cutting out parts that did not generate commitment from industry. It was acknowledged that industry representatives perceived a challenge for engagement based on the structure of the program, in particular the difference in size and financial resources and the divergent time horizons of industry and academia. Re:Source is a newer inititative than BioInnovation, and for that reason the program committee deliberately applies a broad strategy, according to one of the interviewees "to allow all innovative forces in society to come forward". However, the ambition is to gradually narrow the scope to become more specific/targeted as a result of a learning process.

In one of several attempts to address the second barrier, mismatch of incentives and regulations, BioInnovation launched a so-called "Innovation Race": a 60 hour long workshop aimed at identifying ideas for promoting the bioeconomy in Sweden and – importantly – communicating these to decision-makers such as the Minister for Enterprise, who participated. The ambition with this was to generate learning through awareness of the potential and relevance of alternative applications of biomaterials and –technologies, and to gain legitimacy. The underlying assumption is that such learning will trigger institutional change towards better harmonization of incentives and regulations. RE:Source has taken a different approach towards targeting institutional mismatch by launching a very instrumental project specifically aimed at (1) drawing policy implications from other activities taking place in RE:Source, as well and in non-RE:Source activities carried by actors who are part of RE:Source, (2) storing these results in a database, and (3) communicating them to decision makers. The expectation is that gathering and communicating policy implications will over time lead to a regulatory environment, which is increasingly favourable towards minimising and utilising waste. The challenge which remains to be dealt with in this regard is of course the all-emcompassing nature of waste management which on the one hand underscores the wide relevance and potential impact of the program but at the same time, on the other hand, makes it hard to identify which actors are the most natural leaders and which institutions are the most relevant. As one interviewee puts it: "Basically everything in society turns into waste sooner or later, except jewelry. Of course we should have to decide where these money makes the biggest difference".

6. Conclusion

In summary, the current chapter has suggested an analytical framework for identifying barriers towards system innovation and analysing whether policy initiatives are targeting issues of importance for system innovation. Applying the framework to a specific policy initiative, the Swedish Strategic Innovation Program, we conclude that the analytical framework indeed is helpful for recognising some important merits of the programs in terms of initiating and organising activities, which target some of the key identified barriers to system innovation. In table 6.1 we summarize the main findings from our case studies on Bioinnovation and Re:source.

	Directionality	Demand articulation	Experimentation	Policy learning and coordination
Actor interests and capabilities	*Broad, catch-all agenda-setting* > **more fine-grained operationalization & agenda-setting along the way**	*Lack of innovation procurement capabilities* > **explicit call for projects on public procurement and innovation**	*Lack of involvement by small firms* > **active management of project consortia by expert teams & focus on small-scale projects** *Co-funding remains difficult for small firms* > unresolved	*Mismatch between the interests, routines and professional cultures of industry and academia* > **greater attention and focus on industry engagement**
Networks	*Unresolved conflicts of interest within and across value chain due to power and knowledge assymetries* > **active search and enrolment of new actors by program managers**	*Insufficient user-producer interaction* > **active and prominent involvement of users as necessary condition for innovation project proposals**	*Closed collaboration networks* > **active management of project consortia by expert teams & focus on small-scale projects**	
Institutions	*Little evidence of institutional change in the form of aligned values, norms and strategic objectives* > unresolved.	*Little attention for changing consumer attitudes and practices* > unresolved		Institutional mismatch in terms of incentives and regulations between industry and academia > **exlicit attention for learning about need for changes in**

				regulation and policy

Table 6.1: *Barriers* and **Responses** to system innovation: the case of Strategic Innovation Programs

Applying the analytical framework to the two cases opens up for a comparison of the activities of the two SIPs (that are both focused on the circular biobased economy) with the priorities laid out in the FORMAS (2012) report (see section 4), which is currently the most high-level policy document in the field (see table 6.2). The activities of BioInnovation and RE:Source are quite aligned with the priorities emphasis in FORMAS (2012) regarding experimentation, and policy learning and coordination. Concerning experimentation, there is joint focus on initiating and supporting collaboration in new constellations, both across industries, but also encompassing non-traditional collaborators, e.g. end-users. Also, a joint focus is found concerning the need for coordinating policies to eliminate unnecessary barriers towards the bioeconomy. However, in terms of demand articulation, some differences are found as the SIPs are not explicitly targeting consumer attitudes and practices, the importance of which is something underlined in FORMAS (2012). Finally, regarding directionality, a somewhat different focus can be observed. FORMAS (2012) underlines the important of continuously assessing that the development towards the bioeconomy is not carrying negative consequences with it, i.e. not taking the current direction for granted, while the SIPs are more concerned with setting a direction, but with an emphasis on what is possible, rather than the overall vision.

	FORMAS (2012)	**BioInnovation & RE:Source**
Directionality	Analysing potential negative social and environmental effects (wicked, not simple problems)	***Different focus***. Less attention to potential negative effects; setting a direction, but with an emphasis on what is possible
Demand articulation	Attention to consumer awareness and purchasing habits; involvement of users	***Partly similar focus***. Involving users; little focus on consumer attitudes & practices
Experimentation	Widespread collaboration across unrelated industries and sectors	***Similar focus***. Breaking up old collaboration patterns; involving new actors
Policy learning and coordination	Policy coordination across multiple policy spheres	***Similar focus***. Drawing attention to necessary changes in policies

Table 6.2 Comparing identified challenges in FORMAS (2012) with activity focus of SIPs

Furthermore, the analytical framework draws attention to some points where the activities of the programs are constructed in such a way that important barriers remain either unaddressed, for instance when it comes to involvement of SMEs in experimentation activities, or where targeting one barrier leads to another issue, such as in the case of combining different agendas into one.

Finally, it should be added that the bottom-up approach of the overall SIP program appears to result in a diversity of responses to system innovation barriers. Generally, we find that the two studied programs, BioInnovation and RE:Source, deal with similar barriers in quite different ways. At a later point in time, this should hopefully provide good conditions for additional policy learning.

Our analysis has primarily yielded insights how policy programs have been targeting system innovation taking a vantage point in actor interest and capabilities and network configurations. Given the limited timespan of the SIPs (as well as of this specific research project) it has proven to be difficult to identify and analyse conditions for system innovation that are of a more institutional character. This would require further research and probably also a more fine-grained analytical framework that addresses institutional change.

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