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The Scope and Outcomes of Transformative Policy Missions: A Conceptual Framework and Empirical Exploration of Swedish Industry Decarbonization

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Introduction

Global warming, biodiversity loss, rising inequality, increasing polarization, and other grand challenges compel society to achieve numerous interrelated transitions to more equitable, resilient, and environmentally benign socio-technical systems. This is not merely about accelerating the pace of innovation, but also involves shaping its directionality towards what can be perceived as desirable outcomes from a local and global context (Andersson et al., 2021). Indeed, the outcomes of transitions will

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both determine if grand challenges are met and shape the characteristics and distribution of future welfare as they involve industrial creation, transformation, and decline.

In this context, transformative innovation policy has emerged as an alternative to traditional growth-oriented policy approaches (Schot & Steinmueller, 2018). The general idea is to design policy mixes that can mobilize, support, incentivize, and guide a broad range of actors in a collective effort to achieve socio-technical transitions that address societal problems, rather than merely fixing market and system failures (Rogge & Reichardt, 2016; Weber & Rohracher, 2012). However, transitions are cumulative and path dependent, yet complex and uncertain processes, characterized by tensions between established and emerging structures (Geels, 2002; Rip & Kemp, 1998). This makes it genuinely difficult to influence their direction and outcomes, and gives rise to new challenges for policymakers, industrial firms, and other societal stakeholders.

With climate change, biodiversity loss, and other pressing grand challenges, transformative innovation policy increasingly departs from concrete and ambitious goals. These are often set by governments at local, regional, national, and supra-national levels, but may also emerge from, or be further specified within, collaborative stakeholder processes (Haddad et al., 2022). It is also common to frame transformative innovation policy in terms of missions, a notion that draws inspiration from large-scale and government-led scientific programmes such as the twentieth-century mission to put a man on the moon. However, today's missions may not only promote scientific and technological progress, but also focus on shaping systemic change or act as long-term policy frame (Wittmann et al., 2021).

In this chapter, we use the term *transformative policy missions* to refer to major government initiatives that involve goals and interventions oriented towards challenge-driven transformation of socio-technical systems. Previous research has highlighted how the wicked nature of concurrent sustainability challenges gives rise to complexity, uncertainty, and contestation (Levin et al., 2012; Scoones, 2016), and mission-oriented policymaking can be seen as a way to address this wickedness (Janssen et al., 2021). Scholars, not the least in transition management, have also developed conceptual frameworks and related policy recommendations, which emphasize the need for participatory approaches that involve a broad range of actors in collective prioritization among relevant problems and solutions (Voß et al., 2009). However, while the existing literature offers a few analytical frameworks that highlight important aspects (e.g., Andersen et al., 2024; Elzinga et al., 2023; Wanzenböck et al., 2020; Wittmann et al., 2021), there is still a need to bring these insights together in a comprehensive conceptual overview of how the scope and outcomes of transformative policy missions may differ. A shared understanding of these dimensions is important for both analytical and practical purposes.

Our ambition with this chapter is therefore to suggest and illustrate a conceptual framework that can be used for comparing the intention, design, implementation, and outcomes of transformative policy missions. We begin with a discussion based on the scientific literature and introduce the framework, which is then used to explore the ongoing decarbonization of Swedish industry. The empirical account specifically highlights the Industry Leap, which is a major policy programme that departs from the Swedish climate goals to foster collaborative innovation projects oriented towards reaching net-zero emissions from industrial production in Sweden before 2045 (Swedish Government, 2016, 2017).

Framing the Scope and Outcomes of Transformative Policy Missions

Socio-technical systems may develop along different trajectories, which bring vastly different implications for human and non-human stakeholders (Andersson et al., 2021; Stirling, 2011). A defining feature of transformative innovation policy is that technological development is approached not as a means to stimulate economic growth, but as a way to address climate change, biodiversity loss, inequality, poverty, and other societal problems. Innovation is thus understood in terms of the transformation rather than expansion of production and consumption systems, and the focus is on multi-dimensional change through technical, organizational, social, and behavioural solutions. Transformative policy missions acknowledge this directionality of innovation processes, depart from the idea that some development trajectories are more desirable than others, and give governments a central role in providing goals and guidance.

To design, implement, analyse, and evaluate transformative policy missions, there is a need to explore variety in numerous dimensions. An appropriate starting point is the conceptual framework developed by Andersson et al. (2021), which relates the directionality of innovation processes to a basic morphology of socio-technical systems. In addition, a recent stream of publications that engage with transformative innovation policy offer complementary insights. Wanzenböck et al. (2020) highlight that missions involve contestation and convergence in relation to both problems and solutions. Wittmann et al. (2021) move beyond the distinction between accelerator and transformer missions, as they introduce a more elaborate typology that highlights differences in how missions are defined, designed, and implemented. Elzinga et al. (2023) adopt an innovation systems perspective, proposing a framework for analysing structural and functional change processes generated by missions. In addition, Andersen et al. (2024) demonstrate the importance of a multi-sectoral perspective that accounts for links and dynamics across different socio-technical systems. In the following, we bring together insights from this literature as we frame the scope and outcomes of transformative policy missions.

Transformative Orientation, Policy Interventions, and System Focus

The scope of a transformative policy mission describes its ambition and delineation in multiple dimensions. To begin with, there is a transformative orientation that departs from an interest in addressing societal problems, which can have a social or environmental character, relating to issues such as poverty, inequality, climate change, and biodiversity loss. These problems can be defined in specific or general terms and be more or less open to different interpretations. For example, some missions may have a narrow focus on the reduction of greenhouse gas emissions, while others promote the global sustainability goals.

Depending on the characteristics of the problem in focus, different solutions become relevant. These may involve a broad spectrum of technical, organizational, and behavioural changes that amount to the development and diffusion of novel products and processes. Although not always associated with the current discourse on missions, solutions may, and often should, also amount to the dismantling and decline of existing structures. However, missions often involve implicit or explicit boundary conditions that exclude some solutions and highlight others. For example, addressing problems within a certain timeframe often requires the scaling up of solutions that already have been tested at a smaller scale rather than pursuing completely new innovations from basic research (Azar & Sandén, 2011). Efforts to address the societal problem in focus may also be coupled with ambitions to realize economic opportunities associated with the development and diffusion of solutions.

Another central aspect that defines transformative policy missions is the policy interventions made. Missions concretize the problem in focus by setting goals (Mazzucato, 2018; Robinson & Mazzucato, 2019), which introduces more or less specific, measurable, and time-bound objectives that serve to guide innovation activities. A defining feature is that overarching goals are set by governments at local, regional, national, or supra-national levels (Haddad et al., 2022). However, these goals may be further specified through collaborative stakeholder processes in which shared problem definitions and objectives emerge. An important difference between missions is accordingly the specificity of overarching goals set by policymakers, which determine the extent to which stakeholders can influence the direction of transformative change. Furthermore, missions involve specific policy instruments oriented towards the set goals. Missions are often linked to major programmes that channel public resources to the development, demonstration, and implementation of new solutions, but they may also employ other tools, such as market subsidies, tax incentives, and regulations, that further catalyse progress in relation to the transformative focus (Sovacool, 2011). The policy instruments associated with missions are parts of broader policy mixes that differ in numerous dimensions, including the underlying policymaking and implementation processes, the objectives and strategies, the design of individual instruments, as well as the overarching consistency, coherence, credibility, and comprehensiveness (Rogge & Reichardt, 2016).

In addition, transformative policy missions focus on different socio-technical systems, which consist of interlinked actors, institutions, and technologies that govern how societal functions related to production and consumption are fulfilled (Andersson et al., 2021). The system focus has a sectoral dimension in which a mission can be broad, with an ambition to transform the entire economy, or focused on a specific industry or value chain defined at some technological scale (e.g., energy, heat and power production, or waste combustion in combined heat and power plants). Similarly, there is a geographical dimension where a mission can be global or focused on a specific region defined at some geographical scale (e.g., nation, county, or municipality).

Notably, different sectors and geographies become relevant depending on whether a mission is approached from the perspective of problems, solutions, policy goals, or policy instruments. For example, solving a problem defined in relation to a specific industry and region is often contingent on innovation processes that transcend pre-conceived boundaries in both sectoral and geographical dimensions (Coenen et al., 2012). Also, policy goals and instruments introduced in a given jurisdiction may be oriented towards transformation in a different geographical region (Sovacool, 2011).

Taken together, this highlights that missions are not only associated with different systems, but also create new multi-system interactions (Andersen et al., 2024; Andersen & Markard, 2020; Rosenbloom, 2020). In addition, the system focus has a temporal dimension, which relates to the time scales at which causes and consequences of problems appear as well as to the short as opposed to long-term viability of solutions. Notably, the temporal orientation is reflected in how time-bound policy goals are defined to create a sense of urgency, stimulate action, ensure consistent progress monitoring, and thereby enable adaptive responses (Mazzucato, 2018).

Structural and Functional Transformation Processes

Whereas transformative orientation, policy interventions, and system focus together define the scope of a transformative policy mission, its basic purpose is to enact outcomes in terms of dynamic processes that transform real-world socio-technical systems. As shown by the literature on innovation systems (Bergek et al., 2008; Edquist, 1997; Elzinga et al., 2023), these outcomes can be approached from a structural or functional perspective. The former emphasizes how missions give rise to new constellations of actors, institutions, and technologies that engage with activities oriented towards the transformative focus. Indeed, developing and diffusing solutions that address today's grand challenges require cross-sectoral collaborations among both old and new actors, institutions that dislodge lock-ins to unsustainable pathways, technological capacities that allow experimentation and demonstration, and other structural changes.

The functional perspective emphasizes how missions influence transformation processes. It has traditionally been common to distinguish innovation processes, such as knowledge development, entrepreneurial experimentation, market formation, resource mobilization, and legitimation, that govern the emergence of new technologies and industries (Bergek et al., 2008; Hekkert et al., 2007). However, recent literature has shown that when applied to missions, the functional perspective can be extended to also highlight the emergence of directionality and coordination as well as the destabilization of existing systems (Elzinga et al., 2023). Drawing on these insights, we conceptualize the functional outcomes of missions as processes of directionality & coordination, innovation, and destabilization.

Importantly, structural and functional transformation processes initiated and shaped by missions continuously influence their context. Indeed, achieving change in socio-technical systems is why missions are imagined, promoted, and implemented in the first place. However, transformation processes may also shift the transformative focus of a mission and lead to new or re-designed policy interventions. There is accordingly important feedback between the scope and outcomes of transformative policy missions, which suggests that policy interventions should be multifaceted and adaptive to effectively address the resulting complexity and dynamism (Edmondson et al., 2018; Rogge & Reichardt, 2016).

Analytical Framework

In Figure 13.1, we summarize the discussion with a framework that highlights the scope and outcomes of transformative policy missions. With regard to the scope, missions may have different sectoral, geographical, and temporal delimitation, address different problems and solutions, and involve different policy goals and instruments.[1] On the one hand, missions differ in their focus; some may address climate change while others engage with biodiversity, some may strive for a transformation in Sweden while others target Germany, and so forth. On the other hand, missions differ in their breadth; some initiatives focused on climate change may engage with any means to solving this problem while others only engage with a specific set of solutions, some may have an ambition to promote global change while others have a narrower interest in a specific country, and so forth. Our framework makes it possible to highlight these differences and monitor how the scope of a mission evolves in time. Similarly, as is common in the innovation system literature, analysing structural and functional outcomes reveals whether, and how, a mission promotes dynamic change processes in line with its transformative orientation and system focus. In the next section, we illustrate the merits of this framework as we explore the mission to decarbonize Swedish industry.

[1] As noted above, the policy goals and instruments associated with missions are parts of broader policy mixes, but it is beyond the scope of our framework to capture this complexity.

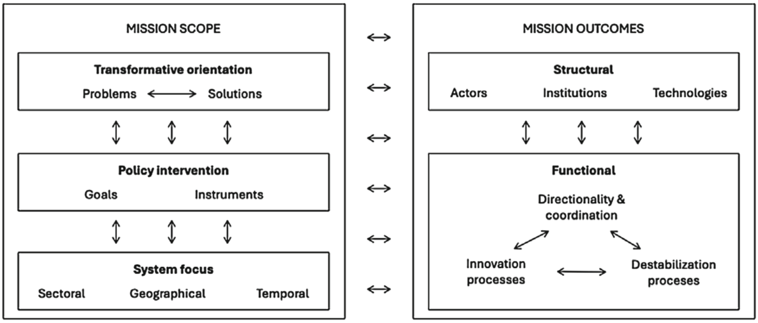

Fig. 13.1 A conceptual framework that highlights the scope and outcomes of transformative policy missions

Exploring the Mission to Decarbonize Swedish Industry

An interesting case to explore with the framework introduced in the previous section in the decarbonization of Swedish industry. Although this sector's climate footprint has decreased, slowly but steadily, since the 1990s, recent years have seen an increased focus on net-zero emissions. The development and diffusion of low-carbon industrial solutions have co-evolved with more focused and forceful policymaking, both in Sweden and at the EU level. In 2016, the Swedish climate policy framework introduced the goal to reach net-zero emissions in 2045 (Swedish Government, 2016). To reach this goal several policy instruments have been introduced. A particularly salient instrument at the national level is the Industry Leap (see below for more details), which outlines concrete decarbonization objectives and distributes public funding to research, development, demonstration, and implementation of solutions (Swedish Government, 2017).

Although policymakers in Sweden do not explicitly refer to the decarbonization of Swedish industry as a mission, we here take note of the fact that the government has introduced a bold and time-bound objective, together with forceful and specific policy instruments, to tackle a grand challenge. This is why we conceptualize the decarbonization of Swedish industry as a mission (in an analytical sense). We begin by characterizing the scope of this mission and then use data about projects (co-) funded through the Industry Leap to shine light on some of its structural and functional outcomes. Although this data does not provide a complete picture, it gives a strong indication of general developments oriented towards the mission. This is partly because the Industry Leap is by far the largest national funding scheme for industrial decarbonization, but also since the resources it provides enable Swedish actors to apply for EU-funding, private/public loans, and support through other policy instruments (Andersson & Hellsmark, 2024; Swedish Climate Policy Council, 2024).

Mission Scope

System Focus

The mission to decarbonize Swedish industry focuses on socio-technical systems that govern the production of goods in the economy (i.e., not including energy, transportation, agriculture, etc.). This sector can be decomposed into several more specific industries centred around products such as steel, cement, and chemicals. In addition, the Industry Leap and some other policy instruments oriented towards decarbonization associate the production of heat and power in plants fuelled by waste and biomass with the industry sector, since they share many potential solutions (Andersson & Hellsmark, 2024). Note also that reducing industrial emissions is contingent on enabling developments in adjacent sectors (e.g., increased supply of electricity to reduce industrial emissions), while industrial development is necessary to decarbonize yet other activities (e.g., increased supply of electric vehicles to reduce transport emissions).

In the geographical dimension, the mission primarily addresses industrial emissions caused by production activities in Sweden. This means that emissions embedded in imported inputs, as well as emissions arising when exported products are consumed, are excluded (even though they are included when firms disclose their Scope 3 emissions[2]). At the same time, the mission has strong links to developments in other regions. Reducing industrial emissions in Sweden depends on foreign firms, markets, and policies. Developments in Sweden may also play an important role in the decarbonization of economic activities in other regions.

In the temporal dimension, lastly, the mission starts at some point in recent years when the decarbonization of Swedish industry began to take shape as a transformative policy mission. Although efforts to reduce industrial emissions have been in place for decades, it was not until the Swedish climate policy framework was established in 2016 that legally binding goals were put in place. Around the same time, the Industry Leap was launched as a specific policy instrument oriented towards industrial decarbonization. We therefore see 2016 as a starting point for the mission, even though it is certainly contingent on prior developments as well. Furthermore, the temporal scope ends at some point when the mission can be considered complete, which given the current climate goals is around 2045.

Transformative Orientation

The mission has a transformative orientation that revolves around climate change and the need to rapidly reduce anthropogenic emissions of greenhouse gases (IPCC, 2018). Although this is challenging for most parts of the global economy, it is considered especially difficult for the industry sector (Energy Transitions Commission, 2018; Löfgren & Rootzén, 2021). In particular, emissions from energy-intensive process industries, which produce products such as steel and cement, result not only from the need for heating, but also process-related emissions from the chemical conversion of raw materials such as iron ore and limestone (Energy Transitions Commission, 2018). This means that a shift to renewable energy is not sufficient and highlights the need for a more fundamental transformation. Moreover, process industries are based on

[2] This is similar to the consumption of international air travel and imported goods and services that give rise to emissions in other countries.

continuous and large-scale operations, face long investment cycles, and are exposed to global markets (Löfgren & Rootzén, 2021; Nilsson et al., 2021; Wesseling et al., 2017). As a result, there are high barriers to entry for entrepreneurs and innovative firms as well as a strong lock-in effect to existing technologies.

Not surprisingly, the decarbonization of Swedish industry is slow compared to other sectors. In 2022, industry (including heat & power) was responsible for 18 Mtons CO2eq, which corresponds to 38 per cent of the total emissions in Sweden (Swedish Environmental Protection Agency, 2023a). Almost all fossil emissions stem from energy-intensive process industries, and they are concentrated in a few firms and industrial facilities that produce steel, cement, chemicals, and refined fuels. This can be compared with the heat & power sector, where the emissions are distributed over many organizations and facilities (Fig. 13.2).

Furthermore, reaching the global climate goal of staying within 1.5 degrees will likely require the production of negative emissions through the removal of greenhouse gases from the atmosphere (IPCC, 2018). While this can be achieved in different ways, one of the main options is to capture and store emissions of biogenic carbon. This particularly relevant from a Swedish perspective since the production of pulp and paper, as well as the combustion of biomass and waste in heat and power plants, give rise to very large biogenic emissions (Swedish Environmental Protection Agency, 2023b). Although these emissions are commonly allocated to the land use, land-use change, and forestry (LULUCF) sector, they can accordingly be used by Swedish industrial firms in the production of negative emissions.

Similarly, the industry sector plays an important role in the decarbonization of other sectors. For example, reducing emissions in the transport sector is dependent on the creation of a new industry for the production of batteries in electric vehicles and/or the development of existing industries to produce renewable fuels (Hellsmark & Hansen, 2020). Here as well, Swedish firms may be able to draw on domestic resources, such as renewable electricity and biomass, to meet this demand.

Swedish industry thus plays a dual role in relation to the problem in focus of the mission. On the one hand, there is an urgent need to reduce

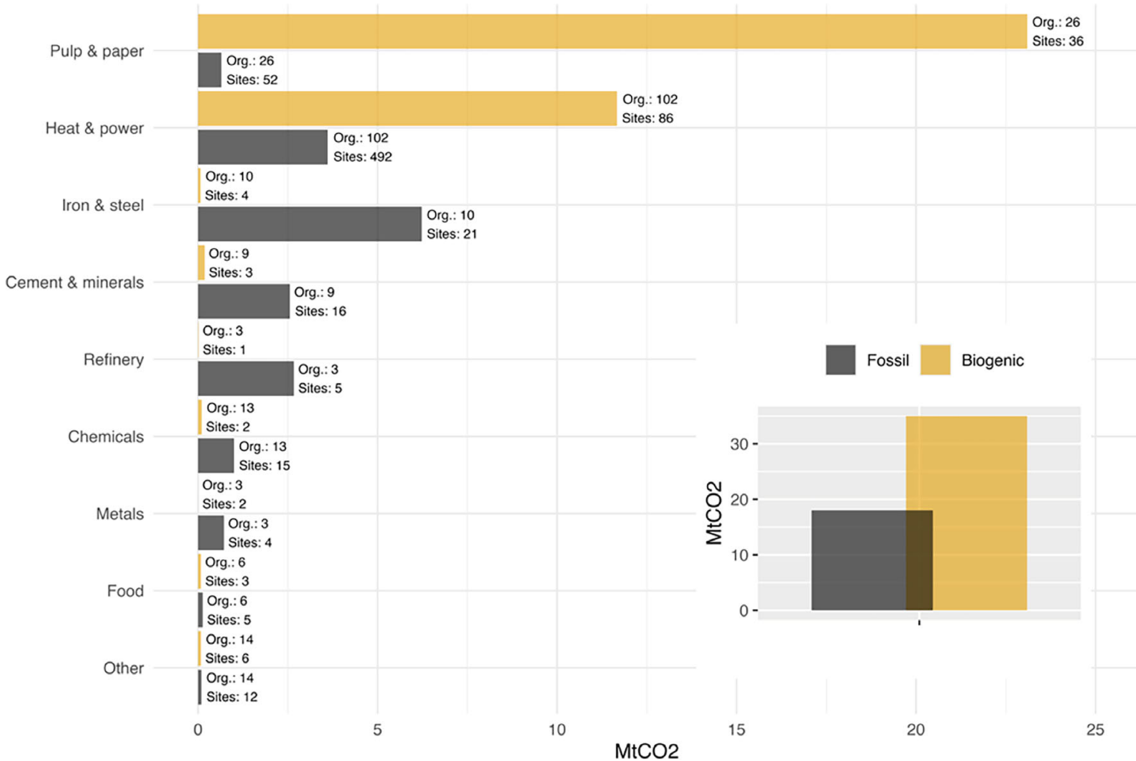

Fig. 13.2 The distribution of biogenic and fossil emissions (MtCO2) between industry sectors, including heat & power, as well as the number of organizations and industry sites responsible for the emissions within each sector. *Source* Swedish Environmental Protection Agency (2023a)

emissions by transforming existing production activities. On the other hand, the demand for negative emissions, and products that are key for the decarbonization of other sectors, call for the development of new industrial value chains. As we will see in the next section, this is also reflected in the goals introduced by Swedish policymakers.

The mission is accordingly directed towards problems related to climate change. Solutions to these problems have not been specified a priori but rather emerge as actors engage with innovation activities oriented towards the mission. While addressing climate change calls for multiple interlinked solutions that have both technological and social characteristics, a few generic solution pathways can be identified (Andersson & Hellsmark, 2024). First, 'carbon capture' refers to capturing, transporting, and utilizing or storing emissions. As noted above, this pathway can lead to reduced emissions from existing production activities or to the production of negative emissions, depending on whether the technology is applied to emissions with fossil or biogenic origin. Second, 'electricity & hydrogen' involves replacing production processes based on fossil fuels and materials with processes that use renewable electricity and hydrogen as key inputs. Third, 'biofuels & biomass' rather involves replacing existing production processes with processes based on biomass, either as a fuel or as a raw material. Fourth, 'process efficiency' is about increasing the energy or materials efficiency of existing production processes, in order to reduce (but not eliminate) the need for fossil fuels and material. Fifth, 'recycling' involves replacing virgin raw materials with recycled alternatives or circular flows and thereby reducing and possibly eliminating the need for fossil fuels and materials. Lastly, there are numerous 'other solutions' that are not captured by the mentioned pathways, such as radically different production processes, alternative products, and downstream transformations that reduce or eliminate the demand for industrial products.

Policy Interventions

The mission departs from the overarching Swedish climate policy framework, which stipulates that domestic net emissions, from all economic sectors, shall be zero by 2045 and that negative emissions shall be realized thereafter (Swedish Government, 2016).[3] The Industry Leap decomposes this goal into three interrelated objectives associated with the industry sector:

A. To **decarbonize existing industries** that give rise to fossil emissions.
B. To create new industries that **replace existing industries** with fossil emissions or that offer solutions for decarbonizing other sectors (e.g., transport, agriculture, and energy).
C. To create new industries that **produce negative emissions** (e.g., using biogenic emissions from existing industries).

These objectives reflect the transformative orientation discussed in the previous section and thereby foreground different industries and value chains. When it comes to the decarbonization of existing industrial facilities (A), the focus becomes industries with large fossil emissions (Fig. 13. 2). For the creation of new industries (B), a broad variety of low-carbon products and processes become relevant. Some of these constitute alternatives to existing value chains with large fossil emissions, while others are key resources for the decarbonization of other sectors. Lastly, the creation of new industries that produce negative emissions (C), is strongly associated with production processes that give rise to biogenic emissions.

As mentioned, the Industry Leap is the most salient policy instrument associated with the mission. Between 2018 and 2022 it distributed approximately 200MEUR (2 billion SEK) to over 100 different research, development, demonstration, and implementation projects. The Industry Leap has recently been complemented by the Impact Innovation programme, where two focus areas, developed by stakeholders in a bottom-up process, are highly relevant for industrial decarbonization. Besides these two major funding programmes, the government offers credit guarantees to large investments in low-carbon production plants

[3] The climate policy framework also establishes the Swedish Climate Policy Council as an advisory body, providing guidance on how climate goals can be met and ensuring that measures taken are consistent and effective in reducing emissions.

(Swedish Environmental Protection Agency, 2022) and promotes bio-CCS through a proposed funding mechanism based on reversed auctions and the facilitation of a value chain for carbon transport and storage (Swedish Energy Agency, 2021). There are also a number of national policy instruments that support decarbonization in general or in other economic sectors, such as a carbon tax (from which most industrial emissions are exempted) and various funding programmes. In addition, Swedish policymakers have established the platform Fossil Free Sweden (Fossil Free Sweden, 2021), which facilitates decarbonization dialogues among firms and other actors. This has resulted in several interrelated roadmaps towards industry decarbonization, often supported by broad networks of actors in different sectors.

Lastly, it should be noted that the mission is governed not only by national policy instruments, but also by EU-level climate policy. In particular, the long-standing Emissions Trading System (ETS) allows industrial firms to buy and sell emission allowances within a continuously shrinking emissions budget. This provides a financial incentive for decarbonization, while ensuring that emissions are reduced over time. More recently, the ETS has been complemented by policy instruments that offer additional support and incentives for decarbonization, including the Carbon Border Adjustment Mechanism (CBAM), which aims to prevent carbon leakage and promote a level playing field for European producers, and the Innovation Fund, which supports the development and deployment of low-carbon technologies.

Mission Outcomes

The outcomes of the mission to decarbonize Swedish industry will be described in two parts focusing, respectively, on structural and functional change. First, we show how the Industry Leap has mobilized actors to engage in networks that cut across sectoral systems. Second, we uncover the formation of directionality by analysing how decarbonization projects (co-)funded by the programme relate to different policy goals, technological solutions, and sectoral systems. Structural and functional outcomes are thus highlighted in relation to some but not all dimensions of the mission scope (Fig. 13. 1). The analysis draws on several interrelated research projects that use emissions statistics, information about collaborative innovation projects, and stakeholder interviews (see e.g., Andersson & Hellsmark, 2024; Hellsmark et al., forthcoming).

The Emergence of Actor Networks

Industrial decarbonization relies heavily on collaborative networks that involve multiple stakeholders to realize and integrate new solutions in established industries with significant emissions. The Industry Leap has contributed to mobilizing and connecting actors by (co-)funding projects that often involve broad consortia of public and private organizations. In the following section, we examine this structural outcome by identifying and analysing the network of actors that forms through project collaborations. Fig. 13.3 illustrates this network by linking actors that participate in the same project as well as to target industries in focus of decarbonization efforts.[4]

By the end of 2022, 136 actors had received funding from the Industry Leap, including private and public firms, research institutes, universities, and governmental bodies, and 62 of these had received more than 0.1 MEUR. The total budget of all 103 (co-)funded projects amounted to approximately 700 MEUR, out of which 200 MEUR is public funding from the Swedish Energy Agency (Andersson & Hellsmark, 2024). Together, actors involved in the Industry Leap thus make significant investments in development, demonstration, and implementation of low-carbon solutions. Furthermore, actors from all parts of the industry sector are actively engaged, except for the food industry which only accounts for a smaller share (1.5%) of the total industrial emissions (Swedish Environmental Protection Agency, 2023). In terms of reach, the participating firms are responsible for 86% of fossil emissions and

[4] We only consider actors connected to the project leader, not assuming all partners collaborate directly. This approach is essential for large projects, as it highlights central hubs and potential fragmentation, offering a clearer view of collaboration dynamics and actor roles. Note also that for clarity Fig. 13.3 only includes actors that receive more than 0.1 MEUR.

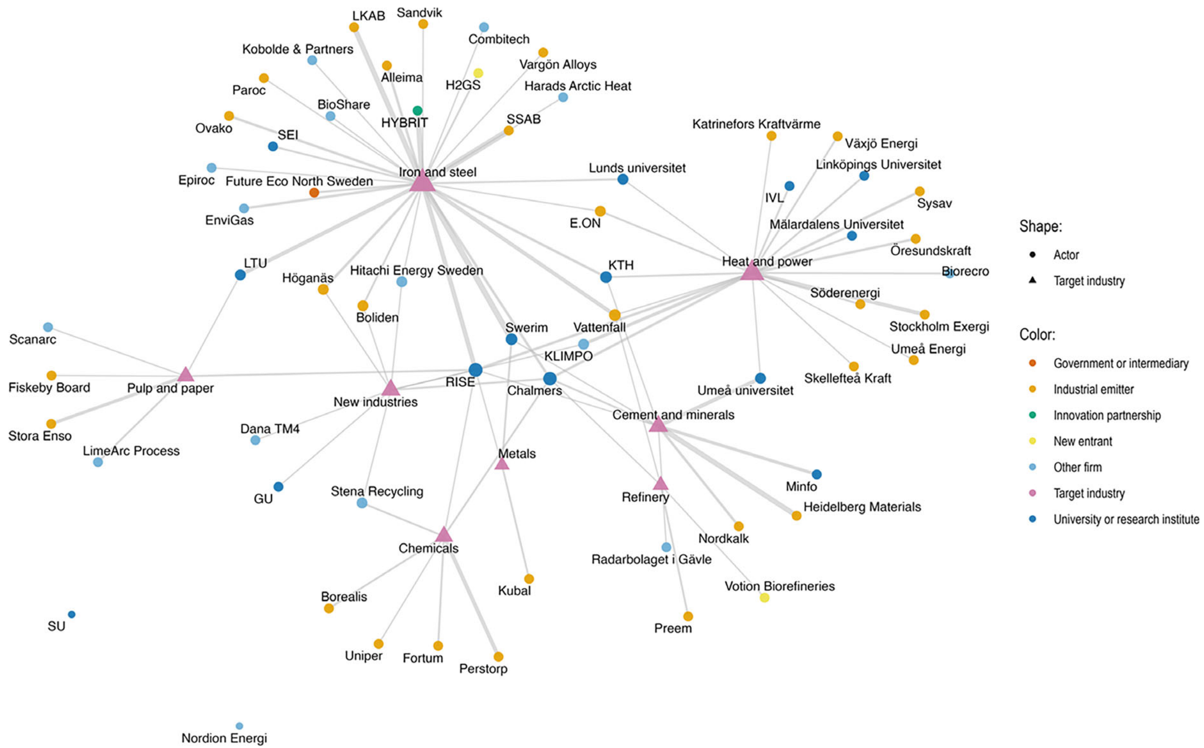

Fig. 13.3 A network of 62 actors (circle nodes) that receive more than 0.1 MEUR in funding from the Industry Leap to engage in the decarbonization of 9 target industries (triangle nodes). Actors are connected to each other if they participate in the same project and to target industries if they participate in projects with that sectoral system focus. *Source* Hellsmark et al. (forthcoming)

49% of biogenic emissions from industry. Indeed, 19 of the 20 largest emitters are active in the programme. An important mission outcome is thus a high degree of involvement from the incumbent firms.

When examining more closely which actors are engaged in the Industry Leap network, we only find two new entrants. The first one, H2 Green Steel (H2GS), aims to produce steel with reduced carbon emissions using green hydrogen, and the second, Votion Biorefineries, attempts to convert agricultural and forestry residues into biochemicals and biofuels. Both firms are supported by large private investors, including potential customers. Interestingly, the new entrants do not collaborate with other actors in projects (co-)funded by the Industry Leap. This does certainly not mean that they lack such collaborations, but further underlines how the main policy instrument associated with the mission has given rise to a network with a strong focus on incumbents.

The network also includes several strategic collaborations between energy utilities and industrial firms, focusing on reducing emissions in the Iron & steel, Cement, Chemical, and Refinery industry. Utilities, such as Vattenfall, Fortum, Uniper, play an especially important role as "system entanglers" (Löhr & Chlebna, 2023), connecting industrial decarbonization with the energy sector. This is a role that includes facilitating learning and building crucial infrastructure for electricity and hydrogen production (Hedeler and Hellsmark, forthcoming).

In addition, we find that many actors bridge decarbonization efforts across sectoral systems by participating in projects that target different industries. Research institutes and universities often take on this role, with Chalmers University of Technology having the most central position in the network. However, interconnections between the decarbonization of different industries are also created by industrial emitters and other firms, including Borealis, Boliden, Stora Enso, Höganäs, KLIMPO, and Stena Recycling.

What sets the Swedish industry sector apart compared to equivalent actors in other European countries is that almost all incumbent firms have adopted net-zero-emission targets that are more ambitious than, or at least in line with, Swedish and European climate goals (Hansen et al., 2024). Only one of the 20 largest emitters has not declared an ambition to become fossil-free by mid-century or earlier (Hellsmark et al., forthcoming). However, even though the main emitters have high ambitions and almost all industries are active in the network, we do find significant differences in the level of engagement across individual actors and industries. This becomes particularly evident when focusing on large emitters and relating their fossil emissions to both their co-funding and the number of collaborations with other actors in the network. There are a few main emitters with very focused and strategic collaborations with a handful of actors to realize their technology strategies. In particular, the collaboration between SSAB, LKAB, and Vattenfall (i.e., the HYBRIT innovation partnership), which aims to produce fossil-free steel using hydrogen, stands out in terms of their co-funding in relation to governmental funding. This does not come as a surprise since the technology is being scaled up and implemented at a commercial scale. Other salient large emitters are the oil refinery Preem and the cement producer Heidelberg Materials. Preem has the most collaborations of all the main emitters, searching and exploring different solutions that could be scaled up in the short as well as medium term. Heidelberg Materials is primarily focused on collaborating with actors that could enable CCS on the medium to long term. On the other side of the spectrum (i.e., large emitters investing very little in relation to their ambitions and emissions), we find another oil refinery, St1, as well as municipal firms such as Renova and Tekniska Verken i Linköping with large emissions that originate from waste incineration. Quite surprisingly, these actors have no significant participation in decarbonization projects (co-)funded by the Industry Leap, even though their ambitions in terms of reaching net-zero emissions are high.

The Formation of Directionality

We now shift focus to the functional perspective on mission outcomes by exploring the formation of directionality as indicated by the orientation of decarbonization projects (co-)funded by the Industry Leap. The analysis decomposes the total budget (public and private) in relation to three aspects of the mission scope: sectoral system focus, policy goals, and solutions (Fig. 13.4).

Our results show that the iron & steel industry is targeted by 48% of the total project funding, followed by the chemicals industry with 35%. There is, accordingly, a significant concentration of resources to projects that target these two industries. At the same time, projects that target pulp & paper, heat & power, cement & minerals, metals, and other [5]industries receive a significant but much smaller share of the total funding, while the refinery and food industries gather minimal attention. Also, projects that target multiple industries at the same time are

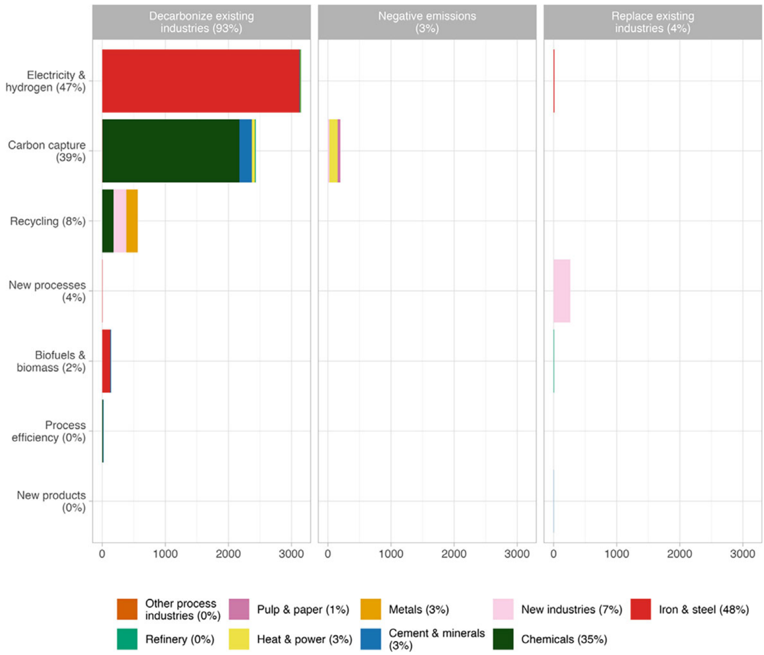

Fig. 13.4 A decomposition of the total budget of projects (co-)funded by the Industry Leap (MSEK and per cent) in relation to the policy goal, industry, and solution in focus

[5] 1 EUR ≈ 10 SEK.

relatively rare and mainly focus on early-stage knowledge development and policy studies, rather than concrete technological innovations.

When it comes to policy goals, the majority of decarbonization projects focus on reducing emissions from existing industries, which accounts for 93% of the total Industry Leap budget. Less emphasis is placed on efforts to achieve negative emissions through capturing and storing biogenic emissions (bio-CCS), representing only 3% of the total budget. The remaining four per cent is allocated to developing industries and technologies that have the potential to replace existing high-emission industries with new ones that have significantly lower emissions. This clearly aligns with the essence of the Swedish climate goals, which is to rapidly reduce fossil emissions. However, it stands in contrast to the likely need for negative emissions to compensate for residual emissions that are hard to abate (e.g., from the agricultural sector). The relatively low investment in new industries may indicate high entry barriers and a focus on established industries.

In terms of solutions, there is a strong emphasis on electricity & hydrogen and carbon capture, which together make up 86% of the total Industry Leap budget. Hydrogen-based solutions dominate the broad range of projects targeting the iron & steel industry, which reflects significant and focused investment in transitioning to fossil-free steel production. Carbon capture projects are numerous but generally smaller in scale, targeting both the reduction of fossil emissions and the production of negative emissions across various industries. Besides these dominating technological pathways, recycling, biofuels & biomass, and process efficiency receive markedly less attention. Recycling projects mainly target the chemicals industry, aiming to reduce dependence on fossil feedstock through thermochemical plastics recycling. Biofuels & biomass projects are mostly associated with the iron and steel industry, where they explore the use of biomass as a process input and biogenic coal production. Process efficiency projects are scarce but target energy efficiency improvements in the chemicals industry and material efficiency in the cement industry. In addition, there are a few projects oriented towards other solutions that are not easily categorized into generic technological pathways.

Taken together, our results indicate that the formation of directionality is somewhat imbalanced in relation to the mission scope. Decarbonization projects have a strong focus on the iron & steel and chemicals industries, mainly explore technological pathways based on electricity & hydrogen and carbon capture, and pay relatively little attention to the production of negative emissions. However, a broad range of solutions must be implemented across all industrial sectors, albeit in different combinations, to reach net-zero emissions and beyond. This further highlights the salient dominance of incumbent industry in the actor network mobilized by the Industry Leap and suggests a need to stimulate broader experimentation that involves and initiates links between stakeholders from all industry sectors.

Discussion and Concluding Remarks

In this chapter, we have introduced and illustrated a basic framework for analysing the scope and outcomes of transformative policy missions. The framework decomposes the mission scope into a transformative orientation towards certain problems and solutions, policy interventions including both goals and instruments, as well as a system focus in sectoral, geographical, and temporal dimensions. It also distinguishes structural and functional outcomes, specifically highlighting that the latter involve the provision of directionality and coordination, innovation processes that promote the emergence of new solutions, as well as destabilization processes that govern the dismantling of established systems.

Together with our illustrative case study of industrial decarbonization in Sweden, the framework brings several contributions to the literature. To begin with, it adds depth to the literature on multi-system dynamics by highlighting how missions give rise to interconnectedness and interdependencies across various dimensions. As noted by scholars such as Kanger et al. (2021) and Andersen and Geels (2023), understanding the speed and pathways of net-zero transitions requires a nuanced analysis of how technologies, actors, and institutions interact across multiple systems. Our approach captures these interactions, highlighting the role of cross-sectoral collaborations and system entanglements in driving innovation. This is crucial for understanding how policy interventions in one sector or region can influence and be influenced by developments in other sectors or regions, as seen in the Swedish case where industrial decarbonization is closely linked to the energy and transportation sectors.

Second, the framework advances the literature on transformative innovation policy by supporting the design, implementation, and evaluation of missions. This complements the work of Rogge and Reichardt (2016) and Edmondson et al. (2018), who highlight the need for adaptive and multifaceted policy mixes to address the complexity of socio-technical systems. By departing from a clear idea of the key dimensions of transformative policy missions, policymakers may develop a better understanding of the directionality of mission-driven innovation processes, ensure that interventions are targeted and coherent, and anticipate and manage the complexities and uncertainties associated with transformations that span multiple systems. For instance, in the decarbonization of Swedish industry, understanding the geographical links and dependencies helps in designing policies that leverage international collaborations and market dynamics. Similarly, recognizing the temporal aspects of innovation processes enables the setting of realistic and ambitious timelines for achieving net-zero emissions, ensuring that short-term actions align with long-term goals. This holistic perspective is vital for creating policy mixes that are not only adaptive but also synergistic, addressing multiple barriers and drivers of change simultaneously.

Third, the framework echoes the findings of Andersen and Markard (2020) in emphasizing the importance of context-specific solutions and the need for tailored policy interventions. In the Swedish context, the focus on decarbonizing existing industries, developing new low-carbon industries, and producing negative emissions demonstrates how different goals require different technological and social innovations. Our approach may here help identify the most effective policy instruments for each specific goal and context, enhancing the strategic coherence and effectiveness of transformative innovation policies.

In addition, the framework facilitates a more inclusive and participatory approach to policy design and implementation. By explicitly considering the diverse perspectives and needs of various stakeholders, as highlighted by Heiberg et al. (2022) and Ohlendorf et al. (2023), policymakers can foster broader acceptance and support for transformative initiatives. This is particularly important in addressing the contestation that often arises in multi-system transitions, ensuring that the benefits of innovation are widely shared and that the burdens are equitably distributed.

At the same time, the chapter has limitations that suggest promising avenues for future research. The framework remains formulated at a quite general level and would clearly benefit from more detailed conceptualizations of its constituent parts. In particular, continued conceptual development should engage with the parallel development of theoretical ideas related to mission-oriented innovation systems (Elzinga et al., 2023), which is likely to bring additional insights in the years to come. Future research is also needed to test the framework in broader empirical studies that investigate different types of transformative policy missions. This is the only way to validate that the concepts used to describe and decompose the scope and outcomes of missions are useful for comparative analyses and cumulative knowledge development. In addition, the illustrative case study presented in this chapter should be complemented with investigations that offer a comprehensive account of structural and functional outcomes. This involves moving beyond the limited perspective highlighted here and analysing how missions (i) result in organizational, institutional, and technological change at the structural level, (ii) propel processes of coordination, innovation, and destabilization at the functional level, and (iii) involve feedback between these outcomes and the underlying mission scope (i.e., system focus, transformative orientation, and policy interventions). As with other types of research on sustainability transitions and related policymaking, identifying data sources that can reveal the characteristics of these processes is challenging. Although resource demanding, comprehensive analyses are likely to require a combination of stakeholder interviews and information from a wide range of secondary sources. In this chapter, we relied largely on project data from the Industry Leap, which can be considered a good indicator of broader mission outcomes. However, further explorations in the Swedish context should also assess the Impact Innovation programme, which can be expected to play an important role for future missions related to most sectors and challenges.

In the end, we hope that the analytical framework and illustrative case study presented in this chapter will help bridge the gap between theoretical concepts and practical policy applications. After all, clearly delineating the space in which transformative policy missions unfold is essential for designing effective and coherent policy interventions that drive sustainable and equitable transitions towards net-zero emissions and other societal objectives.

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