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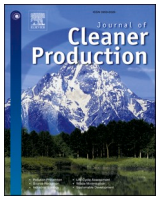

Frames of systems change in sustainability transformations: Lessons from sociotechnical systems and circular economy case studies

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ABSTRACT

Tackling the world's most complex challenges requires transforming systems purposefully, which involves reflecting on the directionality of ongoing systems transformations and the design of policy mixes capable of steering systems in more desirable directions. It is argued that a framing lens helps to advance understanding of this challenge by surfacing situated and heterogeneous perspectives on systems change. Frames are knowledge structures and default assumptions that help to guide action. This paper examines the frames of 'systems change' in purposeful sustainability transformations. To this end, a meta-synthesis of 155 case studies of sociotechnical systems change for sustainability and circular economy was conducted. Inductively coding these cases and comparing the emergent themes, four frames of systems change for sustainability were identified, varying depending on what they deem feasible and desirable change, the mechanisms and processes of change-making, and the different actor roles in these pursuits. A process model is developed to explain how explicit attention to frames can support opening up the directionality of purposeful systems transformations in ways that inform the design and implementation of more plural policy mixes. This contributes to the literature on directionality by providing insights on the boundaries of frames for systems change and the policy mix literature by identifying ways to engage directly with key assumptions guiding change-making efforts.

1. Introduction

The world is grappling with complex and persistent challenges, such as inequality and climate change, that are deeply interconnected and widespread across different regions and time periods (Reinecke and Ansari, 2016; Rittel and Webber, 1973). Addressing these challenges effectively requires not just technological innovations but also transformations in the sociotechnical systems that underpin modern society. These systems—such as those related to transportation, housing, energy, and food—are composed of interdependent components including technologies, infrastructures, markets, regulations, and social practices (Geels, 2002, 2004, 2018). The alignment of these components often leads to resistance to change, a phenomenon known as path dependence (David, 1985; Arthur, 1989).

In the context of sustainability, transforming these sociotechnical systems is particularly challenging. Sustainability transformations involve not only introducing new, greener technologies but also reshaping the social practices, institutions, and cultural norms that interact with these technologies (Markard et al., 2012). Understanding how these systems can be steered towards more sustainable outcomes—referred to as 'directionality'—is crucial. Directionality reflects how systems evolve in certain directions based on factors like dominant interests, institutional structures, and cultural norms (Stirling, 2009; Weber and Rohracher, 2012). However, there remains a gap in the current understanding of how different actors, such as policymakers and researchers, perceive these sustainability transformations and how these perceptions shape the development of effective policy strategies (Fischer and Newig, 2016).

One key concept in guiding sustainability transformations is that of 'policy mixes.' Policy mixes refer to the combination of various policy instruments and strategies that are used together to achieve a specific goal, such as promoting sustainability (Flanagan et al., 2011). These mixes can include regulations, incentives, and other tools that work together to influence the direction of sociotechnical systems (Rogge and

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Reichardt, 2016). Despite their importance, the literature has yet to fully explore how different actors understand and utilize policy mixes in the context of sustainability transformations (Kern and Howlett, 2009).

This study aims to fill this gap by focusing on the different 'frames' through which researchers and policymakers view systems change, particularly in the context of sustainability. A frame is essentially a way of interpreting and understanding the world, shaping how people perceive challenges and opportunities (Goffman, 1974; Schön and Rein, 1994). These frames influence how scholars and policymakers understand, explain, and predict system dynamics and outcomes (Starbuck and Milliken, 1988, p. 51; Benford and Snow, 2000). By examining these frames, we can gain insights into how different approaches to sustainability are developed and implemented in complex situations (Schot and Steinmueller, 2018).

To address the research question—What are the frames of systems change in the context of purposeful sustainability transformations?—we conducted a meta-synthesis of 155 case studies from two key areas of sustainability research: sociotechnical systems change for sustainability (ST) and circular economy (CE). Through this analysis, we identified four distinct frames that reflect different perspectives on what constitutes feasible and desirable change, how change should be pursued, and the roles of various actors in these processes.

In this study, we contribute to the literature in three ways. First, we deconstruct the logic behind each of the four frames, showing how they support certain policy decisions while potentially overlooking others (Schön and Rein, 1994; van Hulst and Yanow, 2016). Second, we develop a process model for policymakers that encourages the integration of multiple perspectives while ensuring consistent and coherent policy approaches (Schot and Steinmueller, 2018; Stirling, 2008). This model includes three stages—reflecting, comparing, and connecting—which help incorporate diverse viewpoints into policy discussions. Finally, we explore how these frames shape the way researchers and policymakers approach sustainability transformations, providing a new lens for understanding the balance between directionality and diversity in policy development. The conclusion also addresses the limitations of our study and suggests directions for future research.

2. Theoretical background

2.1. Frames of systems change

Sustainability challenges are inherently complex, involving interconnected and multidimensional issues that span across different sectors and scales (Levin et al., 2012). These challenges—often described as 'wicked problems'—resist simple solutions and require a nuanced understanding of the systems in which they are embedded (Rittel and Webber, 1973). In addressing these challenges, representations of purposeful 'systems change' inevitably highlight certain aspects while downplaying or overlooking others, leading to different interpretations and approaches (Coburn, 2006; Schön and Rein, 1994). Frame analysis is a powerful tool for unpacking these interpretations, revealing not only what is seen or done but also how certain perspectives are silenced or marginalized in policy discourse (Schot and Steinmueller, 2018; van Hulst and Yanow, 2016).

The concept of 'frames' was popularized by Goffman (1974) and has since been widely adopted in management, sociology, and policy research. Frames are "schemata of interpretation," or cognitive structures that guide how individuals process, organize, and interpret information (Goffman, 1974). These knowledge structures are composed of historically persistent assumptions that shape how actors perceive the world, form conjectures about past events, and make predictions about future outcomes (Barsalou and Hale, 1993; Benner and Tripsas, 2012). As such, frames are critical for reasoning, as they influence how actors "comprehend, understand, explain, attribute, extrapolate, and predict" (Starbuck and Milliken, 1988, p. 51) phenomena in their environments. They also dictate the repertoire of actions deemed appropriate or viable in any given situation (Kaplan, 2008; Seo et al., 2010).

Frames are not static; they are sustained through repeated enactment and can become conventionalized over time (Collins, 2004). Some scholars argue that frames are relatively stable, built on both conscious and unconscious knowledge that is activated by contextual cues (Epley and Gilovich, 1999; Lombardi et al., 1987; March and Simon, 1958). This perspective suggests that frames are deeply embedded in our cognitive processes and are resistant to change. However, other scholars contend that frames are dynamic and socially constructed, meaning that their meanings are fluid and subject to negotiation and redefinition through social interactions (Cornelissen and Werner, 2014; Gray et al., 2015; Hallett and Ventresca, 2006). This view aligns with the idea that meaning is not simply accessed but is constructed and reconstructed in interaction with others (Tannen, 1985).

This study builds on the understanding of frames as both stable and dynamic. While frames provide a certain stability of meaning—serving as "tacit theories about what exists, what happens, and what matters" (Gitlin, 1980, p. 6)—they are also socially constructed and can evolve over time. Through communication and social interaction, certain aspects of reality become more salient, shaping problem definitions, causal interpretations, and policy recommendations, often to the exclusion of alternative perspectives (Entman, 1993). For instance, in the context of sustainability, frames can determine which environmental or social issues are prioritized in policy discussions and which are sidelined.

In this research, frames are understood as dynamically stable schemas that connect the past, present, and future, forming the foundation for policy action. While frames are deeply entrenched in how individuals and groups judge contexts and make decisions, they are also responsive to changing circumstances. This responsiveness is because meaning is continually negotiated and legitimated through ongoing social interactions (Creed et al., 2002; Schot and Steinmueller, 2018). Changes in frames can occur when different frames collide, leading to moments of tension and potential transformation (Fuglsang and Hansen, 2022). Additionally, frames can be deliberately modified through processes such as bridging (connecting different but ideologically compatible frames), amplification (reinforcing core values), extension (broadening a frame's scope to include new perspectives), and transformation (altering the symbols or meanings associated with a frame) (Benford and Snow, 2000).

2.2. Directionality and policy mixes

Frames play a crucial role in guiding the directionality of systems transformations. Directionality refers to the process of intentionally steering innovation and market developments toward specific societal goals, ensuring that system changes align with these goals (Bergek et al., 2013; Weber and Rohracher, 2012). This concept is particularly important in sustainability transformations, where the goal is not just any change, but change that leads to more sustainable outcomes for society and the environment (Geels, 2011). In this process, frames influence which aspects of a system are perceived as important and which are emphasized in decision-making, thereby shaping the trajectory of system change.

The concept of directionality is critical because there are multiple ways to interpret a system and approach systems change. Without a clear sense of direction, sustainability efforts can become fragmented or misaligned, failing to address the core issues (Bergek et al., 2023; Parks, 2022; Weber and Rohracher, 2012). Therefore, directionality is essential in ensuring that sustainability transformations are coherent and targeted toward achieving specific societal goals. Moreover, scholars argue that policy should be designed to promote a plurality of pathways and ensure democratic accountability in the pursuit of sustainability (Ely et al., 2014; Savaget and Acero, 2018). This means that policies should not only guide system changes but also be flexible enough to accommodate diverse perspectives and adapt to changing circumstances.

In the context of large-scale transformations of sociotechnical

systems, it is crucial to consider how decisions are made, whose interests are prioritized, and what mechanisms are used to guide these transformations (Leach et al., 2007; Voβ et al., 2006; Smith and Stirling, 2010). For example, in the transition to renewable energy, directionality would involve not only promoting the development of green technologies but also ensuring that these technologies are accessible and beneficial to all sectors of society. This requires a careful balancing of competing interests and the development of policies that are both effective and equitable.

There is also a growing recognition of the need to understand the connection between directionality and the design and implementation of policy efforts (Bergek et al., 2023). Systems transformations require a complex mix of policies to steer innovation in ways that benefit the environment and society (Edmondson et al., 2019; Kanger et al., 2020). The literature on policy mixes has expanded significantly over the past decade, particularly in the context of sustainability. A policy mix refers to the combination of overarching objectives and a variety of policy instruments used to achieve those objectives (Rogge and Reichardt, 2016). These instruments can include regulations, incentives, and informational tools that work together to influence system change.

However, much of the focus in the existing literature has been on the specific instruments that make up the policy mix, with less attention given to how these instruments align with overarching objectives, often referred to as policy strategies (Costantini et al., 2017; Kern et al., 2019; Schmidt and Sewerin, 2019; Trotter and Brophy, 2022). This gap is significant because the effectiveness of a policy mix depends not only on the instruments themselves but also on how well they are integrated into a coherent strategy that reflects the desired directionality of system change (Flanagan et al., 2011). For instance, in the context of climate change, a policy mix might include carbon pricing, subsidies for renewable energy, and regulations on emissions. The success of this mix depends on how well these instruments work together to achieve the overarching goal of reducing greenhouse gas emissions. Frame analysis can help close this gap by connecting overarching policy goals with the specific instruments used to achieve them. By examining the frames that underlie policy decisions, scholars and policymakers can gain insights into how directionality is constructed and how it influences the design and implementation of policy mixes (Schot and Steinmueller, 2018; Stirling, 2008). This approach allows for a more nuanced understanding of the relationship between directionality and policy, helping to ensure that systems transformations are not only effective but also aligned with societal goals and values.

3. Methodology

3.1. Choice of literature

This work investigates 'systems change' frames through a meta-synthesis of case studies of two literature strands emphasizing large-scale efforts to steer society toward more sustainable directions: Circular Economy (CE) and Sociotechnical Systems Change for Sustainability (ST). These two bodies of literature were selected as they have grown considerably in the last decade, looking at sustainable change but building on different assumptions.

Both literatures highlight the importance of systems change to achieve sustainability goals; they recognize the interplay between technological, social, and institutional factors in driving transitions toward more sustainable systems. Other literature bodies with a systems perspective – e.g., complex adaptive systems and system dynamics – were excluded from analysis because they did not have an intrinsic focus on influencing systems change to meet sustainability goals. These two streams were therefore selected as means of exploring systems change that is purposeful in addressing socioenvironmental challenges.

However, the streams differ in their analytical focus. While ST literature examines transitioning from one sociotechnical system to another, CE literature explores ways for closing material loops and shifting from a linear to a circular production and consumption system. Sociotechnical systems fulfill societal functions like mobility and transportation, housing, energy, materials supply, and sustenance (Geels, 2002, 2004, 2018) and comprise interdependent elements such as technologies, supply networks, infrastructures, markets, regulations, user practices, and cultural meanings (Geels, 2005, 2018). Sociotechnical systems consist of the three different system levels of landscape, regime, and niches: The sociotechnical landscape refers to aspects of the wider exogenous environment like macroeconomics, political ideologies, and demographical trends (Geels and Schot, 2007; Geels, 2011). The regime can be understood as the deep structure of the whole sociotechnical system (Geels, 2004). The actions of incumbent actors in existing systems are guided by these sociotechnical regimes, which are the "semi-coherent set of rules" (Geels, 2011, p. 27) – e.g., shared beliefs, user practices, institutional arrangements, and regulations – that guide and reproduce, and therefore stabilize, the system's elements and trajectories (Geels, 2018). Radical novelties developed by small networks of dedicated actors emerge in the sociotechnical systems' niches, which serve as spaces of protection to shield young innovations, provide space for learning processes, and for building up support networks (Geels, 2004, 2005; Geels and Schot, 2007).

Accordingly, ST unpacks the coevolutionary and multi-dimensional dynamics between technologies, institutions, actors and networks, infrastructure, policies, and other features that explain change or the lack thereof (Freeman, 1995; Geels, 2002; Malerba, 2002). CE, alternatively, starts from a more specific frustration, often referred to as "cradle-to-grave" (McDonough and Braungart, 2002): the linear system of extraction, production, consumption, and disposal, which leads to the waste of finite materials and energy resources, consequently causing environmental degradation (Geissdoerfer et al., 2017; Jurgilevich et al., 2016).

Although not exhaustive, the case studies in these two bodies of literature offer the opportunity to inductively reveal researchers' frames of systems change, which can, in turn, generate new insights for the literature on directionality and policy mixes. For that, the starting point is the assumption that a 'system' is an analytical tool, not a 'thing' – and, therefore, it has been framed in different ways to examine past, present, and future change and to justify what is desirable or appropriate. Across these two bodies of literature, there is recognition of complexity, indeterminacy, heterogeneity, and uncertainty that arise from the co-evolution of organizations, technologies, and practices, and that explains the inertia and pervasiveness of problems that span beyond the ability of single organizations to solve. This approach ensures comparability (Granqvist and Ritvala, 2016) between these two streams of literature while also allowing for the exploration of variations in how they implicitly frame 'systems change'—differences that have yet to be systematically mapped and understood.

3.2. Meta-synthesis

Scholars have adopted a 'frame' lens to interpret the current priorities, emphases, and contradictions within and across bodies of literature (Geels and Verhees, 2011; Schot and Steinmueller, 2018). This helps to shed light on the microfeatures of theories that are reinforced via in-group communication, how communities strategically mobilize around meanings and interpretations (Lempiälä et al., 2019; March and Simon, 1958), and how frames shape the ways phenomena are interpreted (Pansera and Owen, 2018), recommendations drawn, and power exerted (Rasmussen, 2011; Schmidt, 2000).

Meta-synthesis is a particularly helpful method to 'surface' frames. It is a qualitative approach to extracting, analyzing, and synthesizing qualitative evidence from case studies which authors arguably used to build or extend theory (Eisenhardt and Graebner, 2007). This method facilitated the assembly and comparison of evidence from published case studies (Hoon, 2013; Paterson, 2001; Rauch et al., 2014) in ST and CE.

As theory is "inextricably linked with both data and conclusion about data" (Paterson, 2001, p. 5), it was considered that a meta-synthesis of multiple published ST and CE case studies would enable the abstraction of frames of systems change within and across these bodies of literature. The primary data is heterogeneous – even though cases were used to extend or build on the same bodies of literature, they were originally conducted in disparate contexts (e.g., different geographies, actors, or sociotechnical systems). However, the cases were not analyzed *per se*; the objective was to reveal underlying assumptions of 'systems change' in *how* each case was interpreted by its authors.

A meta-synthesis is transparent, systematic, and explicitly documented. It includes sequential and replicable steps for sampling and analyzing data (Hoon, 2013; Paterson, 2001; Rauch et al., 2014). The following sections describe how each of these steps was conducted.

3.3. Data collection

The Scopus database was chosen as the primary source for articles, for being inclusive (Falagas et al., 2008) and covering a range of multidisciplinary outlets where ST and CE research are published. A range of search strings and selection criteria were used to identify relevant articles as described in Table 1. The difference in the number of initially identified papers (145 for ST and 2111 for CE) is explained by the fact that ST literature is more circumscribed to studies on science, technology, and innovation within the social sciences, whereas CE includes studies in various other disciplines, such as engineering and material sciences. Furthermore, the focus was on articles with a case study, so that the framings used in their analysis could be unpacked and in ST only system change towards sustainability was examined (see search strings). However, it could be noted that, while CE is a label that has been consistently used throughout the studies, the term 'socio-technical' has been used, for example, in articles on information security and other focal areas that diverged from our motivation.

As demonstrated in Fig. 1, the search on Scopus shows that case study publications in ST literature and CE emerged in 1999. Between 2015 and 2021, the number of ST case studies grew by a magnitude of 222%, and CE cases by 306%.

Papers were not excluded based on the journals' impact factor nor the journal ranking, as the aim was to capture the breadth of frames, not only the ones reproduced by a few research outlets. The 100 most cited articles from each literature strand were selected, as these studies have been cited by other studies, meaning that multiple scholars have built on their original assumptions on systems change. The sample was then representative of how systems change has been framed within these two bodies of literature. Following a multistage screening process of titles, abstracts, and then full texts, 78 articles on CE and 77 on ST were obtained for analysis. The selected articles were published in a variety of journals. The journals in which the largest number of ST articles are published focus on topics related to energy, the environment, sustainability, technology, and society. In the CE literature, the papers were published in a range of sustainability-related outlets, mostly with a managerial or organizational focus. The journals with the highest number of publications are the Journal of Cleaner Production and Resources, Conservation & Recycling (Appendix A).

In ST, articles were excluded if they did not consider a *process* of change in their case study (and instead look at phenomena like risk prevention, community resilience, or students' residential satisfaction), if they did not focus on complex *sustainability* challenges (but for example on the adoption of transition management approaches or the development of information security government arrangements) or if the case study is anecdotal (e.g., uses cases for testing a quantitative model or for the application of developed frameworks or system analysis tools, but does not put the case into focus). In CE, case studies were included if they focused on analyzing a system transitioning from a linear to a circular model and excluded if the case's focus was on CE from another perspective rather than system's change, such as if the case was a testing case for a proposed tool or if the case study was purely looking at quantifying the benefits of CE. In other words, if the change to a circular system was not the paper's focus, it was excluded.

Table 1
Search strings and selection criteria.

ST	CE
Search strings in Scopus	
"sociotechnical trans*" or "socio-technical trans*" or "sociotechnical change" or "socio-technical change" or "socio-technical system trans*" or "sociotechnical system trans*" or "sociotechnical system" or "socio-technical system" and "sustainab*" and "case stud*"	"circular economy" or "CE" and "case stud*"
The search strings were applied for the terms within the title, abstract and keywords and the search was limited to journals as a source type, and to articles written in English and published in and before 2021.	
145 papers identified	2111 papers identified
Selection of articles for analysis	
The 100 most cited articles from each literature strand were selected. Titles, abstracts and full texts were screened in a multistage process.	
Exclusion criteria	Exclusion criteria
- not considering a process of change in their case study - not focusing on complex sustainability challenges - anecdotal case study	- focus on CE from another perspective than systems change; not focusing on change to a circular system
77 papers obtained	78 papers obtained

3.4. Data analysis

There are multiple traditions within framing literature stemming primarily from Goffman's work (1974). These have been used, for example, in studies on social movements (e.g., Snow and Benford, 1992, 1988; Reinecke and Ansari, 2021), formation and transformation of fields (e.g., Ansari et al., 2013; Lounsbury et al., 2003), and institutional practices (e.g., Helms et al., 2012). Despite different focal areas, studies tend to agree that a frame includes 1) *What changes* - a definition of the problem or phenomenon and why it matters; 2) *Primary actors* - an attribution of 'responsibility' or 'accountability,' which connects the problem or phenomenon with certain actor groups; and 3) *Modes of intervention* - an elaboration of action opportunities, of how to intervene in those circumstances. The content analysis thus started from these three core features. Case studies were reviewed inductively, coding first-order concepts that seemed relevant, but with a focus on this definition of a frame with these three different core features informed by theory on frames.

As described by Tsoukas and Hatch (2001), "In narrating, a narrator communicates and captures nuances of event, relationship, and purpose that are dropped in the abstraction process that permits categorization and correlation in the logico-scientific mode" (Tsoukas and Hatch, 2001, p. 998). The underpinning assumptions of 'systems change' are not typically made explicit, let alone how these assumptions prime scholars to focus on some analytical features and overlook others. Therefore, the researchers' interest lay in narratives of case studies, with attention to frame features rather than how authors subsequently abstracted categories from their reports.

This process of reviewing case studies was conducted simultaneously for CE and ST. The coding process involved a great variety of first-order codes inductively derived from the data, which were subsequently grouped as the authors together triangulated, discussed, interpreted the findings, and iterated with extant literature (Gioia et al., 2013). Through this process that oscillated between case studies, their interpretations, and theory, a grounded understanding was identified and developed (Strauss and Corbin, 1990) of the four frames of systems change, as depicted in Fig. 2. They are not meant to be mutually exclusive, but it can be noted that each case has a dominant frame, as indicated in

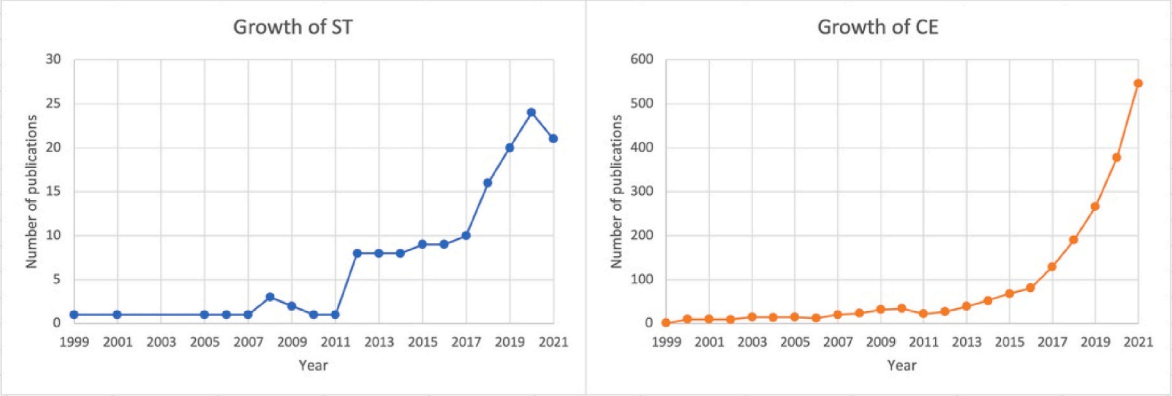

Fig. 1. Growth of ST and CE

		Core features			Frames
		1) What changes	2) Primary actors	3) Modes of intervention	
Expression in case studies	ST	Organizational practices and governance models	Companies on their own, multiple companies, sectors	Integration of new practices, inter-firm relationships	Organizational frame
	CE	Business models, processes, practices, governance models and structures	Companies, value chain partners, government	Development of new capabilities, skills, raising public acceptance; government's redefinition of cognitive, normative and regulative processes	
	ST	Governance mechanisms, business models, behavior, institutions, creation and diffusion of new technologies	Governments and coalitions, industry players, technology adopters	Broader governance processes, stimuli for technological development, creation of an enabling environment for new technology	Incumbent regime frame
	CE	Incumbent practices, technologies/technical arrangements, institutions	Policymakers, NGOs, private companies, integrators, community	Policy, regulation, normative instruments, integration of digital technologies	
	ST	Unsustainability in cities, regions and other local jurisdictions, access to infrastructure, products, and services	Grassroots organizations, users, and NGOs, government and local authorities in cooperation	(Public) projects, governance processes, knowledge transfer, networking	Jurisdictional frame
	CE	Local practices, technologies, methods, processes	Local government agencies	Governments' incentives and favorable conditions, introduction of new technologies, change in regulation	
	CE	Existing industrial ecosystems, organisations' business models	Government, industry, value chain partners	Policy, incentives, financial support	Industrial ecosystem frame

Fig. 2. Identified frames of systems' change in ST and CE case studies.

Appendix B.

While Fig. 2 shows how we identified the four frames based on the three core features that constitute a frame (i.e., what changes, primary actors, modes of intervention), we then started to unpack the nuances within and across frames by delving deeper into the data.

The first pivotal observation when reflecting on the four different frames in Fig. 2 was that the studies did not start from a definition of a 'system' but rather used the term to refer to the unit of analysis of the case studies. Thus, unpacking what 'a system is' was only feasible through further scrutiny of case studies to examine core features, how they were connected, and justified. The authors started asking themselves: what is 'the system' of each case study composed of? How can or are these systems transformed? What does the analysis describe as a priority? What are the boundaries of the analysis (in other words, what is included or excluded from the analysis)?

Guided by these questions, the authors started to code the data from the studies more systematically, in search of similarities and differences in how case studies approached 'systems.' At this point, it was noted that the starting point of their narratives is usually 'why' a topic or situation is critical: organizations impact society, the economy, and the environment; incumbent regimes shape what is viable or desirable; problems in jurisdictions are idiosyncratic, persistent and pernicious; or organizations are part of wider networks of exchange. Diving deeper into these 1) core assumptions on the importance of change-making, the authors also started identifying different patterns in terms of 2) priorities to change in systems, 3) key obstacles for the desired systems change, 4) the analytical boundaries of the system and level of analysis, 5) the mechanisms and key actors of systems change pursuits, and 6) how these pursuits impact systems.

Lastly, reflecting on these six attributes, the authors understood that the first three referred to the 'rationales' of case studies – core assumptions on why change is needed and what needs to change – and the last three features were about the 'reach' – core assumptions on where change should happen and where the analytical boundaries are, who should act and how action should be pursued, and the expected outcomes of action as how the system is impacted.

By identifying similarities and differences across these categories for the 155 case studies, the rationale and reach of the four frames emerged, as depicted in Table 2.

4. Results – frames of systems change

The analysis of CE and ST case studies reveals four different frames of systems change pursuits toward sustainability. They have different core features – the definition of what changes, primary actors, and modes of intervention – and differ in terms of 'rationale' and 'reach'. 'Rationale' includes the starting core assumptions on change making of analysis, the priorities for pursuing desired change in systems, and the key obstacles

Table 2
The rationale and reach of the four frames of systems change.

		Frame 1 Organizational frame	Frame 2 Incumbent regime frame	Frame 3 Jurisdictional frame	Frame 4 Industrial ecosystem frame
Rationale (why and what)	Core assumptions on the importance of change-making	Organizations have a great impact in society, the economy, and the environment.	Regimes are inertial and shape desirable solutions. Technologies and behaviors are intertwined, and, together, shape our unsustainable production and consumption patterns.	Jurisdictions like cities and regions have complex institutional arrangements and idiosyncratic sustainability problems. Some are persistent and pernicious; they resist easy fixes.	Organizations are part of ecosystems as broader networks of exchange, that can be created anew.
	Priority to change in systems	Organizations must develop more sustainable strategies, business models, and practices.	Destabilizing what keeps unsustainable technologies and practices "incumbent". The creation and diffusion of sustainable innovations is key.	Local problems require customized solutions. Assessing and responding to regional challenges through integrative efforts.	Closing the loops of materials and energy to minimize or eradicate waste.
	Key obstacles for the desired systems change	Resistance of key stakeholders, legacy strategies, short-termism.	Lock-ins, dominant designs, institutional constraints. Technical challenges for creation and behavioral challenges for diffusion of technologies.	Problems are amalgamated and poorly specified. Assembling local capabilities and aligning interests for overcoming inertia is challenging.,	Inertia of linear systems, short-termism
Reach (where, who, and how)	Analytical boundaries of the system/level of analysis	Organizational	Incumbent regime	Jurisdictional	Industrial ecosystem/value chain
	Mechanisms and key actors of systems change pursuits	Corporate governance, business model innovation, changes in operations.	Alignment of distributed action to change. Supporting technological development and diffusion, creation of protective spaces (niches) for new technologies.	Stakeholder management, network orchestration, repurposing resources, public governance and policy.	Expanding networks, strengthening connections, orchestrating actors around a value proposition, developing policy and promoting economic incentives.
	How these pursuits impact systems	Reconfiguration of resources and efforts; influence on change-making processes ranging from decision to implementation.	Integration of distributed action; attends to context-specific politics and norms; emphasis on co-evolution.	Local arrangements enable comparison with other jurisdictions; allows for regional planning and takes politics and accountability into account.	Reconfiguration of dominant linear systems; allows for symbiotic arrangements with multi-stakeholder benefits

for the desired systems change. 'Reach' consists of the analytical boundaries of the system and the level of analysis, mechanisms and key actors of systems change pursuits, and the impacts these pursuits are expected to create. Together, the rationale and reach bind together and differentiate four frames (Schön and Rein, 1994; van Hulst and Yanow, 2016) of systems change for sustainability in the sample. Three frames are shared by CE and ST, and one frame is idiosyncratic to CE. First, the frames found in both streams of literature are depicted, then the frame unique to the CE literature stream is unpacked.

4.1. *Organizational frame*

Within this first frame, organizations are assumed to greatly impact society, the economy, and the environment. The organization as a unit or in combination with other organizational units (e.g., as a sector or supply chain) is understood as the system that undergoes a transformation in organizational practices, governance models, business models, processes, or structures towards organizational sustainability.

Accordingly, the starting point of the first frame for change-making is organizational – either within a company, between companies, or across a sector – and cases tend to investigate how organizations can better strategize or develop more sustainable business and governance models and practices: Retail banking practices are to be changed as value-based banks want to diffuse (Seyfang and Gilbert-Squires, 2019), a degrowth perspective is incorporated into design processes (Lizarralde and Tyl, 2018), internal organizational structures are adjusted for democratic platform governance (Martin et al., 2017), and in a food-processing firm sustainable innovation journeys are being explored "focused on practices performed in the firm (e.g. production, sales) and (…) how these develop over time" (Langendahl et al., 2016, p. 110).

Case studies often emphasize processes in which companies reconfigure resources and implement new solutions. Barriers and challenges to organizational transformation include short-termism and resistance to change. Cases often focus on a leading organization and describe other actors with whom the organization collaborates as playing supporting roles in enabling the transformation. The emphasis on industrial performance enables practitioners to attend to corporate governance, business model innovation, and changes in a company's operations. Approaches to change systems tend to rely on novel ways to reconfigure resources and influence change-making processes ranging from a decision to implementation.

ST case studies focus on changes happening either within a single company as a system (Martin et al., 2017; Seidel et al., 2013), between companies (Albino and Berardi, 2012; van Geenhuizen and Ye, 2014) or in a whole sector (Seyfang and Gilbert-Squires, 2019; Vermunt et al., 2020), with a particular emphasis on improved design, production, and sales processes, work practices, technology development and adoption, and inter-firm relationships and the democratization of decision-making processes. Initiatives are being formed, for example, within a software company (Seidel et al., 2013) or for biodiversity-friendly dairy production, consisting of different actors such as consultants, cooperatives, supply chain actors, NGOs, and retailers (Vermunt et al., 2020).

CE case studies focus instead on changes in operations or business model innovation as a means to do so by extending and recirculating products, parts, and materials (Guldmann and Huulgaard, 2020; Nuβholz et al., 2019). As highlighted by Guldmann and Huulgaard (2020), to achieve a regenerative economy, companies need to change the way they operate, and the adoption of circular business models is one means to do so. The organizational changes are typically related to new value propositions, financial models, and managerial practices (Diaz Lopez et al., 2019; Ünal et al., 2019) or regulatory structures that enable the shift toward circularity (Guldmann and Huulgaard, 2020). As posited by Ünal et al. (2019), transitioning to CE requires the "establishment of effective communication with suppliers, retailers, and

end-of-life materials managers, such as the waste industry, as well as with all the actors involved in the supply chain" (Ünal et al., 2019, p. 572). Studies have also highlighted the importance of interventions in norms and regulative frameworks to adjust the misalignment of taxation and policy instruments (Bressanelli et al., 2019) and how standards or operating principles guide companies in moving from linear to circular business models (Stål and Corvellec, 2018).

4.2. Incumbent regime frame

In the second frame, the story of system transformation is built around a particular inertial sociotechnical regime as the core and deep structure of a system, referring to shared beliefs, practices, institutions and regulations that guide, reproduce, and stabilize the whole system (e.g., a mobility system or energy system). The process of system change aims to replace the established beliefs, regulations, technologies, institutions, infrastructures and practices of that regime to bring about a transformation of the whole system, of which the regime is the essential part and shapes solutions one deems desirable or viable. Technologies and behaviors are intertwined. Accordingly, case studies of this frame often focus on the creation and diffusion of technological innovation as key to addressing unsustainability.

When the starting point is inertial regimes, priority efforts revolve around the destabilization of what keeps unsustainable regimes in place – i.e., the interconnected webs of technologies, institutions, infrastructures, and practices. Case studies describe various efforts like improved governance mechanisms for urban development projects (Smedby and Quitzau, 2016), new business models for energy supply (Bolton and Hannon, 2016), and cultural and behavioral change: "the dominant mobility lifestyle (has) to overcome an established regime and will require major changes in culture and behavior" in order to change the mobility sector towards low-carbon mobility (Köhler et al., 2020, p. 1). Others focus on the replacement of incumbent technologies to change the regime, e.g., transforming Portugal's energy system towards multi-scalar solar uptake (Sareen and Haarstad, 2018) and the heating system in Denmark and the Netherlands from coal, oil and gas to district heating (Roberts and Geels, 2019).

Focusing on how a sociotechnical system changes through the creation and diffusion of new technologies and how technologies and behaviors co-evolve in ways that shape unsustainable production and consumption patterns (Lawhon and Murphy, 2012; Papachristos and Adamides, 2016), case studies in ST explore how the diffusion of genetically modified organisms technology is changing agriculture and food production (Lawhon and Murphy, 2012), how the diffusion of functional foods is changing the food and pharmaceutical system (Papachristos and Adamides, 2016), and how the diffusion of 3G, 4G, and 5G technology is changing the telecommunications industry (Liu et al., 2018).

Obstacles highlighted in these cases include technological lock-ins, dominant designs, or institutional constraints that prevent purposeful change. Köhler et al. (2020) summarize "that a technological substitution to low carbon cars (…) would require not only a strengthening of current policies (…) but also a change in attitudes" and a change in culture (p. 27). Mechanisms for pursuing desirable change entail aligning distributed actions, such as changing industrial structures, emulating new market preferences, or designing new policies. Systems change efforts consist of creating enabling conditions for technological adoption or diffusion in a specific sector (Elmustapha and Hoppe, 2020) or business models and policy mixes as purposeful efforts by companies or governments to nurture new technology (Huang, 2019; Yap and Truffer, 2019): In case of the membrane bioreactor technology "particular emphasis is put on the strategic interplay between the government and leading actors in the industry in promoting (the technology) as the dominant technological choice" (Yap and Truffer, 2019, p. 1032), and "5G innovation in China is well organized by government and industry" (Liu et al., 2018, p. 1161). Cases also often describe how investing in technological development and the creation of protective spaces for new technologies is instrumental in promoting more sustainable production (de Boer et al., 2018; Lundström and Lindblom, 2018) or consumption (Kanger et al., 2019; Rolffs et al., 2015). Focusing on what happens in incumbent regimes enables scholars and policymakers to attend to the integration of distributed action, context-specific politics and norms, and the co-evolution of multiple interlocked features.

ST case studies often depict political processes at the core of regime changes (Hoffmann et al., 2017; Kern, 2011; Kern and Howlett, 2009; Smedby and Quitzau, 2016), in which government bodies or representatives join forces with business actors. They have investigated, for example, how governments incentivize low-carbon mobility (Köhler et al., 2020), influence the uptake of renewable energy (Osunmuyiwa et al., 2018), and engage in political consultation and deliberation with multiple stakeholders (Konefal, 2015). Main actors are also industry players (including, but not limited to, incumbent companies) and governments (Hensengerth, 2018; Liu et al., 2018; Ngar-yin Mah et al., 2017; Yap and Truffer, 2019). Technology adopters are also described in a few cases as central to sociotechnical system transformation (Lundström and Lindblom, 2018; Swiergiel et al., 2019):

Modes for intervention involve either direct stimuli for technological development (e.g., investments, R&D, subsidies; Hensengerth, 2018; Swiergiel et al., 2019) or indirect stimuli through the creation of an enabling environment for new technology to flourish and outcompete unsustainable dominant designs, such as through supportive infrastructure (Huang, 2019; Yap and Truffer, 2019) "to shape different layers of the selection environment in a specific sector" (Yap and Truffer, 2019, p. 1030).

CE case studies highlight the role of policymakers in influencing "integrators" – i.e., actors integrating material flows back into circulation (e.g., recyclers, scavengers, and informal workers) (Fatimah et al., 2020; Ferronato et al., 2019); the role of public policies in the creation of reuse schemes and take-back programs and the impact of regulations limiting the use of hazardous substances or material and energy consumption (Ma et al., 2015; Ranta et al., 2018); and the creation of voluntary normative instruments, such as certifications for sustainable and recycled materials (Ranta et al., 2018). As highlighted by Fatimah et al. (2020), "an intervention is needed to bring stakeholders together to solve these waste challenges" (Fatimah et al., 2020, p. 1).

4.3. Jurisdictional frame

The third frame focuses on sustainable development in cities, regions, and other jurisdictions with a concrete need for change in a local system. The change process is initiated because of an individual local demand in that specific system. The analytical boundary of the system is jurisdictional. System transformation then occurs in the direction of, e.g., access to new infrastructure, products, and services, or in the direction of new, alternative practices, technologies, or methods in locally delineated domains – also as part of larger movements.

This frame assumes that cities, regions, or other local jurisdictions have complex institutional arrangements and, therefore, present idiosyncratic sustainability problems. These are persistent and pernicious, resisting easy fixes, thus requiring attention to contexts instead of generic or replicable solutions.

Case studies focus on a specific societal need – e.g., the lack of energy supply in rural Tanzania (Ahlborg, 2018) and poor sanitation in informal settlements of Nairobi (Cherunya et al., 2020). Or they prioritize assessing and responding to more general regional challenges, often highlighting the importance or value of integrative efforts – e.g., changing the regional economic system and "engendering green growth" (Gibbs and O'neill, 2014, p. 212), or green cosmopolization (Blok, 2012), and implementing a project to improve rainwater management (García Soler et al., 2018). The starting point for analysis is thus a problem that needs to be solved through a systems intervention.

The cases assess the system that keeps this problem in place and

identify the system transformations that have been (or that should be) pursued to tackle it. Allon and Sofoulis (2006) look at changing domestic water consumption. The explored projects' objectives are to "benchmark current community attitudes and practices around water (…); discover the obstacles to adopting further water-conserving techniques and technologies; and suggest ideas for community education and intervention strategies" (p. 49). Other case studies look at initiatives and social movements which aim to establish "novel energy-conserving and resource-conserving practices into the mainstream" (Boyer, 2015, p. 320) or reduce individual environmental impact and foster pro-environmental behavior (Hargreaves et al., 2013).

Obstacles include problems being poorly specified and challenges related to assembling a wide array of local capabilities. The mechanisms to overcome these challenges and conceive a contextualized solution involve stakeholder management, network orchestration, and the repurposing of resources: It is, for example, about "improved knowledge, better leadership, fewer obstacles, and more incentives to bring about a shift" (Allon and Sofoulis, 2006, p. 45), and about replicating "alternative practices (…) for example through education, outreach, and on-site activities" (Boyer, 2015, p. 320). Cases often discuss the challenges of aligning groups with different interests or commitments as a means of overcoming inertia. They describe public governance and policy as instrumental in regional development, such as mission-oriented programs, efforts to diversify investments or portfolios, or democratic participation in decision-making. Examples include local authorities in actor networks influencing sustainable regional development in two Swedish municipalities (Von Malmborg, 2007) and an energy transition initiative in Hawaii for the development of an intelligent energy region (Lee et al., 2020).

Systems change efforts range from expanding access to infrastructure, products, and services within a specific geographical region as a system – for example, village electrification (Ahlborg and Sjöstedt, 2015) and initiatives for more sustainable behavior and food consumption (Hargreaves et al., 2013) in ST. With an emphasis on the development of a specific geography, this frame is particularly attentive to planning, as well as the politics and accountability of policymaking processes. For example, in the shifts in transport and mobility examined by Rosen (2001), developers and planners try to shape the processes by which local development strategies are established. Here, "policy often emerges as the outcome of manoeuvrings and negotiations which often reflect not so much the needs expressed by local communities, but those of policymakers" (p. 128). Governments or small-scale grassroots organizations or NGOs (such as local food cooperatives; Hargreaves et al., 2013 and ecovillage projects; Boyer, 2015) are often described as the leading actors. In other case studies, urban sustainability networks (Blok, 2012) and local authorities in actor networks (Von Malmborg, 2007) play the central role. The primary mode of intervention in these case studies is a new public project or governance process (García Soler et al., 2018) or cross-boundary knowledge transfer and networking (Blok, 2012; Dobson, 2019).

In CE, system interventions are often described in terms of 'carrots or sticks.' Whereas 'sticks' are normally centered around new regulations (Bao and Lu, 2020), case studies have described a wide range of 'carrots' – e.g., the promotion or diffusion of new technologies for circularization (Fatimah et al., 2020). Others highlight systems change projects, such as projects to change water consumption through behavioral change (Allon and Sofoulis, 2006).

4.4. Industrial ecosystem frame

The fourth frame was only identified in CE cases. It starts from the recognition that organizations are part of broader exchange networks where waste can be transformed into resources. In contrast to the first frame, the focus here is not on transforming individual organizations, several organizational units, supply chains or sectors, but on creating entirely new exchange networks as new industrial (eco) systems. Through the creation of more sustainable industrial ecosystems, the waste of some can turn into input for others (Yang and Feng, 2008). As highlighted by Domenech et al. (2019) , the creation of industrial symbiosis among multiple organizations has been seen as a "practical approach to enhance resource efficiency, reduce waste generation and GHG emissions via material, energy, by-products exchange between different processes and industries" (Domenech et al., 2019, p. 77).

The obstacles to this goal include the inertia that maintains linear systems of extraction, production, consumption, and disposal, as well as the short-termism of investors or companies.

The key mechanisms for pursuing the desired change include expanding networks, diversifying ties, orchestrating actors around more sustainable value propositions, and developing new supporting policy and financial incentives. As the boundary is an industrial ecosystem (sometimes presented as a "value chain"), this frame allows scholars to focus on the reconfiguration of dominant linear systems, highlighting opportunities for more symbiotic multi-stakeholder arrangements – for example, a recurring approach across cases is "industrial symbiosis" (when different industries create a cooperative network to exchange materials, energy, water, and by-products (Baldassarre et al., 2019). The primary actors in this frame are either companies or governments. Companies, through the formation of new industrial ecosystems that optimize the flows of materials and energy, and governments, through policy and legislation, that facilitate change in these industrial ecosystems. Some cases connect the impact of government and company actions – for example, how industrial symbiosis arrangements emerged due to new policies, such as the EU CE law and the CE law in China (Domenech et al., 2019). Others reflect on the impact of material artifacts, such as new technologies, on enabling such arrangements: A key factor for developing industrial symbiosis is aligning waste supply with demand, but this is hindered by a lack of information between companies "i.e., demand (supply) for a given waste exists but firms producing (requiring) that waste are not aware of such a demand (supply)." While online platforms have been suggested to help create these networks, related environmental and economic benefits have not been thoroughly studied (Fraccascia and Yazan, 2018, p. 474).

5. Discussion

The next section introduces a process model of systems change that directly builds on the analysis of the four frames of systems change for sustainability. These frames provide a structured foundation for reflecting on the directionality of policy efforts, which involves steering innovation and system change toward specific societal goals (Bergek et al., 2023; Parks, 2022; Weber and Rohracher, 2012). Additionally, these frames inform the selection of more plural and inclusive policy mixes, ensuring that policies are better aligned with diverse societal needs (Kern et al., 2019). By integrating these insights, we developed a three-stage process model that connects the theoretical understanding of frames with practical policymaking strategies, as depicted in Fig. 3.

The process model facilitates a systematic exploration of how policies can be designed and implemented to achieve desired outcomes while considering the complexities of systems change. By doing so, it highlights the importance of both opening up policy discussions to consider a wide range of possibilities and closing down to provide clear recommendations and direction (Stirling, 2008). This integrated approach underscores the connection between directionality and policy mixes, motivating the use of the process model as a tool for more effective and reflective policymaking.

5.1. A process model of systems change policymaking

The four frames allow for a systematic reflection on the directionality (e.g., Bergek et al., 2023; Parks, 2022; Weber and Rohracher, 2012) of ongoing policy efforts and the selection of more plural policy mixes (Kern et al., 2019). To achieve this, a three-stage process was developed,

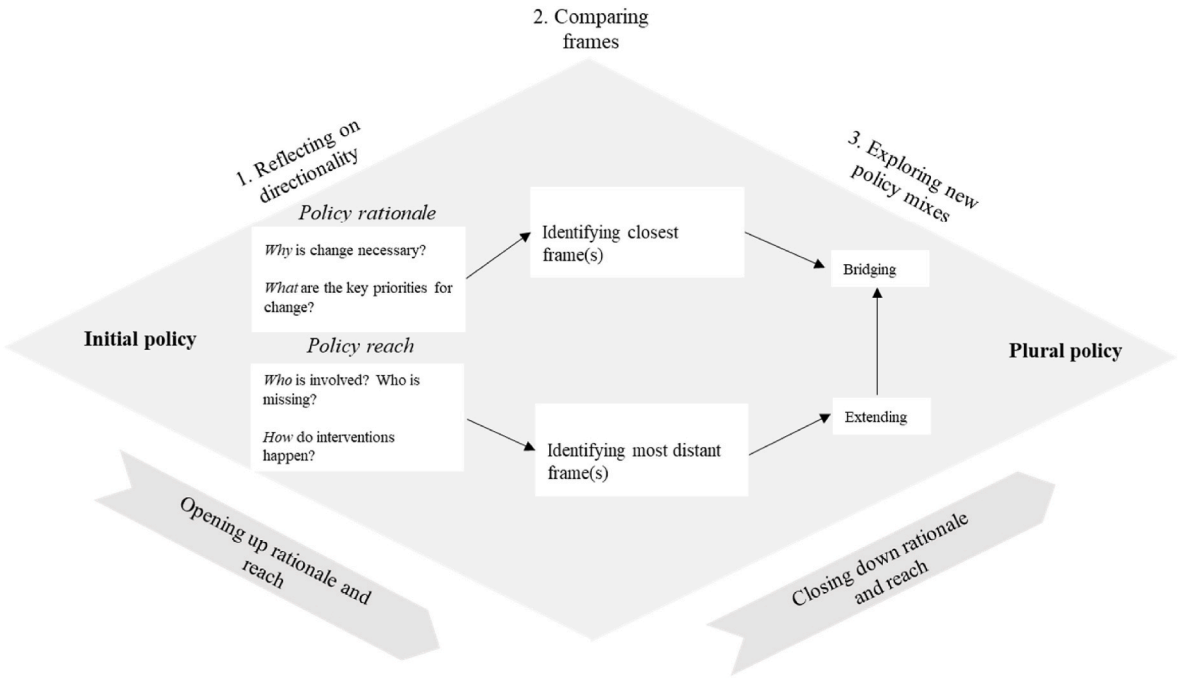

Fig. 3. Opening up policy appraisal and exploring new policy mixes.

as depicted in Fig. 3, building on the similarities and differences across the frames in the results and connecting these with the existing literature on directionality and policy mixes.

The starting point for the model is an existing area of policymaking, which is referred to as the initial policy. In the first stage, the core features of a policy are surfaced and given space for reflection. At this point, an analyst is not necessarily aware of a frame – instead, they start from the 'parts' to identify what frame most resonates with a policy intervention. Then, once these are mapped out, the authors propose how the analysis can be pushed further to both reflect on the directionality of ongoing interventions and explore new and more plural policy mixes. In the second stage, these features are compared with the ones from other frames for systems change. In the third, a process of cross-frame negotiation guides and enables prioritization.

The focus of the model is on identifying ways to combine the benefits of opening up and closing down the process of policy appraisal (Stirling, 2008). Opening up encourages assumptions to be challenged, and neglected issues and actors to be identified which can help to challenge incumbent approaches by introducing a wide range of possibilities. Closing down, however, has the benefit of providing clear recommendations and direction.

5.1.1. *First stage: reflecting on directionality*

The first stage involves reflecting on the current dominant policy frame (Bergek et al., 2023; Parks, 2022; Weber and Rohracher, 2012). The two key features, 'rationale' and 'reach,' help to surface hidden assumptions; they describe how an analytical frame is bounded, forms a cohesive pattern, and leads to certain actions and decisions while hindering others.

Embedded within the rationale in each frame is an assessment of the underlying normative assumptions guiding change (Ely et al., 2014; Savaget and Acero, 2018). Each frame has an often-tacit attribution of a specific failure that necessitates change, leading to different priorities. For example, frame 1 assumes organizational failures hinder much-needed sustainability changes. The focus of this frame is thus on organizations developing more sustainable strategies.

One of the clearest distinctions in reach across frames is the level of analysis ranging from organizational to regimes, local jurisdictions, and industrial ecosystems. Analyzing within specific boundaries provides focus but may limit inclusivity. Frame 1, for example, emphasizes organizations implementing change through business model innovation and operational adjustments, narrowing policymakers' attention to specific actors and instruments.

5.1.2. *Second stage: comparing frames*

In the second stage, policymakers can compare the four core frames for systems change and explore their connections. This allows for a broader examination of the many policy mixes that could inform the design and implementation of new policies for systems transformations.

By questioning the reach and rationale of existing frames, policymakers avoid premature narrowness as they assess alternative policy approaches (Costantini et al., 2017; Rogge and Reichardt, 2016; Schmidt and Sewerin, 2019). Comparing the dominant frame identified in a policy area with other frames for systems change provides an opportunity for policymakers to challenge their assumptions and identify shortcomings of current systems change pursuits. For example, if the starting point is disrupting an incumbent regime (frame 2), policymakers can search for distinct policies, such as those focusing on the development of new technology. Likewise, a policy emphasizing investments in specific technological trajectories can be compared with efforts focusing on stakeholder alignment or orchestration, as typical of frame 4 (industrial ecosystem frame).

5.1.3. *Third stage: exploring new policy mixes*

The second stage lays the groundwork for connecting frames in the third stage and identifying potential tensions before they emerge in policy arenas. This could be done through bridging or extending.

Bridging frames involves connecting "ideologically congruent but structurally unconnected groups" (Benford and Snow, 2000, p. 624). Identifying frames with rationales closest to the dominant frame facilitates comparison without ideological conflict. For example, frames 2 and 3 both focus on the need to overcome inertia as a core dimension of why change is necessary. From a policy rationale perspective, they are closest to each other, but they target different types of actors with a focus in frame 2 on incumbent regimes and frame 3 on regional actors. This suggests an opportunity for policymakers to combine the objectives

and instruments of both. These policy mixes may help to develop more comprehensive interventions across systems (Kanger et al., 2020) and more plural policies, which address the needs or concerns of multiple stakeholders.

Through a process of extension, one can identify frames with 'reach' most distant from the dominant frame to challenge the status quo without immediate ideological conflict. This can lead to engaging stakeholders previously overlooked and discovering new instruments for change, without disputing the underlying reason for change (Benford and Snow, 2000). Extending preserves the underlying reasons for change, reducing short-term inconsistencies and allowing potential bridging in the long-term – with more stakeholders and instruments brought into consideration, more tensions in the 'rationale' of a policy tend to surface. For example, frames 1 and 3 differ significantly in their rationales and reaches, with frame 1 emphasizing organizational sustainability and industrial performance and frame 3 addressing local needs. Extending frame 3 to include local companies as key actors in addressing local problems could allow for creative solutions to emerge and eventually lead to opportunities to renegotiate policy rationales.

5.2. Contributions to the literature on systems change directionality and policy mixes

The first contribution of this work is to the literature on the appraisal of directionality in transformative innovation policy (Bergek et al., 2023; Parks, 2022; Weber and Rohracher, 2012). Scholars have highlighted that the literature lacks practical guidance for policymakers to "capture directionality" (Haddad and Bergek, 2023), and this work contributes to addressing this gap. The frames revealed shed light on how complex, controversial, and politically sensitive policy processes aiming for systems change for sustainability can be, and how assessments can be problematic when frame awareness is only tacit (Tsoukas, 2015). Policymakers tend to implicitly adhere to a frame even if they do not explicitly think about or reflect on them. Paraphrasing Polanyi (1966), actors often find themselves in a situation where they "know more than they can tell" (Polanyi, 1966, p. 4), and the process model offers support to unpacking, discussing, and negotiating directionality of changemaking efforts.

These deliberate, reflexive practices (Schön and Rein, 1994) allow policymakers to appraise a wider range of co-existing priorities, values, and instruments, identify pragmatic possibilities for convergence (van Hulst and Yanow, 2016), and discuss how they could be assembled more plurally and democratically (Beck et al., 2021; Dryzek, 2002; Jasanoff, 2011). Scholars have described, for example, how frames can be used, switched, or combined in collective action (Ansari et al., 2013), how single actions can be coherently interpreted from multiple perspectives simultaneously (Ferraro et al., 2015), and how frames can inform participative strategy development (Zimmermann and Kenter, 2023). This research adds to these contributions not only by revealing four frames currently shaping how systems change is approached but also by offering a model for how these frames can be purposefully used in policy appraisal of systems transformations and in promoting plurality in policymaking processes. More specifically, reflecting on the four frames and their respective rationales and reach through the developed process model, policymakers engaged with sociotechnical systems change can more explicitly locate themselves 'within' a frame so that one can communicate more transparently the assumptions – or, in Foucault's (1970) words, the "epistemes" – upon which their work is built and legitimated, and which they tend to strongly favour and adhere to (Schön, 1963). Even though policymakers might see themselves as part of different communities, the assumptions guiding their analysis might be similar and this work shows how they could explore opportunities for alignment or cross-fertilization (Rogge and Reichardt, 2016). This is particularly important given the nature of many systems change concepts, such as circular economy, that emanate from policy communities and then subsequently require support from scientific communities to ensure that the concept can lead to improved sustainability outcomes (Korhonen et al., 2018). In fact, interaction between policymakers and academics in making frames explicit can provide a helpful route to ensure plurality. Future work could focus on providing practical guidance for policymakers and academics to engage in this collaborative work.

The second contribution of this study is specifically to the literature on policy mixes. The process of combining aspects of different policies has often been viewed negatively (Kern et al., 2019), and this work highlights the benefits of doing so. For example, Howlett and Rayner (2007) identify layering, drifting, and conversion as the most common ways in which policy mixes evolve. Both drifting and conversion have been criticized for leading to inconsistencies and ineffective policy outcomes (Howlett and Rayner, 2007; Kivimaa and Kern, 2016). At the same time, the evolution of policies in these ways is ubiquitous (Kivimaa and Kern, 2016) and, therefore, warrants further attention to improve outcomes.

The focus on the frames underlying policy mixes can help to identify when and how to combine objectives and instruments in ways that can support pluralizing systems change pursuits (Stirling, 2008). Drawing from the literature on frames for social movements, the authors suggest that bridging and extension can provide approaches to engage more directly with frames and, by doing so, overcome the previous limitations of passive frame evolution. The distinction between frame rationale and reach offers a practical tool for policymakers to avoid the incoherence and inconsistencies associated with passive frame evolution, and for scholars to be able to identify where these issues may have originated.

6. Conclusion

This study has provided a detailed exploration of the frames of systems change within the context of sustainability transformations, focusing on the interplay between directionality and policy mixes. By conducting a meta-synthesis of 155 case studies in the fields of sociotechnical systems change for sustainability and circular economy, we identified four distinct frames that shape how researchers and policymakers perceive and approach systems change. These frames offer valuable insights into the underlying assumptions and priorities that guide decision-making in sustainability transformations.

The process model developed in this study serves as a practical tool for policymakers to navigate the complexities of systems change, offering a structured approach to reflect on, compare, and connect different frames. This model underscores the importance of balancing the need for clear directionality with the inclusion of diverse perspectives, ultimately promoting more plural and effective policy mixes.

However, this study has certain limitations that also present opportunities for future research. First, the analysis was limited to case studies within the literature on sociotechnical systems change (ST) and circular economy (CE). Future research could investigate whether the frames identified are unique to ST and CE or if they are applicable to other bodies of literature on sustainable change, such as the growing research on systems change in social entrepreneurship (Newey, 2018; Teasdale et al., 2022).

Another limitation is that this study did not track the evolution of these frames over time. By focusing on the most cited studies, recent and less-cited works may have been overlooked. It is important to consider the four frames not as static typologies but as dynamically stable "guided doings" (Goffman, 1974), which are continually constructed, negotiated, and aligned through social interactions (Cornelissen and Werner, 2014; Gray et al., 2015; Hallett and Ventresca, 2006). Future research could explore how these frames have evolved and whether new frames have emerged, using longitudinal studies to map key milestones, field-configuring events, and the discursive struggles that have shaped these frames (Garud et al., 2017; Hardy and Maguire, 2017).

Finally, this study did not delve into the extent to which these frames are utilized in policymaking or their impact on political decisions.

Future research could analyze policy discourses, negotiations, or new regulatory frameworks to identify other frames not captured in this study. Additionally, exploring the extent and frequency of each frame's use, the influence of power dynamics in frame selection, and whether policymakers adapt different frames in various political arenas would be valuable areas for further investigation.

CRediT authorship contribution statement

Leonie Eising-Mertsch: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paulo Savaget:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Thayla Zomer:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Aoife Brophy:** Writing – review & editing, Writing – original draft, Validation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2024.143976.

Data availability

Data will be made available on request.

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