

Research article

# Rethinking Regional Embeddedness and Innovation Systems for Transitions Towards Just, Responsible, and Circular Bioeconomies

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## Abstract

Few studies have explicitly explored regional embeddedness and both the inconsistencies and injustices of *circular bioeconomy* (CBE) innovations. To better navigate the normative dimension of these innovations and CBE transitions in general, our article presents a threefold argument for the relevance of the regional level of analysis. First, CBE innovations are influenced by and affect regional metabolisms and actor constellations, assets, and (biophysical) resources within *regional innovation systems* (RIS). Second, thoroughly exploring these dimensions of regional (un)embeddedness can reveal ethical concerns, including potential “dark sides” and injustices, such as exclusivity and exploitation. Third, to address these concerns in CBE research and governance, we outline four facets: complementing RIS as a framework and policy approach, balancing creative and destructive measures, addressing the need for more inclusive regional CBE policies, and establishing dedicated intermediaries to better govern regional CBE transitions. In summary, this conceptual article provides starting points for further research and proactive measures that help govern the normative dimension and the design of CBE transitions at the regional level, promoting inclusivity, justice, responsibility, and legitimacy for both innovation and exnovation.

**Keywords:** Circular Bioeconomy, Socio-Economic Embeddedness; Socio-Ecological Embeddedness; Justice, Directionality, Legitimacy, Responsibility, Social Metabolism, Dedicated Innovation System, Challenge-Oriented Regional Innovation System, Regional Policy, Inclusive Innovation, Intermediaries

## 1. INTRODUCTION: THE CHALLENGE OF NAVIGATING JUST, RESPONSIBLE, AND CIRCULAR BIOECONOMY TRANSITIONS

For decades, activists, researchers, and policy-makers have called for transitions from our current linear and fossil-based economic regimes towards more circular and bio-based economies. A circular bioeconomy (CBE)<sup>1</sup> is frequently argued to have the potential to catalyze economic development and create employment opportunities while simultaneously contributing to more resilient, regenerative, and

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<sup>1</sup> Note that not every bioeconomy is necessarily circular and not every circular economy is concerned with bio-based resources, or utilizes biological knowledge, etc. However, for the sake of this article, and due to the simple fact that recent policy strategies and scientific publications frequently highlight the complementarities between bioeconomy and circular economy (e.g., see Ferraz & Pyka, 2023, for a review)—or use the CBE as an umbrella term (e.g., European Commission, 2018; Lang et al., 2023; Morone et al., 2023; Starke et al., 2022; WBCSD, 2020)—we follow this overarching notion in this article.

nature-positive economic systems (e.g., Bröring et al., 2020; Ferraz & Pyka, 2023; Fritsche et al., 2020; Lang et al., 2023; Pyka, 2017; Pyka et al., 2022; WBCSD, 2020). However, it seems that this potential is far from being realized, as the CBE's "normative guardrails" (e.g., Urmeter et al., 2022; Vogt & Frankenreiter, 2022) have crumbled, not least due to the ongoing contestation and conflict between ecomodernist and agroecological visions in their various forms. These visions and their differential enactment in CBE practice correspond to incompatible imaginaries, contested concepts, and divergent discourses (for details and overviews, see, e.g., Biber-Freudenberger et al., 2020; Bugge et al., 2016; D'Amato et al., 2017; Dieken et al., 2021; Friedrich, Zscheischler, et al., 2022; Halonen et al., 2022; Hausknost et al., 2017; Hinderer et al., 2021; Korhonen et al., 2018; Leipold et al., 2023; Onyeali et al., 2023; Pfau et al., 2014; Starke et al., 2022; Veraart et al., 2023; Vivien et al., 2019). Some studies suggest that in several countries, ecomodernist visions dominate, which is particularly reflected in CBE policies, strategies, and funding schemes (Bogner & Dahlke, 2022; Holmgren et al., 2022; Lühmann & Vogelpohl, 2023; Starke et al., 2023). These visions have been fueled, among other things, by what Joly (2010) calls the "economics of techno-scientific promises" or what Blok (2021) refers to as the "dominant techno-economic paradigm of innovation" (see also Eversberg, Holz, et al., 2023; Eversberg, Koch, et al., 2023; Friedrich, Najork, et al., 2022; Lühmann & Vogelpohl, 2023). While the transition towards a CBE is frequently argued to depend on various types of knowledge (e.g., see Chembessi, 2023; Stöber et al., 2023; Urmeter et al., 2018, 2020; Urmeter & Pyka, 2017), the prevalent CBE innovation paradigm remains biased towards the creation and distribution of more *techno-economic* knowledge utilized and introduced into the economy by "the supply side" (e.g., Bogner & Dahlke, 2022; Onyeali et al., 2023; Urmeter et al., 2018; Wilke et al., 2021).

One of the central issues with such a narrow biotechnology or biomass-based understanding of CBEs is that they frequently correspond to (very) weak sustainability approaches (e.g., Chaminade, 2020; Vivien et al., 2019) and thus run the danger of aggravating existing unsustainable and unjust practices (see, e.g., various contributions in Backhouse et al., 2021; see also Häyry & Laihonen, 2024). The issues range from extractivist tendencies (e.g., Backhouse et al., 2022; Holz, 2023) to the unjust distribution of burdens and benefits and the outright exclusion of stakeholders (e.g., Bastos Lima, 2022; Holmgren et al., 2022). Unsurprisingly, therefore, current bioeconomy policies risk aggravating polarization and socio-ecological conflicts in rural regions, as observed in Europe (Friedrich et al., 2023). This starkly contrasts with the explicit aim of the European Commission's bioeconomy strategy to spur a "rural renaissance" (European Commission, 2018; Friedrich et al., 2023).

In our view, the contestation and exclusion of stakeholders in the design of CBE policies and innovations—especially in conjunction with an unjust distribution of benefits and risks—underscore the importance of the normative dimension of the CBE as a whole and of bioeconomic innovation design in particular (see also Hausknost et al., 2017, on a related note). This includes questions of directionality, responsibility, and legitimacy, as well as the associated issues of participation and inclusion (e.g., Andersen & Johnson, 2015; Andersson et al., 2021; Bryden et al., 2017; George et al., 2019; Parks, 2022; Schlaile et al., 2017; Tartaruga et al., 2024; Villalba Morales et al., 2023). Several studies discuss and elucidate how (circular) bioeconomy policies and strategy papers were designed at the national or extra-national<sup>2</sup> level, who participated in their design, and how bioeconomy coalitions emerged (e.g., Bogner & Dahlke, 2022; Holmgren et al., 2022; Lühmann & Vogelpohl, 2023; Starke et al., 2023). These policy strategies frequently emphasize their regional development potential, especially for peripheral and rural regions. For example, the European Commission highlights the potential of the "blue bioeconomy" for the Baltic Sea region, how the Common Agricultural Policy (CAP) is being mobilized for inclusive rural development, and how the bioeconomy has emerged as a topic in smart specialization policies (European Commission, 2018). However, we observe a paucity of discussions about normative issues of CBE transitions at the regional level (although they slowly seem to gain attention, see, e.g., Morales, 2021; Morales & Dahlström, 2023), where the CBE is enacted through bioeconomic activity and innovation design in both novel and existing innovation systems governed by regional and regionally focused policies and strategies (see also Albrecht, 2019; Haarich & Kirchmayr-Novak, 2022; Mubareka et al., 2023; Wohlfahrt et al., 2019, on that note). A large body of research in

<sup>2</sup> By extra-national we mean all types of policy design beyond national borders, which includes supranational and other international levels of governance.

economic geography (e.g., Asheim, 2007; Asheim & Gertler, 2006; Cooke et al., 2005; Isaksen et al., 2022; Rutten & Boekema, 2007) has shown that analysis at the regional level is particularly relevant because innovations are frequently developed in a place-based manner through local (formal and informal) networks, institutions, and assets, among others (e.g., Boschma, 2023; Foray, 2023; and references therein). Although recent analyses of innovation systems suggest that globalization has encouraged innovation to be designed in global networks and via strategic coupling (Binz & Truffer, 2017; Jurowetzki et al., 2018), this trend may be somewhat counteracted in the case of CBE innovation: Because CBE innovation activities build upon the regional availability of resources and waste streams while aiming for the closing of regional cycles (Muscat et al., 2021), they often follow *regionality* as an organization principle. Research on regional CBE transitions emphasizes that these transition processes could alter and reconfigure regional innovation networks by changing the roles and responsibilities of actors and creating new learning opportunities beyond existing techno-economic knowledge (Martin et al., 2023). Moreover, regional characteristics can also be expected to play an important role in the endeavors of bioeconomy actors and their networks to affect and transform institutions—in the sense of “institutional work” (Wilde & Hermans, 2024).

CBE activities presuppose the existence of biophysical resources and funds at the regional level, and they alter existing *socio-metabolic flows* (Marty et al., 2022; Giampietro, 2019).<sup>3</sup> Research and policy have somewhat neglected this regional socio-ecological embeddedness of CBE activities and regional governance (Marty et al., 2022), raising questions about the legitimacy of CBE activities (e.g., Friedrich et al., 2021; Friedrich et al., 2023; Holz, 2023). This calls for a thorough analysis of the normative dimension (Blok, 2023; Schlaile et al., 2017) of regional innovation processes in a CBE context. Such a thorough analysis particularly entails investigating how issues of responsibility, legitimacy, and directionality are considered and navigated within existing—and newly emerging—regional innovation systems (see also Uyarra et al., 2019).

In this conceptual article, we contribute to addressing this gap by making a threefold case for focusing on the regional dimensions of CBE transitions in connection with the normative dimensions of innovation and transition processes. First, in Section 2, we argue that we need to better understand the regional (un)embeddedness of bioeconomic innovation design, both from (2.1) a socio-ecological perspective of socio-metabolic flows and (2.2) within (regional) innovation systems by focusing on the actors, networks, assets, and knowledge flows that fuel bioeconomic innovation systems. In a second step (in Section 3), we argue that such an approach yields insights into regional injustices, aspects of inclusion/exclusion, and legitimacy that are both reproduced in the (epistemic and technological design of) bioeconomic innovations and result from their design and implementation at the regional level. Finally, in Section 4, we propose four selected (governance) pathways towards *more just and responsible* regional innovation and transition design to facilitate the CBE’s inclusivity and regional legitimization. We conclude in Section 5, acknowledge limitations, and provide an outlook on potential avenues for future research.

Before we embark on this conceptual endeavor, however, we would like to stress that we explicitly write “more” just and responsible as we are mindful of the notion that ethical concepts such as justice, responsibility, and sustainability are ideal-typical normative guardrails with different dimensions and inherent normative dynamics and complexities (Schlaile et al., 2017) so that, in reality, the interests and values of stakeholders and perceptions of (in)justice may only be “navigated” (in terms of tensions and trade-offs) but never fully aligned (e.g., Ciplet & Harrison, 2020).

## **2. UNDERSTANDING THE REGIONAL (UN)EMBEDDEDNESS OF BIOECONOMIC INNOVATION**

In this article, we argue that current CBE innovation policy and research approaches have hitherto neglected aspects of socio-ecological dependencies and normativity at the regional level. Thus, to leverage bioeconomic innovation design for more just and responsible CBE transitions, it is crucial to understand an innovation’s regional *(un)embeddedness* both in terms of its (2.1) socio-ecological and

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<sup>3</sup> Socio-metabolic flows encompass the exchange and movement of materials, resources, and energy that “operate and maintain biophysical structures of society, such as buildings, infrastructures or machinery” (Haberl et al., 2019, p. 173).

(2.2) socio-economic entanglements. We use this differentiation in particular to mobilize a socio-ecological perspective. However, 2.1 and 2.2 are not exclusive dimensions of (un)embeddedness; rather, they overlap and intertwine, and socio-economic processes have an inherent metabolic dimension (e.g., Fischer-Kowalski & Haberl, 1998; Pauliuk & Hertwich, 2015). Given our argument and to address the previously underresearched socio-ecological (un)embeddedness, we use this distinction in the remainder of this article. Here, (un)embeddedness should be understood as a continuum rather than a dichotomy between nonembeddedness and embeddedness. We note, however, that the degree of embeddedness is not a specific point along a linear continuum, as there may be multiple different forms, manifestations, and dimensions of (un)embeddedness.

Considering its socio-economic dimension, it can thus refer functionally and relationally to aspects such as *knowledge compatibility* and *concentration* (including well-known issues of dispersion, stickiness, optimal cognitive distance, etc.; e.g., see Graf & Kalthaus, 2023; Nooteboom et al., 2007; Schlaile et al., 2018; Urmetzer et al., 2018; Wanzenböck et al., 2014), *proximity* (e.g., Boschma, 2005; Wilke & Pyka, 2024a,b), and interpersonal relations and *networks* (also in the sense of *social capital*; cf. Cooke et al., 2005; Rutten & Boekema, 2007). Therefore, this socio-economic dimension is mostly connected to two particular strands of literature:

1. The work building on Granovetter's (1985) seminal discussion of embeddedness, which rejects solely rational choice models of economic activity by scrutinizing how economic activity is also embedded in and constrained by social structure(s) (see also Wilde & Hermans, 2024, on a related discussion).
2. The literature on the five dimensions of proximity (cognitive, organizational, social, institutional, and geographical), which was promoted first and foremost by Boschma (2005). Wilke and Pyka (2024a) recently refined these dimensions and demonstrated their relevance in the context of sustainability-oriented innovation networks.

Both strands of literature implicitly and explicitly fuel the concept of RIS (regional innovation systems), within which economic activity is understood as embedded in different forms of regional structures (e.g., social networks, formal and informal institutions, knowledge and financial flows, and other assets and relations) and shaped by the proximity of collaborators and other actors within these networks (e.g., see Asheim et al., 2019, for an introduction to RIS).

However, in our understanding, we explicitly go beyond the socio-economic dimension of (un)embeddedness: Because of the (regional) socio-ecological dependencies and metabolic links of the CBE (e.g., Mubareka et al., 2023; Muscat et al., 2021), we specifically argue for recognizing and accounting for the (*socio-*)*metabolic* (hence, socio-ecological) *dimension* of regional (un)embeddedness (see 2.1). Nevertheless, embeddedness can have multiple meanings and implications, depending on nuances in the different schools of thought. Moreover, the effects of different dimensions of embeddedness on various economic activities and innovation processes are multifaceted and often somewhat ambiguous or contradictory (e.g., see also Heidenreich & Mattes, 2012; Rutten & Boekema, 2007). Such ambiguities also entail difficulties for sustainability-oriented change and economic activity that can emanate from the regional embeddedness of bioclusters (e.g., Hermans, 2021), industries, innovation networks, and policies, especially due to path dependence and lock-in (e.g., Busse et al., 2021; however, see also Martin, 2021; Martin & Sunley, 2010, on the differential, and potentially even enabling, effects of path dependence).

In what follows, we describe the rationale for simultaneously addressing both aspects (2.1 and 2.2) and briefly sketch the potential for a broader understanding of the regional (un)embeddedness of bioeconomic innovation design for more just and responsible CBE transitions. Figure 1 schematically depicts the regional embeddedness of innovation processes for and within a CBE as a multilayered construct where socio-economic embeddedness is explicitly depicted as a proper subset of socio-ecological embeddedness. This depiction accounts for the fact that all CBE activities are also socio-ecological activities in terms of affecting and being affected by metabolism (see 2.1; see also Fischer-Kowalski, 1998; Fischer-Kowalski & Haberl, 1998; Fischer-Kowalski & Hüttler, 1998).

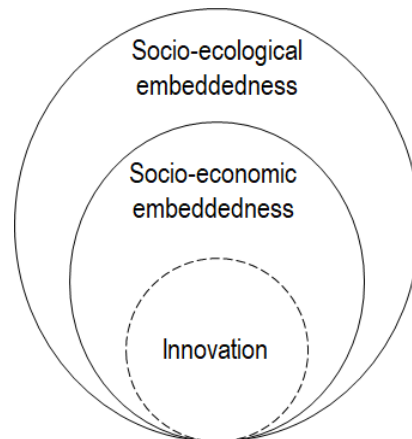


Figure 1: Regional (un)embeddedness of CBE innovation. Source: own representation.

## 2.1 Socio-Ecological (Regional) Embeddedness: Socio-Metabolic Flows of CBE Innovation and Transition Processes

Society–environment interrelations have been conceptualized via their metabolism, and the notion of CBE particularly addresses this metabolic dimension due to its focus on biomass, its potential to substitute for fossil resources, and its ability to close material cycles through circularity. Thus, unlike most other innovation systems, a CBE’s central focus is its effects on and transformation of the “materiality of nature” (Boyer et al., 2023), which is limited by the biophysical availability of bio-based resources (Muscat et al., 2021). In general, *social metabolism* serves as a conceptual lens through which we can explore the complex and coevolutionary interplay between social dynamics and the biophysical foundations of human existence on Earth (e.g., Dorninger et al., 2024; Haberl et al., 2019, 2023; Mubareka et al., 2023). This perspective extends to economic activities, which are inherently intertwined with metabolic relationships with the natural world (*socio-economic metabolism*; see Fischer-Kowalski, 1998; Fischer-Kowalski & Haberl, 1998; Fischer-Kowalski & Hüttler, 1998; Pauliuk & Hertwich, 2015). In this context, the (regional) design of bioeconomic innovation has a distinct metabolic dimension, shaped by specific bioregional flows in social-ecological systems, such as biomass availability or waste streams, as well as their distinct (and socially conditioned) perceptions among stakeholders. Consequently, these resources, their perceived availability, and the perception of “sustainable” biomass treatment form a significant basis for bioeconomic innovations, as innovations both depend on these flows and actively transform them (see also Onyeali et al., 2023, on a related note). The regional availability of these resources emerges as a pivotal factor in the success of bioeconomic activities and the design of innovation, influencing and, in turn, being influenced by regional metabolism. Bioeconomy strategy papers and innovation policies often largely obscure this “materiality of nature” by imagining a decoupling of economic growth from the biophysical basis of bioeconomic activity (Boyer et al., 2023; see also Giampietro, 2019). Notably, this also holds true for the case of the high-tech bioeconomy. Here, the materiality of nature and the place-based origin and spatial embedding of abstract (immaterial) knowledge are obscured in the value-creation process (Birch 2012).

The impact of CBE innovations also extends beyond regional boundaries, affecting various (spatial) scales at multiple levels (see also Wohlfahrt et al., 2019, on a related note). Many of these innovations are rooted in tertiary flows such as “waste” or residues that presuppose primary (e.g., soil) and secondary (e.g., vegetable and human) flows in other regions (Giampietro, 2019), which are connected along value chains and in global production networks. Therefore, adopting a socio-metabolic perspective allows us to gain insights into the (socio-economic) metabolism of regional CBE innovation design, its degree of regional (un)embeddedness, and its broader effects beyond the region. Marty et al. (2022) utilize such a perspective to comprehensively analyze the consequences of changes in regional metabolism during CBE transitions. They emphasize the potential for conflicts, competition, and the restructuring of agricultural metabolism, or conversely, how specific (bioeconomic) practices may reinforce existing

balances by creating additional synergies and circularities within the CBE and regional metabolism.<sup>4</sup> The authors highlight these changes' multi-level impacts and stress the necessity of effective territorial governance mechanisms. These mechanisms facilitate debates on regional developments, recognizing the intricate “glocal” connections of bioeconomic activities within both local and global structures.

In essence, a socio-metabolic perspective on regional CBE innovation design provides valuable additional insights into the convoluted dependence of innovations on existing metabolic configurations within regions. Simultaneously, it sheds light on the implications for various actors relying on these flows for their social and economic activities. This perspective underscores the importance of creating space(s) for shaping and governing the (regional) future (Marty et al., 2022), recognizing the dynamic and (co)evolutionary nature of these socio-metabolic relationships (see also Dorninger et al., 2024; Weisz, 2011; on a related note).

## 2.2 Socio-Ecological (Regional) Embeddedness: Regional Actors, Assets, and Knowledge of Bioeconomic Innovation Design and Transitions

In parallel, many strands of research ranging from economic geography to innovation studies have investigated and highlighted the importance of innovation networks and innovation (eco)systems at various scales (e.g., Asheim et al., 2017; Asheim et al., 2019; Asheim & Gertler, 2006; Breslin et al., 2021; Buchmann & Pyka, 2012; Kanda, 2023; Pyka et al., 2023). Although there is a strong temptation to tell individualistic stories of ingenious inventors and creative entrepreneurs, there is also a robust scholarly consensus that innovation is a multiplayer game: Innovations emerge from complex systems of actors that are linked by coevolutionary relationships involving cooperation and competition for financial flows, knowledge flows, resource and material flows, etc. Many of these processes are known to be highly contingent on particular regions in terms of resource availability, access to financial capital and markets, different types of proximity, cultural and social capital, infrastructure, the regional knowledge base, etc. (e.g., Asheim et al., 2019; Boschma, 2005, 2023; Chembessi, 2023; Cooke et al., 2005; Fritsch et al., 2019; Fritsch & Wyrwich, 2019; Hassink, 2001; Pyka et al., 2023; Rutten & Boekema, 2007; Stöber et al., 2023; Wilke & Pyka, 2024a,b). For example, research on *innovation biographies* (e.g., Butzin & Widmaier, 2016; Suitner et al., 2023) and RIS (e.g., Asheim et al., 2019; Tartaruga et al., 2024; Tödtling et al., 2022; Tödtling & Trippel, 2018) show that the regional dimension is instrumental for the coevolution and (co-)design of innovations. Given the multiple varieties of bioeconomies (e.g., Urmetzer & Pyka, 2017), RIS (e.g., Zukauskaitė, 2018), bioclusters (e.g., Hermans, 2021), and CBE sectors (e.g., Biber-Freudenberger et al., 2020), we regard the regional (un)embeddedness of innovation processes as central both in research and in the design of policy interventions—especially for circularity, as this requires (regional) cooperation along (novel) value chains (e.g., Tapia et al., 2021).

Despite advances in research on RIS and a recent normative turn in innovation studies more broadly (e.g., Daimer et al., 2012; Kattel & Mazzucato, 2023; Lindner et al., 2016; Schlaile et al., 2017; Sjøtun & Njøs, 2019; Uyarra et al., 2019; Tartaruga et al., 2024), socio-economic aspects and the regional and cultural contingency of the normative dimension still are underresearched (particularly in the CBE literature) in comparison to techno-economic aspects. Hence, such socio-economic aspects also run the danger of being underestimated in CBE research, policy, and practice, for instance, concerning the cultural evolution of different worldviews and the related normative and transformative knowledge to be taken up in CBE transitions (e.g., Schlaile et al., 2022; Urmetzer et al., 2018, 2020, 2022).

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<sup>4</sup> Marty et al. (2022) underline how the introduction of biogas plants in Aube (France) has several metabolic links (and competition for resources) because it requires inputs that were previously used for other purposes (e.g., pressed sugar beet pulp that was used for alfalfa production is now used as a biogas input). They emphasize that the metabolic links of bioeconomy development exist through entanglements along value chains and that they affect resources and flows in the Aube region. As a future scenario (only briefly outlined here), they illustrate how the further development of biogas plants could lead to a focus on crop specialization, a focus on energy crops instead of food crops (both of which have negative regional metabolic links in terms of regional funds), and the import of biomass, which would also affect the metabolism of other regions. In contrast to this rather negative scenario, they emphasize how sheep farming could increase the regional availability of nutrients and reduce the use of pesticides.

In general, despite the persistence of the (in)famous “linear model” (e.g., Godin, 2006, 2014), innovation has never been a “one-way street” where incumbent innovation system actors merely create, use, and diffuse knowledge and thus “produce” innovations. Hence, in the context of CBE transitions, bioeconomic innovations can emerge from existing RIS<sup>5</sup>, but they can also be the outcome of novel innovation systems that may even (need to) challenge and disrupt existing RIS (e.g., Martin et al., 2023, describe how CBE transitions can alter existing RIS). This issue also relates to questions of strategic management regarding the *exploitation vs. exploration* (e.g., March, 1991) of knowledge that is deemed relevant in the context of a CBE as well as the *exnovation* and “unmaking” of both institutions and knowledge (e.g., Feola et al., 2021; Ziegler, 2020, 2023) that are deemed irrelevant for—or even detrimental to—transitions towards a sustainable CBE. In this regard, one important question for CBE transition researchers and policy-makers is whether existing RIS with established actor constellations, roles, responsibilities, and power relations will be upheld due to lock-in and path dependence (see also Busse et al., 2021; Harrahill et al., 2023, Martin, 2021; Martin & Sunley, 2010, on related discussions) or whether new actors, altered actor roles and responsibilities, knowledge, assets, institutions, and infrastructure break the path and create new *dedicated* or *challenge-oriented* RIS (Isaksen et al., 2022; Pyka, 2017; Schlaile et al., 2017, 2021, 2022; Tödtling et al., 2022; Tripl, 2023; Tripl et al., 2024). In any case, CBE innovations exhibit strong feedback from multiple regional systems (e.g., see also Albrecht, 2019). Moreover, if an innovation system’s directionality is solely focused on addressing economic interests within the broader imperative of economic growth and a linear notion of development, social and ecological issues are frequently outside of the dominant paradigm and, thus, are downplayed or neglected (e.g., Friedrich et al., 2021; Friedrich, Najork et al. 2022; Schlaile et al., 2017). Therefore, it is crucial to understand which actors, knowledge, assets, formal and informal institutional arrangements, and infrastructure constitute and are impacted by the design of bioeconomic innovations at the regional level to unveil the connections between regional (un)embeddedness and (in)justice in CBE transitions. Ultimately, this augmented understanding may facilitate a paradigm shift towards more holistically addressing sustainability challenges beyond the economic dimension.<sup>6</sup>

In the following section, we further elaborate on these aspects and highlight their implications for a more just and responsible design of CBE innovation and transition processes.

### 3. A PERSPECTIVE ON REGIONAL INJUSTICES AND (POTENTIAL) DARK SIDES OF BIOECONOMIC INNOVATION DESIGN AND TRANSITIONS

Above, we have touched upon the question of how a focus on socio-metabolic flows and regional actors, institutions, assets, resources, and knowledge flows provides insights into the regional (un)embeddedness of CBE innovations and transitions (see 2.1 and 2.2). However, so we argue, these considerations also allow us to shed more light on regional injustices and the dark sides of the CBE. More precisely, a socio-metabolic perspective allows us to understand the effects of bioeconomic innovations on regional (and extra-regional) metabolism more broadly, as they affect both human and nonhuman actors (e.g., Marty et al., 2022). Accordingly, one can better map the negative outcomes or conflicts (e.g., Bastos Lima, 2022; Friedrich et al., 2023; Ramcilovic-Suominen, 2023), “dark sides” (e.g., Blok & Lemmens, 2015; Coad et al., 2021; Pel et al., 2023), and trade-offs or tensions (e.g., Ciple & Harrison, 2020; Morone et al., 2023) of bioeconomic innovations and transitions, which occur not least due to the changed constitution of and coevolution with regional metabolisms. Moreover, “common sense propositions” regarding the use of nature, biomass, and their “materiality” (e.g., “all bio is sustainable”) can be challenged (Boyer et al., 2023). Indeed, such a lens helps reveal relevant actors and the effects of bioeconomic innovation design—also beyond the regional level—facilitating a more

<sup>5</sup> As, for instance, Boschma (2023) puts it, with reference to the literature on *smart specialization* and *related variety* (e.g., Foray, 2023; Frenken et al., 2007): “Regions tend to diversify into new activities that are closely related to their existing capabilities. Place-specific capabilities condition diversification in which geographical, cognitive, social and institutional proximities enable the transfer of capabilities from existing to new activities” (Boschma, 2023, p. 333).

<sup>6</sup> *Paradigms*, as Meadows (2008, pp. 162-163) puts it, are the “great big unstated assumptions ... or deepest set of beliefs about how the world works.” In that sense, paradigms are closely related to *metaphysics* as they focus “on the conceptual frameworks with which we *generally* deal with reality” (Schramm, 2022, p. 261).

comprehensive understanding of the (evolving) contestation of the CBE on and between different spatial scales. More practically, this perspective could be mobilized to paint a more nuanced picture of the actors that need to be considered in technology assessment or regional (CBE) innovation policies (see below, Section 4).

In addition to the socio-ecological perspective, a focus on the socio-economic aspects that fuel innovation design in RIS can provide insights into the epistemic and normative considerations and blind spots of CBE design processes (see also Häyry & Laihonon, 2024, on a related discussion). In bioeconomic innovation design, an innovation paradigm that exaggerates the role of science, technology, and the “supply side” is perpetuated by a linear and mechanistic understanding of knowledge (and knowledge creation) in techno-economic terms (e.g., Blok, 2021; Bogner & Dahlke, 2022; Friedrich et al., 2021; Onyeali et al., 2023; Urmetzer et al., 2018, 2020; Wilke et al. 2021; Zwart et al., 2024). Arguably, such a conception of knowledge can also be detected in the quest for the quantification of sustainability through indicators and numbers (see Boyer et al., 2023), which often neglects the ambiguous and normative contradictions of sustainability (see also Muller, 2018, on a more general but related argument). After all, “not everything that can be counted counts, and not everything that counts can be counted” (Cameron, 1963, p. 13). The “negative image” of bioeconomic innovation design in RIS, metaphorically speaking, can thus reveal what is being neglected, referring, for example, to the following:

1. Different types and forms of knowledge (such as implicit/tacit knowledge and, in particular, systems knowledge, normative/target knowledge, and transformative knowledge) that are not—or insufficiently—feeding into the innovation process (Urmetzer et al., 2018; see the related notions of *epistemic injustice*; e.g., Fricker, 2007, and *cognitive (in)justice*; e.g., Hall & Tandon, 2017).
2. Regional actors and values or perspectives involved in sustainability discussions that are (un)intentionally excluded (which also relates to issues of *recognition* and *procedural (in)justice*; e.g., Schlosberg, 2007; Young, 1990).
3. The allocation of assets and profits among only a few actors that fuel innovation design capacities (which links to questions of *distributive (in)justice*; see also Deutsch, 1985; Dobson, 1998; Traub & Kittel, 2020).

Nevertheless, given the multiscalar or “glocal” nature of CBE transitions, which frequently depend on and contribute to RIS but are also entangled in both *global* value chains and innovation systems (e.g., Binz & Truffer, 2017; Jurowetzki et al., 2018), it is often impossible in the design of innovations for a CBE to consider all upstream material flows and their stakeholders all over the world, especially at early stages where the consequences of an innovation may not even be foreseeable (cf. “Collingridge dilemma”; Collingridge, 1980; Genus & Stirling, 2018). In this regard, innovation is frequently discussed in terms of risk and uncertainty. However, according to Knight's (1921) seminal distinction between risk and uncertainty, risks can be calculated while uncertainties cannot. We emphasize that CBE innovations exhibit additional uncertainties rather than risks due to multiple metabolic linkages. This issue calls for accepting and embracing uncertainty as an inherent property of innovation processes (see also Pyka, 2014, on a related note), for example, through tentative and adaptive governance approaches that facilitate navigating uncertainties and (unintended) side effects (see, e.g., Weber & Rohracher, 2012; Wiarda et al., 2024; or the edited volume by Scoones & Stirling, 2020). Hence, innovations in the context of CBE transitions not only raise questions of “which” knowledge counts, in the sense of incorporating additional knowledge types and modes of learning and inquiry but also “whose” knowledge counts, in the sense of which actors are and should be involved in the co-creation of innovations and, thus, the joint definition of an innovation system’s directionality (Schlaile et al., 2017; Urmetzer et al., 2018). If these questions are not considered adequately and productively or if they are intentionally ignored, the results can miss opportunities for broader sustainability transitions (see also Vogel et al., 2023, on a related discussion). This includes missed opportunities for exnovation or phase-out and, as a potential consequence, the reproduction of unsustainable and unjust approaches to regional bioeconomy transitions (e.g., Albrecht, 2019) and inequitable power relations (e.g., Harrahill et al., 2023). Moreover, as we know from the literature on responsible (research and) innovation, there is also a greater danger of negative (regional) effects of innovation if the diversity of stakeholders, their knowledge, and their value conflicts/contestation are inadequately considered and addressed (e.g., Blok, 2023; Hoes et al., 2021; Owen et al., 2012; Stilgoe et al., 2013; von Schomberg, 2013; Zwart et al.,



2024). Relatedly, stakeholders' values or ethical concerns (such as perceived risks and vulnerabilities) frequently play a decisive role in the market acceptance and societal acceptability of CBE innovations (see also Bunker & Zscheischler, 2023; Zscheischler et al., 2022).

In essence, therefore, a perspective on both socio-ecological and socio-economic (un)embeddedness of regional CBE innovation facilitates mapping and understanding the following aspects and implications for more just and responsible CBE transitions: (i) actors relevant in the design of innovations (including change agents and intermediaries); (ii) relevant knowledge types, resources, assets, and capacities for regional change; (iii) (unintended side-) effects of innovations on other industries, natural systems, and different types of actors; and (iv) extra-regional effects on and within socio-metabolic flows, value chains, and global production networks.

That said, how can these aspects be mobilized in research on CBE innovations, transitions, and governance? Below, we sketch four facets that build upon and extend recent arguments in the literature on challenge-oriented and dedicated innovation systems, sustainability transitions, and innovation policy.

#### **4. FOUR FACETS OF RESEARCHING AND GOVERNING REGIONALLY JUST AND RESPONSIBLE CBES**

The sustainability challenges we face and, by extension, the resultant transitions of socio-technical systems and innovation systems are marked by “wickedness” (Andersson & Törnberg, 2018; Rittel & Webber 1973; Schlaile et al., 2017; Urmetzer et al., 2018). Put simply, this means that problems and solutions are characterized by normative ambiguity/contestability (e.g., due to value conflicts), complexity, and uncertainty (Waddock, 2023; Wanzenböck et al., 2020). Given this wickedness, it is unsurprising that discourses on regional sustainability transitions (including CBE) reflect contested narratives, (normative) framings, and sociotechnical imaginaries, as already mentioned in the introduction (e.g., see Friedrich, Zscheischler et al., 2022; Leipold et al., 2023). Therefore, to embrace this wickedness and due to the associated political nature of transformation processes (e.g., see Patterson et al., 2017), the design and governance processes for both CBE innovations and transitions need to become more just and transdisciplinary<sup>7</sup> (e.g., Friedrich et al., 2021; Friedrich, Najork et al., 2022; Wiarda et al., 2024). In general, there are numerous ideas for and approaches to making the design of innovations, technologies, and transitions more just and inclusive (e.g., Bryden et al., 2017; Costanza-Chock, 2020; Herwix et al., 2022; Klingler-Vidra et al., 2022; Morena et al., 2020; Purvis et al., 2023; Stilgoe et al., 2013; Ziegler, 2020). In the following (sub)sections, we aim to contribute to this body of research by outlining facets of governing more just and responsible regional CBE innovation and transition processes (see also Figure 2 below for a schematic overview and summary of this section). Arguably, these facets are selective, and we do not want to create the impression that we are proposing a universally applicable “blueprint”. Nevertheless, our suggestions are based on the discussion in the previous sections and the following line of argument, which is derived from a narrative literature review and some of our own previous publications:

First, we share the view that changing a paradigm and the respective worldview can be an important lever for systemic changes in general (e.g., Abson et al., 2017; Meadows, 2008; Schlaile et al., 2017, 2022), which, consequently, also holds for the governance of and research on sustainability transitions aimed at creating more just and sustainable CBES. In our case, we contribute to such changes by offering a novel lens that complements the RIS framework—through which regional innovation processes can be analyzed and governed (see below, subsection 4.1). This aligns with recent propositions on dedicated innovation systems and challenge-oriented RIS. In doing so, we propose basic conditions for an epistemic lens through which regional CBE transitions can be designed and governed in more just and responsible ways.

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<sup>7</sup> We only make a very brief case here for the need for transdisciplinary research that is better able to tackle the “wickedness” of problems and account for different forms of knowledge. We will not discuss this in detail within this article but refer to the literature on the topic (e.g., Lang et al., 2012; Jahn et al., 2012; Pohl et al., 2017; Zscheischler & Rogga, 2015; Zscheischler, 2021).

Second, transformations and transitions<sup>8</sup> are inherently political, have different (even redistributive) effects on people and nature, and are based on conflicting values, normative orientations, and directionalities (e.g., Patterson et al., 2017; Schlaile et al., 2017; Schlaile & Urmetzer, 2021; Vogel et al., 2023). Because of this political nature, governance aspects become a crucial issue when aiming at steering these complex processes, especially since the legitimacy for creating or shaping directionality is not self-evident in such multi-level governance contexts that transcend the authority of national governments (e.g., Patterson et al., 2017; Schlaile & Urmetzer, 2021; Weber & Rohrer, 2012). Therefore, complementing the RIS framework to account for and address wicked problems (subsection 4.1) also implies and calls for transforming governance regimes (see also Patterson et al., 2017). We follow this call by sketching potential pathways towards more just and responsible CBE governance. We focus on three aspects of governance (see subsections 4.2, 4.3, and 4.4 below) that accompany and influence CBE transitions:

1. Subsection 4.2 focuses on the role of regional innovation policies (especially since regional policies frequently draw upon the RIS framework, e.g., see Asheim et al., 2020) and the consequences of an explicit normative reorientation for (regionally) transformative CBE innovation policies. This discussion is relevant because the issue of directionality in the context of multi-level governance is far from straightforward (e.g., Parks, 2022). Moreover, CBE policies frequently strive for decarbonization and defossilization, which warrants more attention to the interplay of innovation and exnovation (policies).
2. Bioeconomy and circular economy strategy papers at the national level impact (regional) innovation design (e.g., Bogner and Dahlke, 2022). As our focus lies on more just and responsible CBE transitions and innovations, in subsection 4.3, we follow the long-standing arguments for more procedural and recognition justice and the related calls for more inclusive and participatory CBE policies that involve more relevant stakeholders and more “dedicated” knowledge types (e.g., Purvis et al., 2023; Urmetzer et al., 2018).
3. In subsection 4.4, we complement these two previous aspects by outlining how installing dedicated intermediary organizations can create the conditions for more just (especially recognition and procedural justice) and non-state governance of horizontal arrangements of actors within the region (the relevance of diverse governance forms has also been raised in the context of *transformative capacity*; see Wolfram, 2016).

As all of these propositions create additional complexities and potential trade-offs that cannot be fully addressed within the limited space of this article, we also acknowledge some (again, non-exhaustive) challenges arising from each of these propositions, which we briefly reflect in our concluding Section 5. Despite these limitations and additional challenges, we aim to give readers a novel perspective and fruitful starting points for contributing to more just and responsible CBEs. Once more, we would like to acknowledge that the following propositions are intended to provide a foundation for further theoretical and empirical work and that there are, of course, other relevant ideas and approaches to ensuring or facilitating just transitions and transformations (e.g., see Bennett et al., 2019; European Environment Agency, 2024; McCauley & Heffron, 2018; Stevis, 2023; Swilling, 2020; Upham et al., 2022). We explicitly invite colleagues and other CBE enthusiasts to engage with us in a fruitful dialogue on these points, critically scrutinize their empirical relevance, and develop them further to identify auxiliary interventions.

#### **4.1 Complementing RIS as an Analytical Framework to Study Regional Innovation Processes**

Innovation systems have been mostly conceptualized as inter-organizational networks through which innovations are created and where innovation is implicitly regarded as something both new and good *per se* (e.g., Schlaile et al., 2017). Only recently have normative issues, major societal challenges, and

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<sup>8</sup> Note that, in this section, we distinguish transitions from transformations in that the former mostly refer to systemic changes in socio-technical systems, while the latter encompass various other forms of fundamental socio-political and socio-ecological change (Hölscher et al., 2017). Nevertheless, transitions and transformations are not perfectly distinct notions, nor are they mutually exclusive, and conceptual nuances and differences may also result from different intellectual histories and scholarly communities (Hölscher et al., 2017; see also Schlaile & Urmetzer, 2021).

how to address them gained increasing interest in the RIS literature (e.g., Isaksen et al., 2022; Rehfeld, 2019; Tödting et al., 2022; Tödting & Tripl, 2018; Tripl, 2023; Uyarra et al., 2019). Various questions remain about how transformative knowledge and different stakeholders can both feed into and co-design the directionality, responsibility, and legitimacy of RIS (cf. Schlaile et al., 2017; Uyarra et al., 2019) and, thus, the trajectories of regional CBE transitions. However, to create the conditions for regionally just and responsible innovation processes, the actors and knowledge that fuel the design of innovations must be pluralized (as already highlighted by Warnke et al., 2016, in a more general context), and the notion of RIS must be conceptually complemented (see also Isaksen et al., 2022) to more adequately account for both dimensions (see above 2.1 and 2.2) of regional (un)embeddedness (see Table 1 for a juxtaposition).

Moreover, the transition towards a CBE either implicitly or explicitly aims at the decarbonization and defossilization of the economy. While national and regional bioeconomy policies and strategies have much in common with (and arguably require) innovation policy (e.g., Bogner & Dahlke, 2022), the sustainability-oriented aims of decarbonization and defossilization imply that exnovation and an active destabilization or phase-out of fossil fuel regimes are also necessary elements of CBE transitions and their governance—as has been similarly argued in the context of renewable energy transitions (e.g., Davidson, 2019). Hence, we argue for a novel perspective on the design of CBE innovation in networks, one that also includes viewing RIS as regional exnovation systems (see also Tripl et al., 2024, on a related note) and that also explicitly accounts for social innovations (e.g., Wittmayer et al., 2024), social entrepreneurship (especially in the context of network governance and network orchestration; see Busch & Barkema, 2019), and systems entrepreneurship (Schlaile et al., 2021). This perspective, we argue, could help to consider (ex)innovations<sup>9</sup> in regional networks not only along existing (informal) networks and knowledge flows but also with regard to the socio-metabolic links and coevolutionary interactions within regions, among different RIS actors, and between various other socio-economic and socio-ecological (sub)systems (e.g., Almudi & Fatas-Villafranca, 2018, 2022; Breslin et al., 2021; Fritsch et al., 2019; Weisz, 2011). These configurations may be neglected in monolithic views of bioeconomy networks (see also Eversberg, Holz, et al., 2023, on a related note). In addition, such a perspective can reveal the types of knowledge, values, and actors whose voices are currently neglected but could form a valuable knowledge base for transformative ideas while being affected by CBE transitions (e.g., local environmental NGOs, farmers, local transition initiatives, currently neglected academic disciplines). As CBE activities already alter the constitution of existing RIS in terms of actors' roles and responsibilities (e.g., Martin et al., 2023), this will ultimately also affect the focus on problems and solutions within RIS. Solving these problems involves a heterogeneity of actors, new actor roles, and responsibilities other than those that are (conventionally) part of the RIS (see Table 1).

Therefore, we propose mapping actors (roles) and knowledge flows within existing bioeconomic innovation networks (which could be conceived as the “conventional way”) in combination with actors affected by the changed regional metabolic configuration and actors relevant to sustainability discourses in general in the respective region. This can provide both novel and broader perspectives on the regional (ex)innovation network (including heterogeneity of actors and types of knowledge), both transformational and missed opportunities, and potential *boundary objects*<sup>10</sup> through which regional change processes could be governed. Table 1 displays this conceptual complementation of RIS through additional components.

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<sup>9</sup> By (ex)innovation, we mean both innovation and exnovation in the sense of a processual openness of the result of RIS.

<sup>10</sup> With the term boundary objects, we want to stress the importance of translation between different social worlds. We understand boundary objects as “both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation” (Star & Griesemer, 1989, p. 393).

Table 1. Comparison of “Conventional” RIS and Dedicated/Challenge-Oriented RIS for Just & Responsible CBEs (Source: own compilation based particularly on Asheim, 2007; Asheim et al., 2016; Isaksen et al., 2022; Meadows 2008; Schlaile et al., 2021)

“Conventional” RIS	Dedicated/Challenge-oriented RIS (for more just & responsible CBEs)
<p>Elements:</p> <ul style="list-style-type: none"> <li>● actors (firms, universities, policy-makers, innovation intermediaries)</li> <li>● resources (including assets, infrastructures)</li> </ul> <p>Interconnections (and constraints):</p> <ul style="list-style-type: none"> <li>● institutions (e.g., informal/formal rules and norms, regulations, legal frameworks)</li> <li>● knowledge flows (analytical, synthetic, symbolic)</li> <li>● financial flows (capital, assets)</li> </ul> <p>Purpose/function (depending on use as either <i>ex post</i> analytical framework or <i>ex ante</i> policy approach): scientific understanding of regional innovation (<i>ex post</i>) vs. leveraging innovation for regional development, growth, competition (<i>ex ante</i>)</p>	<p>Elements:</p> <ul style="list-style-type: none"> <li>● actors (firms, universities, policy-makers, innovation intermediaries)</li> <li>● inclusive actors (transition initiatives, farmers, local environmental NGOs, dedicated intermediary organizations)</li> <li>● resources (including assets, infrastructures)</li> <li>● bioregional/biophysical resources (in social-ecological systems)</li> </ul> <p>Interconnections (and constraints):</p> <ul style="list-style-type: none"> <li>● institutions (e.g., informal/formal rules and norms, regulations, legal frameworks)</li> <li>● knowledge flows (analytical, synthetic, symbolic)</li> <li>● financial flows (capital, assets)</li> <li>● (dedicated) transition knowledge flows (systems knowledge, normative knowledge, transformative knowledge)</li> <li>● regional metabolism and metabolic links</li> <li>● (just) distribution of resources/biophysical flows</li> </ul> <p>Purpose/function (depending on use as either <i>ex post</i> analytical framework or <i>ex ante</i> policy approach): better understanding (from multiple relevant perspectives beyond academia) and governing the just and responsible design of innovations and exnovations for sustainability transitions towards a CBE to better address wicked problems</p>

## 4.2 Adaptation of RIS as a Directional Innovation Policy Approach to Regional Governance

The RIS framework is not only used as a conceptual lens to study regional innovation processes (see above, subsection 4.1) but also frequently mobilized as a policy approach to regional innovation policy (e.g., Asheim et al., 2016, 2020; Uyarra et al., 2019). In our view, against the background of more just and responsible sustainability transitions, the conceptual complement of RIS (see 4.1) must also be reflected in an adaptation of its use as a policy approach. Innovation policies generally draw on a wide range of policy measures and policy mixes to create incentives and fruitful conditions for innovation development and sustainability transitions (e.g., Kern et al., 2019; Kivimaa & Kern, 2016). This is also the case for regional innovation policy (e.g., Pyka et al., 2019; Sjøtun & Njøs, 2019; Uyarra et al., 2019). However, given the potential “dark sides” of innovations and the necessity of phasing out and

destabilizing existing fossil regimes (see Section 3 above), we make a case for regional and place-based CBE policies that incentivize both innovation and exnovation—in line with the discussion on creative vs. destructive policies (Kivimaa & Kern, 2016; see also Ziegler, 2023). Such policies facilitate path creation for dealing responsibly and responsively with biomass, for example, and path destruction for merely growth-oriented policies or, for that matter, currently dominant science, technology, and innovation policies that often feed into bioeconomy policies instead of more transformative ones (Bogner & Dahlke, 2022). In the latter regard, current ideas and approaches from *mission-oriented innovation policy* (e.g., Janssen et al., 2021; Kattel & Mazzucato, 2023) and *transformative innovation policy* (e.g., Schot & Steinmueller, 2018; Haddad et al., 2022, for a systematic review) may be utilized for both regional and national CBE policies (see also Isaksen et al., 2022). Accordingly, such a regional innovation policy approach could open the horizon of possibilities beyond the continuation of unsustainable modes of production and consumption. It could also incentivize different scaling mechanisms for bioeconomic innovation design, biomass extraction, and natural resource use. This involves, among other things, providing normative guardrails and funding options for responsible biomass use and the inclusion of a heterogeneous set of actors in technology assessments to anticipate, govern, and navigate unintended side effects (e.g., Purvis et al., 2023; Zscheischler et al., 2022, on a related note) and change metabolic configurations as early as possible. Arguably, such an approach would transcend a solely techno-economic understanding of knowledge and oscillate between different types of knowledge, thus opening space for innovations beyond technology (e.g., creating and recognizing opportunities for social innovation and social and systems entrepreneurship contingent on regional problems and contested solutions). Although this may provide a novel approach to regional innovation policy, one could argue that current CBE policies implicitly or explicitly follow a “mission-oriented” policy approach. This points to questions of how missions are and should be defined and operationalized to account for dimensions of (in)justice and questions of responsibility, which we strive for below (4.3).

### **4.3 More Inclusive and Deliberative Design of Regional Policies for Just and Responsible CBE Transitions**

More than a decade ago, McCormick and Kautto (2013) concluded: “As there are so many issues, trade-offs and decisions to be made on the design and development of the bioeconomy, a commitment to participatory governance that engages the general public and key stakeholders ... appears vital” (p. 2603). Although the CBE and socio-ecological pathways are more generally contested at both the regional and national levels, this is (still) often not represented in policy design for the CBE (e.g., Eversberg & Fritz, 2022). Research shows that bioeconomy policies at the (extra-)national level have mostly been designed exclusively by specific actors from science, economy, and politics<sup>11</sup> (e.g., Holmgren et al., 2022; Lühmann & Vogelwohl, 2023). On the one hand, this calls into question the legitimacy of these policies at the national level, while their differential effects at the regional level (e.g., in terms of shaping innovation) consequently also raise questions of legitimacy specific to regional needs.<sup>12</sup> On the other hand, we may assume that exclusivity is also true for the design of regional CBE policies since there is a lack of research analyzing regional strategies, which is particularly problematic since CBE transitions change and coevolve with regional metabolisms and, accordingly, must be regionally governed (see, e.g., Albrecht, 2019; Marty et al., 2022; Mubareka et al., 2023). We can thus regard contemporary regional CBE policy design as mostly exclusive to a few actors, which also

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<sup>11</sup> In Germany, this meant that a select list of actors from universities in combination with economic actors such as RWE and BASF formed the original Bioeconomy Council, which developed the Bioeconomy Strategy together with the Federal Ministries of Education and Research and of Food and Agriculture, while excluding the general public, NGOs, and regional councils such as the “Länder” (see Lühmann and Vogelwohl, 2023).

<sup>12</sup> In a review on the geography of environmental innovation, Losacker et al. (2023) point out how national (environmental) policies affect regionally heterogeneous innovation development and diffusion. One example where this gets tangible is the German Fertilizer Ordinance, which is considered a bioeconomy policy (see BMBF & BMEL, 2020). It regulates the amount of manure and mineral fertilizers that farmers can apply to their fields. As a result, regions with intensive livestock production and higher amounts of manure are particularly affected by this regulation, which particularly provokes bioeconomy innovation activities in these regions (e.g., Friedrich et al., 2021; Friedrich, Najork et al., 2022).

influences how the RIS framework is mobilized as a regional innovation policy approach (see also above, subsection 4.2). Therefore, an inclusive regional policy design must take into account the tensions and plurality of actors and knowledge types, for example, building on the principles of *shared power and shared responsibility* (Rau, 2023; Young, 2011; see also Purvis et al., 2023, on a related discussion). In particular, integrating a plurality of knowledge types, such as systems knowledge, normative knowledge, and transformative knowledge (Abson et al., 2014; Bogner & Dahlke, 2022; ProClim-, 1997; Urmetzer et al., 2018), would pave the way for more inclusive CBE policy. However, as these three types of knowledge are often highly implicit/tacit and generated by a variety of regional stakeholders—not just businesses, policy-makers, or scientific research—a multitude of actors and their ideas, visions, and narratives are relevant to an inclusive CBE policy design and mission-orientation (Purvis et al., 2023; Urmetzer et al., 2018). Consequently, these different perceptions, opinions, and perspectives require communication, mediation, and navigation costs in governance, and they necessitate navigating the power asymmetries, tensions, normative aspects, regional challenges, and metabolisms in a more just and responsible way than currently done (see below, subsection 4.4).

We propose that including more relevant actors<sup>13</sup> in transition and policy processes and the focus on normative issues, regional challenges, and both innovation and exnovation opportunities will ultimately lead to a more nuanced perspective on the pluralized yet contested landscape of actors and perceptions. Therefore, we see the need for appropriate governance mechanisms that go beyond regional innovation policy design (in line with the requirements of *polycentric governance*; cf. Ostrom, 2010) and support more inclusive processes despite political uncertainties and policy changes (see below, 4.4).

#### 4.4 Complementing Regional Transition Governance through Dedicated Intermediary Organizations

The challenges that arise from these polycentric and multi-level governance aspects of CBE transitions, the multiplicity of horizontal stakeholders, and the politics of transformations (Patterson et al., 2017) point to the need for a complementary form of socially embedded governance (e.g., Purvis et al., 2023; Wolfram, 2016). Therefore, we advocate for the active establishment of intermediary CBE transition organizations and platforms dedicated to facilitating more just and responsible CBE governance at the regional level (cf. *system intermediaries*, Kivimaa et al., 2019; or the related notions of *systems entrepreneurs*, Schlaile et al., 2021; or *transformation catalysts*, Waddock, 2023). These dedicated intermediaries, as understood here, differ from those usually emphasized in the (conventional) RIS literature—such as labor unions, universities, or more general organizations and actors that facilitate innovation and coordinate knowledge flows within these networks (e.g., Mattes et al. 2015; Lepore, 2023; Warnke et al., 2016). Although arguably having certain commonalities, they also go beyond those intermediaries emerging from public procurement processes in the circular economy (Vanacore et al., 2023) or those discussed in the context of the high-tech bioeconomy (e.g., Watkins et al., 2023; Holland et al., 2024). Dedicated intermediaries can be described as organizations moderating, navigating, and mediating different narratives of change against the background of inclusion (e.g., Dobroć et al., 2023), thereby counterbalancing existing power asymmetries that risk leading to a cooptation of these processes by powerful actors (e.g., Morales & Dahlström, 2023). They can thus *catalyze*, *moderate*, and *mediate* regional CBE transitions and the contested narratives about bioeconomy (e.g., Friedrich, Zscheischler et al. 2022) and circular economy (e.g., Leipold et al., 2023). Hence, dedicated intermediary organizations can support RIS actors in discussing and ideally aligning their different narratives of change, that is, individual understandings of (regional) sustainability transitions debates (Dobroć et al., 2023), thereby improving both epistemic and recognition justice.

It is important for a dedicated intermediary organization's (local) legitimacy to be recognized by other RIS actors as independent (e.g., not directly affiliated with or primarily funded by one political

<sup>13</sup> Relevant actors are those stakeholders affected by and with an influence on both the problem definition and the solution attempts to wicked problems offered by CBE innovations. This comprises actors having socio-metabolic relationships that are being affected by CBE transitions (e.g., farmers) and actors having contested perceptions of problems that are being altered by CBEs (e.g., transition initiatives, NGOs).

party, industry, etc.) and to exhibit a secure legal structure, a transparent mission<sup>14</sup> (e.g., to uphold the common good and the proliferation of transitions), and secure funding that overrides conflicts of interest and is sustained across electoral cycles and legislative periods. They can either be specifically established (Kivimaa et al., 2019) or emerge from an ongoing transition process, such as *dedicated grassroots actors* (Mendoza Barajas, 2022). Dobroć et al. (2023) show how such (dedicated) intermediaries can be central navigators in the context of an inclusive design of (socio-technical) future visions. Therefore, we propose that they can support the catalysis, moderation, mediation, and, ultimately, navigation of actors, knowledge, interests, narratives, worldviews, and metabolic configurations of CBE transitions. These organizations can offer spaces where place-specific and contextual narratives can be discussed, meta-narratives for change can be developed, and contested framings of wicked problems and transitions can be conveyed in common transition directionalities (see also Waddock, 2023, on a closely related discussion). This includes creating a chain of commitments (Schlaile et al., 2021) to promote common normative guardrails of CBE transitions or jointly developing principles for the just design of regional CBE transitions (e.g., see Costanza-Chock, 2020 on *general just design principles*).

Although the practical guidance on how such dedicated intermediary organizations might take shape must remain an avenue for future research, we would like to briefly reflect on particularly important characteristics of these actors against the backdrop of their regional (un)embeddedness. Given the heterogeneous group of RIS actors that such an organization must navigate, a multidisciplinary background may be key (as also found by Urmetzer et al., 2020, in their analysis of bioeconomy study programs). This adds to the knowledge of regional socio-economic embeddedness in terms of historical processes and transitions (conflicts), networks, power dynamics, and the modes of communication particular to the place (e.g., colloquial language, dialects, implicit taboos, etc.), which may be key to navigating competing regional directionalities. On a related note, and due to the complex coevolutionary relationships between nature and culture (e.g., Weisz, 2011; Schlaile et al., 2022), it seems crucial that dedicated intermediaries are embedded and well-versed in regional cultural ideas, traditions, habits, and myths (e.g., Onyeali et al., 2023; Waddock, 2023). As mentioned above, these actors must also walk a fine line between cultural embeddedness and being perceived as independent to increase their legitimacy (as also emphasized by Mendoza Barajas, 2022). Finally, these actors work towards the proliferation of knowledge exchange and the navigation of contestation, conflict, and competing normative visions and statements of what ought (not) to be. Therefore, they can only *create the conditions for the emergence* of more just and responsible CBE transitions but *cannot actively steer or operationalize* such transitions. We urge our readers to take this as a starting point for delving deeper into practical translations, potentials, and pitfalls, critically scrutinizing our propositions with empirical and place-specific realities of dedicated intermediary organizations.<sup>15</sup>

Figure 2 schematically summarizes our discussions and propositions in this section.

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<sup>14</sup> Here, we explicitly avoid using the notion of “challenge orientation” to leave room for the different perceptions of regional sustainability issues that social actors may have and that need to be discussed and/or aligned before common ground or a joint directionality can be found.

<sup>15</sup> While the empirical research and case studies on dedicated intermediary organizations remain an important avenue for future research, related work by Mendoza Barajas (2022) on dedicated (grassroots) actors in Mexico or the work on transition intermediaries in the context of transitions towards low-energy homes in the United Kingdom by Kivimaa and Martiskainen (2018) shows that such organizations can exhibit very diverse characteristics, funding structures, and legal forms (see also Kivimaa & Morgan, 2023).

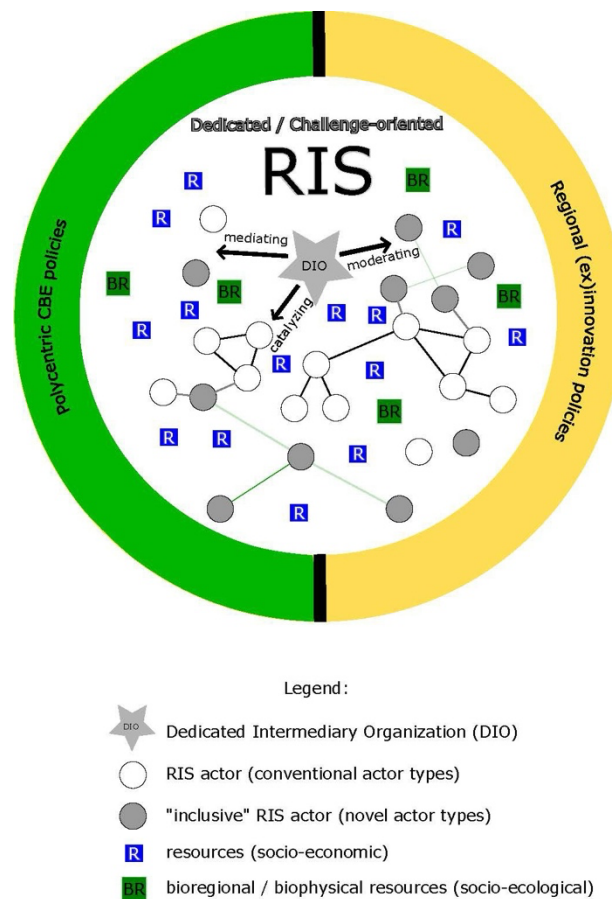


Figure 2: Schematic depiction of Dedicated / Challenge-oriented RIS (and their governance) for more just and responsible regional CBE transitions. Source: own representation

## 5. CONCLUSION: SUMMARY, LIMITATIONS, AND OUTLOOK

In this article, we have outlined how both researchers and policy-makers can focus more on the regional (un)embeddedness of bioeconomic innovations and CBE transitions to better understand regional injustices and govern the inherent complexities and politics of just and responsible CBE transitions. We have argued that the regional (un)embeddedness of bioeconomic innovations can be understood more comprehensively by focusing on socio-ecological dimensions and the socio-economic embedding of innovation processes. Taking these perspectives and questions of regional embeddedness seriously allows us to better understand the ethics of CBE innovations and transitions at the regional level, including different dimensions of justice depicted in aspects such as “dark sides”, issues of exclusivity, and exploitation. Finally, the politics of CBE transitions point to a need for change in terms of governance and research on regional CBE transitions. In this regard, we have outlined four facets of changes in research and governance. More precisely, we have argued for complementing conventional RIS as a conceptual framework and analytical heuristic. This approach facilitates the mapping of diverse actors and knowledge and improves how regional policy-makers can balance destructive and creative regional CBE policies, while being informed by more inclusive governance approaches and a socio-ecological perspective. In doing so, we do not seek to stretch concepts (such as RIS) but rather acknowledge the need for complementing and adapting innovation systems frameworks to meet the challenges of the present (e.g., Schlaile et al., 2017, and references therein), for which the consideration of different normative and transformative forms of knowledge and the socio-ecological embeddedness of innovation processes play important roles. We have further outlined the critical role of dedicated intermediaries as a form of “socially embedded governance” (Wolfram, 2016) in governing horizontal regional CBE transitions. These dedicated intermediary organizations may navigate contesting



(regional) narratives of change and proliferate transformative knowledge. In summary, our article seriously considers the normative dimension of RIS and sustainability transitions (e.g., Schlaile et al., 2017; Urmetzer et al., 2022) by highlighting the importance of focusing more on the regional embeddedness of innovation design to facilitate more just and responsible CBE transitions. Hence, we provide a novel perspective on how to broaden the actors and knowledge relevant to RIS, which can be taken up in policy approaches and as a complementary research concept, especially for emerging CBE transitions and their governance. In addition, we offer a perspective that combines socio-ecological, socio-technical and socio-economic approaches, which is an emerging and promising theme for solution-oriented transitions and economic geography more generally.

Nevertheless, our arguments have some limitations and potential trade-offs that need to be addressed. First, we emphasize that participation should not be seen as a “panacea” for inclusive and just processes, nor should a soft or superficial implementation of the concept be used as a “fig leaf” for justifying the legitimacy of CBE innovations. There is also a risk that (powerful) actors who might actively work against sustainability transitions capture such processes (or even eradicate new possibilities, thereby “emptying the future”; see Friedrich & Tups, 2023), and there are potential trade-offs in terms of accelerating transitions (possibly circumventing democratic decision-making; see Ciplet & Harrison, 2020; Skjølsvold & Coenen, 2021, for in-depth discussions of tensions between urgency/acceleration and inclusion/participation). However, a lack of participation and legitimacy (particularly in the context of phase-out and exnovation processes) can lead to what is currently discussed as “transition pain” (Bogner et al., 2024), which can arguably generate obstacles to accelerating transitions in general. Therefore, ensuring participation and increasing perceived justice in transitions are essential to the successful governance of such transitions. In this context, it is important to consider the role of public administrations, which have to mediate and manage conflicts arising from processes that are perceived as unjust (i.e., relevant actors do not feel heard because their thoughts and values are not taken seriously, which can lead to a reduction in the ambition of policy goals). Therefore, we suggest that policy-makers and CBE researchers must be open but critical about participation given its potential and pitfalls; however, they should not close this avenue *a priori*. In addition, our four facets provide a selective picture that can be included in more elaborate and complementary approaches to regional development and just sustainability transitions. Transformative education, for example, in the context of bioeconomy study programs and curricula (Urmetzer et al., 2020), and other aspects, as outlined in the literature on leverage points (Abson et al., 2017) or transformative capacity (Wolfram, 2016), may well complement our conceptual elaborations. Moreover, CBE transitions may emerge as part of global value chains, global regimes, or global innovation networks and systems (e.g., Binz & Truffer, 2017; Jurowetzki et al., 2018), and we deliberately neglected these (multiscalar) aspects of the CBE by focusing on regional innovation and transition processes and their (un)embeddedness. However, these strands of literature may well inform complementary perspectives on just and responsible CBE transitions in future research. Since we aim to make a conceptual case for the normative dimension of regional CBE transitions and highlight relevant facets of their governance, we use this space to encourage others to scrutinize, complement, and contrast our elaborations based on rich empirical work.

In this sense, future conceptual and empirical research is needed to (simultaneously) address the key issues of directionality, responsibility, and legitimacy (Schlaile et al., 2017; Uyarra et al., 2019) in the context of regional bioeconomic innovations and CBE transitions. Due to the central role of new forms and types of knowledge, one potential avenue (among various others) could be to build on and *extend* research on innovation biographies (Butzin & Widmaier, 2016) to scrutinize the regional (un)embeddedness of bioeconomic innovation design, key actor relationships, and networks beyond “traditional” (and informal) collaborations. For example, this extension may be achieved by explicitly incorporating the analysis of socio-metabolic linkages, possibly yielding insights into transition tensions (e.g., Ciplet & Harrison, 2020). Dedicated and challenge-oriented innovation systems consist of more actors (including actors with metabolic links), different actor roles, and responsibilities than “conventional” innovation systems (Isaksen et al., 2022; Schlaile et al., 2017, 2021; Tödting et al., 2022; Tripl et al., 2024); therefore, new forms of (network) mapping (e.g., inspired by and building on *participatory influence network mapping*; e.g., Sattler, 2022; Schiffer & Hauck, 2010) may be both developed and applied to unveil linkages between different actors that also depict power relations, metabolic linkages, the distribution of contributions and benefits of CBE innovations, and different degrees of inclusiveness or exclusiveness in innovation design. In this respect, transdisciplinary research

processes should be taken up (e.g., see Zscheischler & Rogga, 2015; Zscheischler, 2021) to provide a more holistic understanding of the specific regional challenges, needs, and interests and to deliver “socially robust” (e.g., Nowotny, 2003) normative and transformative knowledge for more just and responsible CBE transitions. This will also allow us to gain a comprehensive picture of the contested nature of the dedicated or challenge-oriented regional (ex)innovation systems through which CBE transitions unfold and to identify points of intervention for tailored policies and dedicated intermediary organizations to accelerate genuine regional and place-based sustainability transitions and the phase-out of unsustainable industries in more just and responsible ways.

## **AUTHOR CONTRIBUTIONS**

**Michael P. Schlaile** (ORCID: 0000-0002-9269-0306) and **Jonathan Friedrich** (ORCID: 0000-0003-2340-6719) contributed equally as lead authors: conceptualization, visualization, writing original draft, review and editing.

**Jana Zscheischler** (ORCID: 0000-0002-9062-820X): conceptualization, funding acquisition, project administration, supervision, review and editing.

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