Received: 18 March 2022 | Revised: 11 August 2022 | Accepted: 18 August 2022
DOI: 10.1002/bse.3247

RESEARCH ARTICLE

Business Strategy and the Environment WILEY

From waste to market: Exploring markets, institutions, and innovation ecosystems for waste valorization

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Funding information
This work was supported by the European Regional Development Fund, INTERREG VB Northern Periphery and Arctic, through the "Energy Saving Lighthouse Cities in the NPA region" project (e-Lighthouse 2014-2020) and by the European Commission H2020-SC5-2018-2 through the CityLoops project (Project ID: 821033, 2019–2023). The funding sources were not involved in the design, analysis, or interpretation of this study, and also not involved in writing or decision to submit the article for publication.

Abstract

This article explores the emergence of waste valorization innovations to investigate how they interact with incumbent waste management systems and what roles markets play in the process. We build upon innovation ecosystems as an analytical framework and investigate empirically three cases distributed across the waste hierarchy pyramid: (i) upcycling of discarded fishing gear; (ii) reusing constructions and recovering demolition waste; and (iii) establishing a biomass-based district heating facility. Our cases indicate that waste valorization initiatives are deeply entangled in incumbent waste management systems and that markets alone appear to be insufficient to drive innovations in waste valorization. Our analysis also points to a relationship between the position of waste innovation in the waste hierarchy and the presence and effectiveness of markets. Markets function better when resources already have some economic value, which is what waste valorization processes seek to obtain. When the environmental value is higher than the economic value, other mechanisms are needed to enable innovations, markets, and sustainability transitions. Support from the public sector in various capacities, from international regulation to demand shaping, seems to be essential for circular economy transitions. Understanding issues such as how waste innovations reach the market and how markets for waste resources function is imperative for circular economy transitions.

KEYWORDS
circular economy, innovation ecosystems, market formation, public sector innovators, sustainability transitions, waste institutions, waste management, waste valorization

1 | INTRODUCTION

Discourses and imaginaries around the circular economy (CE) promise to rearrange linear systems of production and consumption, and reintroduce waste back into productive use (Friant et al., 2020; Hermann et al., 2022). The CE has appealed to academics, policymakers, and the private sector alike because it promises to realize the ambition of sustainable development, at the same time that it allows for greater profits through resource efficiency, as well as it opens avenues for new businesses (Geissdoerfer et al., 2017; Korhonen et al., 2018). The European Commission and several national governments have formulated strategies exalting circularity (European Commission, 2020; Klima- og miljødepartementet, 2020), and a number of companies have adopted the rhetoric of recirculation (e.g., H&M, 2020; Nespresso, 2017), even though there are several unknowns on the way to realizing these ambitions.

Given this interest of businesses, the topic of CE transitions has been taken up by management and strategy scholars (Arekrans et al., 2022; Esposito et al., 2018; Sehnem et al., 2022). Prevailing work on the CE has looked into the technologies and innovations needed to increase the yield of resources (Antikainen et al., 2018; Blomsma et al., 2019; Liu et al., 2022; Pieroni et al., 2021; Suchek et al., 2021). It has sought to develop business models, supply chains, and innovation practices that support circular value propositions (Ferasso et al., 2020; Galvão et al., 2021; Geissdoerfer et al., 2018; Hopkinson et al., 2018; Lüdeke-Freund et al., 2019; Sehnem et al., 2022). More recently, scholars have begun to address the CE from an ecosystem perspective (Kanda et al., 2021; Konietzko et al., 2020b; Parida et al., 2019; Trevisan et al., 2022). Despite the enthusiasm for the CE, little is known about how markets form and how they function, or fail to function, in this context. This represents a knowledge gap, since markets are one of the key instruments to allocate distributed resources and coordinate collective action (Lee et al., 2018), and therefore of consequence to CE transitions. Questions abound on the roles, abilities, and limitations of markets as an instrument of resource allocation and coordination and as a driver of innovations that sufficiently challenge the status quo (Genovese & Pansera, 2020; Hobson, 2020).

In this article, we investigate organizational arrangements of CE innovation ecosystems and their markets. CE innovation can take many forms, from incremental process innovation to radical new business models (see Blomsma et al., 2019). We focus on waste valorization (or waste-to-value innovations), meaning the processes by which resources that are discarded acquire value and become raw materials. Residues, sidestreams, and by-products can be valorized both through changes in material properties and changes in markets (Klitkou et al., 2020).[1] Many waste resources currently lack markets in which they can be traded, and in cases where resources do have economic value (e.g., nylon and aluminum), further challenges appear regarding logistics, volumes, the need for sorting and cleaning, etc. Moreover, the degree of systemic complexity and strength of existing value-chain arrangements are high, which can hinder the transition from ideals to practice (Konietzko et al., 2020a, 2020b). Waste-to-value innovations need to create synergies across industrial contexts that until then were separate, and which have their own trajectories, markets, institutions, and governance structures. Also, the societal stakes and environmental risks of faulty innovations are high, which makes the notorious Silicon Valley approach of "moving fast and breaking things" unsuitable to this context.

We conceptualize the CE as processes at the mezzo level of socio-technical systems, characterized by the intertwining (and contestation) of facts and values, as well as by challenged legitimacy, and continuous tensions between stability and change (Köhler et al., 2019). We take as a starting point the premise that existing institutional arrangements for waste handling were founded upon a linear logic in which waste resources are economic bads or externalities outside the domain of markets. While many actors in the waste sector appear to have transcended this view, the economic system at large has been slower in catching up. A key obstacle in the process is that such new arrangements must spring from established systems while challenging them (Nelson & Winter, 1982; Schumpeter, 1983; Young et al., 2008). Amidst both the enthusiasm and skepticism regarding the CE, more empirical knowledge is needed about the dynamics of waste valorization, as well as about their markets and institutional setup.

To address this need, this article explores the emergence of waste-to-value innovations in three empirical settings to address the following research questions: (i) How do waste-to-value innovations interact with incumbent waste management systems? and (ii) what roles do markets play in this process? We build upon the lenses of innovation ecosystems (Adner, 2013, 2017; Konietzko et al., 2020b) as an analytical framework to examine the case study of waste management services in the county of Nordland in northern Norway and three instances of emergent waste-to-value initiatives in the region. The cases are (i) upcycling of discarded fishing gear, (ii) reusing constructions and recovering demolition waste, and (iii) establishing a biomass-based district heating facility. We seek to illuminate how actors organize and orchestrate the realization of their value proposition and the main drivers behind the emergence of these initiatives. Subsequently, we analyze patterns across cases and discuss the roles of private and public actors and the functions of markets and policy in the context of secondary resources. We conclude with the main takeaways and suggestions for further research.

2 | MARKET FORMATION AND INNOVATION ECOSYSTEMS

In a straightforward definition, markets are trade arenas that connect those who provide a value proposition (VP) and those who seek it and where the worth of this proposition will be negotiated and measured in monetary terms (i.e., through prices). In this vein, market formation is about collective action in constituting arrangements for organization and trade, as well as for aligning distinct interests (Struben et al., 2020). We can also see market formation as processes through which innovations break through their early niches and reach a broader adopting audience (Boon et al., 2020). In both standpoints, market formation is not a spontaneous process, as markets are in fact performed by ongoing cycles of exchanges, representations, and normalization practices (Kjellberg & Helgesson, 2007). This performative characteristic is even more pronounced in markets for sustainability transitions, and scholars have called for a directed effort to advance transitions through mission-oriented innovation (Hekkert et al., 2020; Mazzucato, 2018).

As a result, the creation of markets might involve policies to stimulate both supply and demand—although supply has weighed more heavily in economic instruments of innovation policy (Borrás & Edquist, 2013). On the supply side, scholars have recognized the role of niches as spaces of experimentation, where innovations are protected from competitive pressures before they are mature enough to reach the market (Geels, 2004; Hekkert et al., 2007; Schot & Geels, 2007). Moreover, programs that focus on fostering science and

[1]Waste valorization and recycling can be said to be synonyms in common speech. Yet, the first calls attention to the question of how value is perceived in resources, while the latter emphasizes material properties and manufacturing processes. As such, attributing value to waste resources is a precondition for recycling to occur.

technology, such as the European Green Deal, are also examples of prominent supply-side policies for transitions. On the demand side, the task of market formation entails turning grand ambitions of sustainable production–consumption systems into concrete demand for products and services that embody these (nonmonetary) values. Focus on the supply side is pronounced in the criticisms that the CE discourse is dominated by technocratic and ecomodernist concerns, at the expense of more holistic conceptualizations of transitions (Clube & Tennant, 2020; Friant et al., 2021; Genovese & Pansera, 2020; Hermann et al., 2022).

Picking up the thread of markets as a vehicle for collective action mediated by trade (Struben et al., 2020), we analyze waste-to-value initiatives through the lenses of innovation ecosystems (IE) (Adner, 2013, 2017). Following Adner (2017), we understand ecosystems as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (p. 42). Implicit in this definition is that this materialization takes place through markets, and it is especially relevant when markets are themselves nascent. Key elements in this approach are (i) the VP, (ii) system integrator, (iii) inputs and suppliers, (iv) complementary goods and services needed for the VP to be delivered, and (iv) customers. Figure 1 illustrates the analytical framework. This allows us to examine the patterns of activities stemming from a focal VP and to map who is involved and how actors relate (Adner, 2017). Innovation ecosystems also support a diagnosis of the strengths and shortcomings of an ecosystem in light of its professed purposes (as illustrated in Nogueira et al., 2022). Innovation ecosystems are about value creation (Gomes et al., 2018). They facilitate that a diverse group of actors organizes to bring a VP to market, which neither of them could do alone. This is crucial in the CE.

We add to Adner by explicitly addressing the aspects of institutional landscape, which are of particular relevance when it comes to pro-environmental behaviors and systemic change (Olsen et al., 2020; Skorstad, 2008), and represent a crucial underlying structure of the ecosystems we seek to elucidate. Moreover, established institutions concerning resource-intensive production–consumption systems are being challenged by the CE. We adopt Young et al.'s (2008) definition of institutions: "a cluster of rights, rules, and decision-making procedures that gives rise to a social practice, assigns roles to participants in the practice, and guides interactions among occupants of these roles" (p. xxii). Social institutions are stability-enhancing mechanisms and patterns that are themselves subject to evolutionary pressures. Thus, innovation ecosystems and their surrounding institutional landscape mutually influence one another in a co-evolutionary trajectory.

3 | RESEARCH DESIGN, METHODS, AND DATA

Our approach to this study is based upon an intensive research design, in which we analyze a small and nonrandom sample, with the ambition to provide contextually grounded knowledge of high internal validity (Danermark et al., 2001; Gerring, 2004). We selected our cases purposefully to represent diverse levels of the waste hierarchy (European Parliament, 2008). That is, within the same overarching institutional landscape, we examine the dynamics of waste valorization at distinct levels of value retention, as shown in Figure 2.

Our research design and methodological procedures are informed by a systems perspective, the principles of co-production of knowledge and engaged scholarship (Jasanoff, 2004; Norström et al., 2020; Van de Ven, 2007). That is, data for this study stem from the authors' engagements in applied research projects, which took place between 2015 and 2022 and encompassed various aspects of secondary resources and waste management systems. Some characteristics are shared across projects: First, they had the goal of building local capacity for reuse, recycle, and recovery; second, the projects involved dialogue meetings with municipalities and other public authorities, as well as industry actors and civil society; third, the projects involved analysis and documentation of waste practices, and in some cases, calculation of energy efficiency and greenhouse gas emissions. Through these hands-on activities, the authors collected data in the form of formal and informal interviews, workshop participation, documents, scientific and technical reports, and newspaper articles. The wealth of experiences accumulated under the domain of these research projects provided in-depth knowledge about the waste management system, as well as of nascent waste valorization activities they embed.

Data analysis took place in two stages: individual case and cross-cases. In the first stage, we identified the VPs of each initiative, and we wrote vignettes that outline what the initiative is, how it came to be, and how the operation works (see Supporting Information).

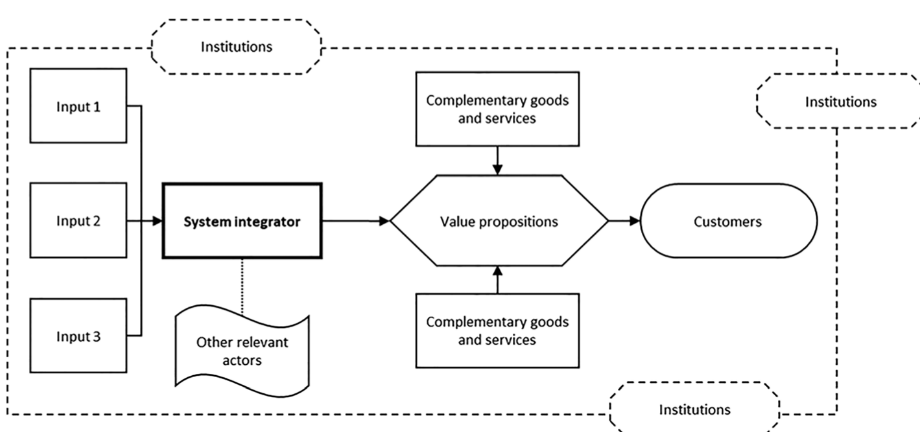

FIGURE 1 Archetypical structure of an innovation ecosystem (*Source*: The authors, inspired by Adner & Kapoor, 2010, p. 309)

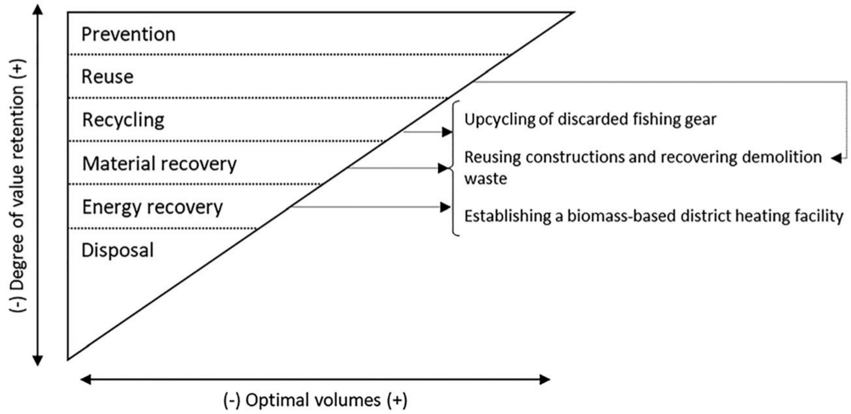

FIGURE 2 Case studies in the waste hierarchy (*Source*: Based upon European Parliament, 2008, article 4)

TABLE 1 Dimensions of analysis

Dimension of analysis	Guiding questions
Value proposition	What are the VPs of each initiative? Have they changed over time?
Activities/functions	Which activities must be undertaken for the VP to materialize?
Actors and positions	Who is responsible for each activity? What are the individual goals of actors? Do these align with the system's VP? What other parallel initiatives need to be in place before the VP can materialize?
Markets	What characterizes the markets? What is the scope and degree of maturity of markets? How do actors relate to each other? Who needs to buy into the VP?
Policies and institutions	What are common practices, rules, and regulations influencing (positively or negatively) the execution of activities? What are the incentives and deterrents driving the behavior of actors?

We then proceeded to model the ecosystem surrounding each case. In this task, we examined activities and functions, actors and positions, ecosystem characteristics, and the institutional setup. As the analysis proceeded, we collected additional data in the form of newspaper articles, company documents, and interviews to address eventual gaps. Practitioners central to each case read and commented upon the vignettes for the sake of ensuring the validity of our interpretations. Table 1 depicts these analytical dimensions and some guiding questions we posed each case.

The second stage of data analysis refers to the contemplation of patterns across the cases. For this stage, we adopted an in vivo approach to theory building, which relies upon abduction (Andersen & Kragh, 2011). As an outcome, our approach results in plausible rather than necessary propositions. We seek to illuminate the underlying elements that enable/constrain innovation ecosystems to emerge and thus markets for secondary resources to emerge and establish (Danermark et al., 2001). Among the limitations of our approach is that our sample and data do not allow inferences about all the conditions in which these circumstances are activated and that findings cannot be generalized in the statistic sense.

4 | THREE CASES OF WASTE VALORIZATION

In this section, we introduce three cases of waste-to-value initiatives found in the county of Nordland, Norway, and their surrounding innovation ecosystems: (i) upcycling of discarded fishing gear, (ii) reusing constructions and recovering demolition waste, and (iii) establishing a biomass-based district heating facility. Complete case descriptions are available in the Supporting Information, including more details concerning the Norwegian waste management sector and the county of Nordland.

4.1 | Upcycling of discarded fishing gear

With an extensive coast of cultural and economic significance, marine litter presents one of the key waste concerns in Norway. Discarded fishing gear has long been a challenge for both the waste companies and the seafood industry, due to the lack of sufficient and environmentally friendly solutions for their recycling and disposal (Nogueira et al., 2022). Nofir is a company that implements a recycling scheme for discarded gear from fisheries and aquaculture. The opportunity/need that Nofir addresses emerged as a response to the inadequacy of the institutionalized waste system in ports, combined with Nofir's ability to integrate several actors alongside the recycling value chain.

The firm was founded in 2008 through a partnership between the local waste management sector and a manufacturer of fishing gear and in the aftermath of two research projects that investigated the viability of such a scheme (Olafsen, 2007; Sundt, 2008). Nofir orchestrates the integration of diverse stakeholders. When waste owners have enough materials to fill a truck/shipping container, they inform Nofir, who arranges for collection. Nofir then transports these materials to their facilities in Lithuania, where gear is cleaned, sorted into polymers and metal parts, and dismantled, in preparation for recycling. Fishing gear consists of highly diverse items and therefore heterogeneous materials (Deshpande et al., 2020; Nogueira et al., 2022). Different fractions entail different methods for recycling and have different economic values in secondary markets. Nylon represents the highest value material, as not only can it be recycled without loss of material quality, but also there is a large demand for nylon for textiles and apparel. Nylon is sent to Slovenia and is upcycled into new textile products; PE/PP is sent to Denmark and results in various other products (shopping baskets, benches, chairs, and kayaks); metals are sold locally to metal recycling facilities (Stolte et al., 2020).

In a strictly traditional business value chain, the seafood sector is a supplier to Nofir, while the recycling companies correspond to customers. However, by collecting gear, Nofir also provides fishers with a service and, as a result, functions as a connecting hub. Nofir might pay for specific types of high-quality nylon, with the contingency of transportation costs. But most of the time, the seafood sector will cede materials for free, or even be charged a fee for collection. We note that Nofir does not operate under extended producer responsibility (EPR) regulation, unlike other types of waste fractions, and despite the popularity of this instrument in Norway. Nofir managed to establish a market-based system for material recirculation in which the higher value of nylon compensates for the lower profitability of other fractions. In October 2021, Nofir's largest client—the Italian publicly traded firm Aquafil—acquired a 31% interest in the firm.

4.2 | Reusing constructions and recovering demolition waste

Construction and demolition waste (CDW) consists of various blended materials, from metals to bricks and concrete. Soil is especially challenging, as it is nonrenewable and soil from urban areas is considered polluted per definition, according to Norwegian regulation (Forurensningsforskriften, 2004, § 2–3). Moreover, the quality of materials varies significantly, and as a result, so do their economic values. Against this backdrop, CityLoops Bodø is a research and innovation project that demonstrates local recirculation solutions for CDW, including soil, in the city of Bodø, Norway. Up to now, the main recirculation alternative for CDW is backfilling. While backfilling does count as material recovery, it is a low-value application, only marginally better than disposal, and represents a substantial deterioration of the original value and quality of materials. CityLoops involves the development of higher-value applications for CDW.

The initiative emerged as a spin-off of a large urban development project taking place in Bodø, which became known as "New City, New Airport." Because the new urban space is in the area where there is currently a military airport, the city needs to demolish existing structures before development can take place. CityLoops is organized in three phases: inception, demonstration, and replication. The first phase involves the development of a three-dimensional (3D) GIS-based tool for visualizing and monitoring building infrastructure and mass flows, as well as testing of innovative methods for on-site treatment of soil. Together, these allow city planners to assess the quality of materials and determine the potential for reuse (not all structures need to be demolished, and some will be repurposed). The project partners are also developing guidelines for circular procurement. The second phase concerns the actual demolition and on-site testing of the methods developed in the inception phase. The third and final phase escalates the project's tools and procedures to address the entire "New City, New Airport" project and extends it beyond the immediate partners.

In short, the CityLoops approach aims to develop markets for technologies and services, as well as protocols that can be replicated in other sites within their local characteristics. This contrasts with developing a market where physical goods are traded, as is the case, for instance, with metals. CityLoops is an ongoing project operating in a protected space of niche experimentation and thus currently functioning outside traditional or established market-based systems. Still, its purpose is that solutions are taken to market.

4.3 | Establishing a biomass-based district heating facility

District heating is a system in which heat is generated in a centralized facility and distributed to customers through a network of water pipes. It is more energy efficient than electricity-based heating, and its adoption relieves some of the demand on power grids, but the upfront costs of such system are high, and the abundant supply of renewable energy at a low cost has led to a delay in developing district heating systems in Norway. This case concerns the establishment of Keiseren bio-heating facility, in Bodø, Norway.

Keiseren is owned by BE Varme, a subsidiary of Bodø Energi AS, which is in turned owned by the municipality of Bodø. The plant became operational in 2015 and runs on regionally sourced waste wood biomass (cleaned of contaminants and ground up). Before, this biomass was transported to southern Norway or Sweden for final treatment. BE Varme has long-term contracts with suppliers that ensure a steady supply of biomass. At the facility, the biomass is deposited in a furnace, where it is burnt. At the customer, heat exchanger equipment is installed, where energy is transferred to the customer's heating system. After the energy exchange takes place, cold water is returned to Keiseren in a closed-loop system that operates continuously. BE Varme has responsibility for the heat exchanger installed at the customer, but not the rest of the waterborne infrastructure. The furnace process also results in ashes, which are landfilled.

Discussion about this initiative came about in the early 2000s, but at the time, the ambition was to establish a general-purpose incineration plant in Bodø. The purpose of handling waste took precedence at the time to the purpose of generating energy. Plans eroded as the consortium could not manage to establish a sound economic model and a stable stream of revenues to sustain the operation. At the time, the price of electricity had been in decline due to a surplus of hydroelectric energy, and by law, the price of district heating cannot exceed the price of electricity. Without a subsidized model, the plant could not sustain itself, and the risk was too great to justify the investment. As a result of these constraints, the partners decided to change the approach and focused on building a biofuel plant instead. This change reoriented the entire ecosystem of relevant actors, and their relative power and importance in the initiative.

Keiseren ended up addressing opportunities and needs that fit better with energy considerations rather than those of waste. Still, the process demanded the integration of various stakeholders with diverse interests and the flexibility to adapt the overall arrangements of the initiative within a set of economic and regulatory constraints.

5 | ANALYSIS: INNOVATION ECOSYSTEMS FOR WASTE VALORIZATION

We set out to examine the emergence of three cases of waste valorization through the lenses of innovation ecosystems. Table 2 summarizes and contrasts key aspects of the cases. As a matter of research design, the three cases share the overarching institutional setup associated with being in the same county, subject to the same trends regarding waste management, climate policies, innovation systems, etc. As for the differences inherent in our design, the cases represent different waste fractions, distributed in different positions in the waste hierarchy. In this section, we analyze cross-case patterns regarding the characteristics of innovation ecosystems, of markets, and the institutional landscape.

5.1 | Innovation ecosystems

Looking at the innovation ecosystems that support each case, we can first note that all cases exhibit a multisided VP that communicates with the interests of different stakeholders. In the fishing gear case, different values are proposed to different stakeholders, as it is through different activities that customers and fishers perceive a benefit to themselves. This is in line with the fact that Nofir functions as a platform connecting those who generate waste and those who recycle it. That is, Nofir is the connection point where fishers' need to discard old and damaged gear adequately aligns with the recycler's interest in sourcing materials for production. This is similar in the CDW case, whose main point is to articulate a system to facilitate reuse and to channel CDW in circular loops. System articulation is inherently an exercise of interest alignment. On the other hand, in the district heating case, which has a more traditional organizational form, the same set of activities offers different types of value to the waste companies and to customers, and these are communicated accordingly. In this case, the alignment and misalignment of interests changed over time, which affected the configuration of the entire ecosystem, starting from the VP. In the early days, the project was about the construction of an incineration facility in Bodø, and the energy generation from this activity was of secondary interest. As circumstances changed, the VP changed accordingly, and the initiative was realized by focusing on district heating as the main driver.

What is special in the case of innovations for sustainability transitions is the need to also articulate a clear value added to society and the environment, which are not paying customers and have only indirect influence on how the innovation ecosystems organizes and operates. We find that it is useful to distinguish between ways to frame VPs that are oriented to consumers, to the ecosystem, and to society and the environment. It is also useful to be clear about both economic and noneconomic value and to whom value is proposed.

A related aspect is the question of who functions as system integrator. While waste management companies are imperative in all three cases, they were not in a position to act as system integrators themselves. Moreover, their position in the supply chain changes both across cases and over time in some cases. In the fishing gear case, the system integrator is a for-profit company that emerged under the umbrella of the public waste company, which has a mix of for-profit and not-for profit activities and is now owned in its majority by private for-profit actors; in the CDW case, the system integrator is a research and innovation project, under the umbrella of Bodø municipality; in the district heating case, the waste company was an early integrator, but as the landscape changed and interests had to be realigned, the local energy company took over the role of system integrator, and the design of the project was altered along these lines.

A functioning ecosystem also depends on complementary goods and services. In the fishing gear case, arrangements for collection such as service stations are key for getting hold of materials, and in this regard, maintaining a relationship with waste management companies is important. In the CDW case, the realization of the VP depends on the development of the 3D GIS tool for mapping materials and planning demolition, as well as the development of techniques for on-site treatment. Co-innovation is innate to the project. Finally, the district heating case depends on extending infrastructure both in the city and in buildings so that the service can reach customers. In sum, discarded gear would not be available to recyclers without service stations, secondary resources for construction cannot reach the construction industry without the innovations such as the ones the CityLoops project is developing, and district heating is not accessible to households if they do not invest in installing suitable equipment. Complementary goods and services are sources of business opportunities to other companies that, although not in the direct supply chain, offer goods and services that are fundamental for the delivery of the VP.

Customers are also key to innovation ecosystems, and we expand on the issue of markets next.

5.2 | Markets

The characteristics and degree of maturity of markets is strikingly different in the three cases. While the fishing gear case is fully operational, and the district heating case is growing into its planned capacity, the CDW case is a localized niche experiment. This reflects not only aspects of the cases themselves, but of their respective markets.

TABLE 2 Key characteristics of cases

	Upcycling of discarded fishing gear	Reusing constructions and recovering demolition waste	Establishing a biomass-based district heating facility
Degree of maturity of the ecosystem	Fully operational	Niche experimentation	Operational (but still below full capacity)
Position in the waste hierarchy	From disposal to recycling	From disposal to recovery/ recycling/reuse	From disposal to energy recovery
Sources of inputs	Fishers and aquaculture facilities	Soil and other CDM from urban development project	Waste wood supplied by waste collection actors
System integrator	Recycler of discarded gear from seafood operations (spin-off from the district's waste company)	Pilot circular economy project (under the umbrella of municipal urban development project)	District heating company (subsidiary of municipal energy company)
Customers	Specialty manufacturers of plastic products	Firms in the construction industry	Public buildings, businesses, citizens, and households
VP for customers	Supply of production materials sourced from discarded products	Supply of secondary materials for construction; implement a system that facilitates reuse and channels CDW in circular loops	Supply of renewable-based/low-carbon and efficient energy for heating
Complementary goods and services	Service stations, waste management companies	Development of a 3D GIS tool and of techniques for on-site recycling	Pipe infrastructure from the incineration plant throughout the city Building infrastructure
Other relevant actors	Gear manufacturers	Waste management company, municipality, other partners in project consortium (pilots in other cities)	Suppliers of technology, engineering services and construction, municipality
VP for the innovation ecosystem	Implement a less costly and more convenient collection system for fishing gear; manage logistics, documentation, and provide suitable treatment and destination for discarded gear	Develop business models and technology for reuse and recycling CDW and soil; leveraging local and decentralized recirculation systems; provide standardization and documentation that support replication in other sites	Improve value capture from biowaste resources; decrease demands on power grid
Broad VP for society and the environment	Contribute to addressing the problem of marine plastics and inadequate waste management system; more circular production systems can lead to less oil consumption and fewer CO_2 emissions	Contribute to smaller footprint of the construction sector; contribute to achieving climate targets and decrease extraction of virgin materials	Contribute to achieving climate targets; more energy-efficient heating systems diminish burden on nature
Geographical scope of markets	International	Local	Local
Pricing	Traditional market-based pricing	Business models not yet established	Concession rules cap: Prices must be equal or lower than electricity pricing
Role of incumbent waste management system	Shareholder	R&D	Supplier
Support from the public sector (instruments for market formation)	Funding for international expansion (grants)	R&D funding Niche development Public procurement	Concession of monopoly, duty of users to connect, CAPEX subsidy
Role of municipality	A group of municipalities own the waste company, which owns the spin-off that acts as system integrator	Municipality drives the urban development project that acts as system integrator	Municipality owns the energy company that acts as system integrator

(Continues)

TABLE 2 (Continued)

	Upcycling of discarded fishing gear	Reusing constructions and recovering demolition waste	Establishing a biomass-based district heating facility
Institutional factors influencing the ecosystem	Pollution Control Act, landfill prohibition, hazardous waste regulations, extended producer responsibility regulations, demand for secondary plastics, demand for recycled products, climate targets, funding (Innovation Norway, SkatteFUNN, EU grants), knowledge surrounding marine litter, alternative uses of plastic waste, alternative materials, oil prices	Pollution Control Act, landfill prohibition, hazardous waste regulations, climate targets, EU funding, demand for recycled products, building regulations, land ownership (the military), urban development, city's zoning plan, alternative uses of biomass, price of virgin materials	Pollution Control Act, landfill prohibition, climate targets, subsidies, EFTA surveillance authority, urban development, building regulations, concession authorities, land ownership, city's zoning plan, alternative uses of biomass, sources of biomass, electricity prices

The fishing gear case is the one with closest proximity to markets. Nylon—a crucial component of various gear—is a commodity with high exchange value and an established demand. For instance, in its early days, Nofir sought customers through Alibaba.com, which indicates that by orchestrating a system to collect gear, Nofir had the challenge to access the market, but not to create it. Prices can either follow pre-established rates or be negotiated on a case-by-case basis. Although there is no organized exchange arena for plastics, as there is for metals, the price of oil influences the demand for and prices of secondary plastics. This vulnerability is a challenge in making the operations profitable when oil prices are too low. Thus, although fishing gear is composed of various composite materials, the fact that one of them is highly valuable makes it possible to access existing markets for secondary resources.

The same cannot be said of CDW. The large variety of materials and their uneven quality make it expensive to sort and difficult to trade. As a result, the market tends to be localized, decentralized, and driven substantially by environmental, rather than economic concerns. Looking specifically at cement, the environmental impact of producing virgin cement is not considered in its prices, and simply becomes an externality. One of the objectives of the CityLoops consortium is to expand the domain of markets by transferring a method of recirculation that can be replicated in various locations instead of promoting global trade of materials. In this way, the market in question is not exactly the market for secondary resources, but a market for expertise-based services and technological solutions, which leverage the properties of each location and avoid transport costs and the CO_2 emissions that a global commodity trade entail. This is possible also due to the decentralized nature of the construction sector.

Finally, the district heating case presents a hybrid between local and global concerns. While the concession area is limited and local, district heating is, nevertheless, embedded in the broader energy system, which determines supply, prices, etc. The fact that the price of district heating cannot by law be higher than that of ordinary electricity puts a cap on revenues and is out of the firm's control. Nonetheless, one of the conditions for establishing the facility was that new builds within the concession area had the obligation to connect to the grid. This safeguards demand, even though prices fluctuate. The fact that Keiseren uses waste wood rather than forestry wood is also important element of the plant's cost structure, since it costs less. This also creates a market for waste wood, which prior to Keiseren was sent for incineration in Trøndelag or Sweden, at a cost to the waste management company.

Greater awareness in civil society concerning environmental issues, such as marine litter and climate change, leads to the adoption of pro-environmental behaviors (e.g., Olsen et al., 2020), which also affect markets. However, waste valorization operates at the level of business-to-business transactions where secondary resources compete with virgin resources as substitute products. As a result, for waste valorization initiatives to reach the market, it is important that the issues important for supply are in place—that is, even quality, steady volumes, sorting and cleaning resolved, and logistics in place. We find that for waste valorization, environmental concerns from final consumers matter in generating in consumers a willingness to purchase a product made from secondary materials, as well as for motivating them to discard materials suitably—for instance, in encouraging fishers to refrain from littering and to retrieve gear they encounter at sea. Yet, concrete action from policy actors that shape the rules governing resource extraction, production, trade, and consumption have a more central role. We discuss issues pertaining to the institutional landscape next.

5.3 | Institutional landscape

Environmental policies have been central in fostering innovation for all three cases. Norway's adherence to CO_2 emission targets and increasing the rate of circularity has spurred a search for sustainable pathways that ultimately created favorable conditions for all three cases to emerge. Those targets affected not only the dynamics of energy markets (including waste to energy) but also led to the landfill restrictions that were announced in 2004 and have been in effect since 2009. Such restrictions pushed for new ways of handling waste that, although costly in the short term, facilitate innovation toward more desirable environmental performances. Nofir and BE Varme were founded around this time (2008 and 2009, respectively); Nofir addressed the need to reduce the amount of materials going to landfill; BE Varme, in its earlier configurations, was also motivated by the need to find alternatives to landfilling. CityLoops came about more recently and operates under the same regime. CityLoops also addresses the requirement from the EU waste directive mandating that at least 70% of materials from construction projects are reused, recycled, or recovered (European Parliament, 2008). Otherwise, much attention in the construction sector has been placed on the energy efficiency of buildings, and less so on the (un)sustainability of cement production. In comparison to the energy and waste management sectors, the relative paucity of regulation to hinder pollution from cement production can be pointed to as the reason why green innovation in this sector has been slower than in energy, and markets less developed.

Nonetheless, in one case, environmental regulation had an adverse effect. In 2018, new EU regulations concerning exports of hazardous waste interrupted Nofir's operations. Aquaculture nets are impregnated with copper to prevent biofouling, and the new rules stated that items that contained more than 0.25% copper were to be classified as hazardous waste and could not therefore be transported across borders. Eventually Nofir obtained the necessary permits, but in 2021, the new Basel codes came into effect, and mandate that special permits are needed to export mixed plastic waste. This compromises its operations of the cross-border recycling of fishing gear. While these regulations aim to hinder the practice of dumping waste materials on countries with weaker institutions and looser requirements for waste treatment, they also hinder (or at lease bureaucratize) recycling networks.

Other than national and international regulation, local government authorities also had a central role in these three cases. Emission targets have been translated into municipal goals, which led Bodø municipality to take on a more active role in facilitating these innovations, if not leading them directly. That is, we can observe the public sector as going beyond framing background conditions and actively promoting and facilitating innovations. For instance, all three cases relied on support of various sorts, and all received some kind of subsidy, either in the form of R&D/innovation grants or direct subsidy for capital expenditure. In the fishing gear case, Nofir received grants from Innovation Norway early on and a grant from the European Research Council to expand the scheme internationally. The CDW case is predicated upon a Horizon 2020 grant, which allowed the demolition of the existing airport to be leveraged as a case upon which to investigate new practices of material recirculation on site. Lastly, the district heating case was only made viable when the project was changed to include a larger share of renewables, which made the project eligible for higher subsidies and guaranteed its economic viability.

In addition, all three cases count with substantial ties with public authorities at local levels. Nofir is owned by the local waste management company, Iris Salten, which in turn is owned by the municipalities of the district of Salten. CityLoops is housed under the "New City, New Airport" project, which is an initiative driven by Bodø municipality. In CityLoops, local public actors also play a role in creating demand for circular innovations through the development of public procurement guidelines. Keiseren and BE Varme are owned by Bodø Energy, which in turn is owned by Bodø municipality. Moreover, the realization of Keiseren relied substantially on coordination from the public authorities for finding a suitable location for the plant, as well as for changing municipal zoning plans, and regulations to safeguard demand through regulation that mandates all new builds in the concession area to connect to the district heating system.

Finally, and most important to our research question, all cases exhibit important ties with the incumbent waste sector, which was integral to their development. This is perhaps most pronounced in the fishing gear case, as Nofir was founded under the organizational patronage of Iris Salten, but Iris Salten is also crucial to the CDW case, as their subsidiary Iris Produksjon is responsible for testing new methods for handling the waste and handling the CDW from the demolition of the existing city. As for the district heating case, Iris Salten was a driving force in the early discussions concerning an incineration facility, when the project was motivated by finding an alternative way to handle waste in the region. This changed, however, as constraints to the project became known, and in the final configuration, the Iris Salten figures as a supplier of biomass to Keiseren, alongside Østbø (a privately owned WM incumbent). In summary, all three cases point to initiatives that emerged from within the incumbent local waste system, as a consequence of the changing landscape of green shift regulations, to a greater extent than disruptions from private actors and market mechanisms.

6 | DISCUSSION OF FINDINGS

At the outset, we proposed to address the following research questions: (i) How do waste-to-value innovations interact with incumbent waste management systems on their way to markets? and (ii) What roles do markets play in this process?

Based on our case studies, we find that the existing waste management system has been instrumental in the emergence of the three waste valorization innovations we explore. The waste sector in Norway is heavily regulated to reduce environmental damage, and the emergence of the CE agenda on the European landscape has led to a range of further changes in regulations and strategies that affect the waste sector. As a result, innovations in this context need to interact collaboratively with incumbent actors, who have both the competence to navigate notoriously complex legal landscape (Bratteng, 2020) and the necessary permits and networks. This does not seem to be a problem: Many waste management companies are well placed to benefit from these changes as their position in the value chain moves from handling the end of life to providing recirculated materials for production. Specifically in the case of Iris Salten (the publicly owned entity in the Salten district in northern Norway, where our study is based), the company has exhibited an entrepreneurial orientation, as they either own or have participation in

10 daughter companies (including Nofir) that range from wastewater treatment to a microbiology/chemical analysis lab. More challenging for transitions is engaging with incumbents in other sectors, such as construction.

When it comes to the roles of markets in waste valorization, we find that contemporary markets alone fail not only to assess and capture noneconomic values but also to stimulate innovations. Markets function better when the waste resources in question already have some recognized economic value, and the challenge is one of coordination; in such circumstances, firms are able to engage with the market and craft strategies for creating and capturing value. This is what we find in the fishing gear case. However, in cases where resources lack economic valuation and the primary driving forces are of a noneconomic nature (such as the CDW case), markets fail to adequately translate these values into prices and thus fail to propel innovations of this sort. In the cases we examined, it was only when the institutional landscape changed that the conditions became conducive to the emergence of these innovations. We can hypothesize that without landfill restrictions, markets would not be accessible for secondary waste resources, with their added costs of cleaning, processing, transporting, etc. What is more, markets' valuations—or lack thereof—are currently failing to account for the future value of secondary resources if/when we experience shortages of virgin resources in regional if not global markets. This applies to all three cases. To the extent that transformation takes place over time, we posit that the type of institutional arrangements we describe will be prerequisites for sustainable valuation in a new paradigm.

Markets are traditionally grounded in linear value chains that rely upon extraction, consumerism, and disposal. Changing how production and consumption systems are organized entails a large-scale disruption that requires changes in norms and values and thus cannot be limited to firm-level product innovations. Other types of innovation are essential in CE transitions, not the least innovation in policy instruments that account for noneconomic interests. As a result, environmental regulation appears to be essential in order to calibrate the scales of how value is conceptualized. Thus, while markets do have a role to play, they are limited instruments for value generation and coordination within CE transitions, if these are to be understood in more transformative perspectives than simply resource efficiency and resource security. Moreover, regulation is not only about command-and-control mechanisms and can also be generative of markets.

Altogether, these cases point to a relationship between the position in the waste hierarchy and the presence and effectiveness of markets. That is because at higher levels of value retention, materials are already conceptualized as goods, while at lower levels they are conceptualized as bads, and the work involved in conceiving of value (i.e., valorizing the waste) is more intensive. Based on the dynamics of these cases, we advance the proposition that the extent to which markets function well as a vehicle for circular innovations is contingent upon position in the waste hierarchy (i.e., how much value can be retained). Figure 3 illustrates this relationship. Moreover, as all cases exhibit multifaceted VPs and point to the need to communicate value not only to customers, as we are used to seeing from the

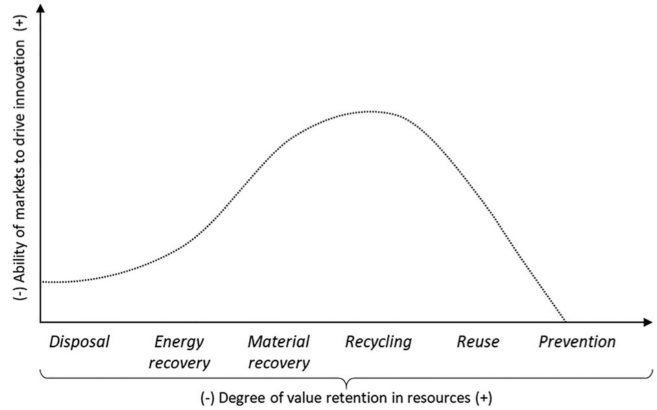

FIGURE 3 Relationship between markets and the value retention in the waste hierarchy (Source: The authors. This image is merely illustrative and not to scale)

management literature, but also to connect this VP to a VP that is oriented toward the ecosystem and to broader societal concerns. In this perspective, demand-oriented policies are essential to the task of connecting immediate customer-oriented aspects with broader societal aspects of VPs. The public sector also has a role to play in market formation for waste valorization innovations by stimulating demand for secondary resources, as we see in the CityLoops case with public procurement.

Focusing on a systems perspective and through a process approach, our findings complement recent studies in business strategy that address individual- and firm-level viewpoints in CE transitions. For example, Droege et al. (2021) show how circular disruptions are contingent on the action of policy entrepreneurs, whose success in pushing for change relies on individual attributes, such as their ambition, tenacity, and perfectionism. In an organizational perspective, Moktadir et al. (2020) identify leadership and top management commitment as the most critical success factor for CE practices, raking above the existence of strong CE legislation toward CE practices. This is crucial because the presence of legislation, though fundamental, does not guarantee that compliance will take place as intended. Hence, for a system to emerge and to facilitate transitions in a predetermined direction, strategic planning and coordination is important. The practices and strategies of firms acting as system integrators are crucial in leading this process (Nogueira et al., 2022; Zucchella & Previtali, 2019).

While attention to individual- and firm-level characteristics, motivations and critical success factors adds to the understanding of how transitions happen at the micro level, they fall short of producing an integrated understanding of the dynamics and process necessary for the transformation toward CE. In-depth investigations of this micro–mezzo interplay of individual actors and the systems in which they are embedded go beyond mere anecdotal evidence, and they matter as they provide a nuanced and context-dependent understanding that is crucial for policy and practice. For example, Gusmerotti et al. (2019) report that regulation, as well as environmental values and resource exploitation risks, exerts no significant influence in manufacturing firm's motivations to adopt circular business models; instead, it is economic drivers that promote engagement with CE practices. Our findings problematize the claim that regulation is negligible in promoting CE.

First, the absence of evidence is far from the same as evidence of the absence. We suggest that the ways in which the policies and more concrete regulation can influence CE transitions is nuanced and require a systemic perspective. Second, the very notion of "regulation" as a variable in a survey leaves room for respondents to have different interpretations on what counts as regulation. A question on compliance to legal requirements appears to be very specific, but a respondent might fail to see how legal requirements that do not apply directly to them might influence how they assess the attractiveness of adopting CE practices. We acknowledge that often actors find a way to comply with coercive regulation with as few changes as possible to their established practices, and it is reasonable to assume that the carrot of economic opportunity is a better driver of change than the stick of regulation. However, in this article, we adopt a broader view on regulation and the role of the public sector that goes beyond instruments specifically targeted to incentivize CE practices in any given sector. Regulations such as landfill bans might not directly make it for attractive conditions for a manufacturing firm to adopt CE practices, but it could lead to the emergence of market conditions in which the adoption of circular business models is an attractive proposition. In such instances, regulation is a forerunner to business opportunities. Another example stems from the connection between science and technology policy and the CE (Hermann et al., 2022), in which policy and regulations encourage market-enabling technologies to emerge and support what actors perceive as economic opportunities.

In short, this study emphasizes the need to explore waste-to-value innovation through a systems approach and process perspective, in addition to the individual-centric and firm-level investigations of CE practices and business models. This entails a shift from the strategies of individual firms to the collective strategy of actors seeking to bring about a CE transition. More research in the field of strategy is needed that emphasize this dynamic and the relationship between each actor's role in a value chain with the others', under the umbrella of social institutions and a strong regulatory setup. Continued engagement with the concept of circular ecosystems is a fruitful avenue in this pursuit.

7 | CONCLUSION

Innovation scholars have long argued that technological change requires a lot more than R&D and engineering: Innovations are embedded in institutional structures that influence their developmental paths and outcomes (Nelson & Winter, 1982; Rip & Kemp, 1998). Firm's strategies and business models also exist within the same landscape. As this article has explored, in line with Adner (2013), in addition to great ideas that are skillfully implemented, successful innovations are also contingent on how various actors in the ecosystem engage in support of delivering the VP to the market. More than technological impediments, it is aspects pertaining to higher-order systems that stand in the way of a widespread transition to CE models (Konietzko et al., 2020a).

Our analysis on the emergence of three instances of waste-to-value innovations highlights considerations on economic and noneconomic value, and the correspondent role of markets in advancing these heterogeneous value propositions. It postulates a relationship between the innovation's position in the waste hierarchy and the presence and effectiveness of markets. This article also brings to the forefront the extent to which innovative and incumbent actors are intertwined, as well as the role of the public sector in advancing transitions to the CE, not only though environmental policy but also through more direct action. Understanding issues such as how waste innovations reach the market and how markets for waste resources function is imperative for CE transitions.

In addition to providing examples of the CE in action, this article also contributes to the strategy and innovation management literatures. These fields most often address ecosystems as either empirical phenomena, such as multisided platforms (Jacobides et al., 2018), or as a normative tool for facilitating ecosystem design (Konietzko et al., 2020a; Talmar et al., 2018). Alternatively, we adopt it as an analytical framework, with the implication that success, effectiveness, or maturity are not preconditions of an ecosystem. This contributes to an emergent field that extends the use of this tool in the context of the CE (Kanda et al., 2021; Trevisan et al., 2022) and reduces the prevalence of innovation ecosystem studies afflicted by selection and success biases (Aldrich & Ruef, 2018).

A key takeaway from this article is that waste valorization innovations exhibit substantial systemic embeddedness and important ties with the incumbent waste sector. Moreover, environmental policies have been central in fostering innovation, and the public sector is imperative to the development of these initiatives. For policymakers, the implication is that they must consider how the waste management institutional setup serves and how it hinders transitions to a new institution in which waste resources have positive value. Waste valorization is essentially about attributing an economic value so that secondary resources can compete as substitutes to virgin materials in parallel markets. However, (free) markets alone are not able to assess and capture noneconomic values and to stimulate innovations in this context, as the presence of value is a precondition for trade. For this reason, the presence and effectiveness of markets appear to be related to the position of commodities in the waste hierarchy. Accordingly, policymakers must consider which actions can facilitate this shift in paradigm, including how they can directly support early initiatives for which markets will not work as a mechanism for driving and scaling waste valorization initiatives. In effect, these are cases in which materials exhibit a benefit to society and nature, even though they lack appeal to markets.

For practice, a key implication of our findings is that firms and individual innovators must consider how waste valorization initiatives fit with or disrupt the institutional setup in which they are embedded. Hence, they need to develop strategies that integrate how they engage with incumbent actors and competences to navigate the ambiguous task of disrupting an institution while building upon it. Although this is easier said than done, it is a central task involved in all instances of sustainability transitions. A crucial issue for further research is how this dynamic plays out in other sociopolitical contexts, especially where trust in public institutions is low, as are their competence and resources of the public sector. Moreover, as our findings indicate that the path that waste-to-value innovations go through on their way to markets is to a large extent influenced by incumbent actors and the politico-institutional landscape. Hence, future research ought to address the action of institutional entrepreneurs, from activist groups to political actors, in changing the policy landscape that sets the stage for the emergence of markets and that regulates the internalization of externalities.

ACKNOWLEDGMENTS

The authors are indebted to all participants and stakeholders and project partners involved in the research projects upon which we base our investigation, especially those who commented on our case vignettes. We also thank Adam King for help with language.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

AUTHOR CONTRIBUTIONS

Leticia A. Nogueira: Conceptualization, methodology, investigation, formal analysis, writing original draft, writing review and editing. **Bjarne Lindeløv**: Investigation, formal analysis, writing—review and editing, funding acquisition. **Julia Olsen**: Investigation, formal analysis, writing—review and editing.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Nogueira, L. A., Lindeløv, B., & Olsen, J. (2022). From waste to market: Exploring markets, institutions, and innovation ecosystems for waste valorization. *Business Strategy and the Environment*, 1–14. https://doi.org/10.1002/bse.3247