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Beyond Networking: Industrial Clusters as Institutional Orchestrators of CleanTech Innovation Ecosystems

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Abstract

Achieving a net-zero economy requires not only technological innovation but also institutional arrangements capable of coordinating collaboration among multiple stakeholders. While the technological dimension of the CleanTech transition has been extensively studied, less attention has been devoted to the governance mechanisms that enable innovation ecosystems to emerge and scale. This paper examines the CECV CleanTech Open Innovation +LATAM-Caribe programme as an exploratory qualitative case study of a cluster-led open innovation ecosystem. Drawing on programme documentation, stakeholder engagement and direct observation, it explores how industrial clusters orchestrate collaboration between large corporations, SMEs, start-ups, research organisations and public institutions. The findings indicate that clusters facilitate knowledge exchange, reduce coordination barriers, mobilise complementary capabilities and align innovation initiatives with the European Net-Zero Industry Act. Beyond networking, clusters emerge as trusted institutional intermediaries that strengthen governance and public-private collaboration. The study proposes a three-layer governance framework for analysing cluster-led collaboration in emerging CleanTech ecosystems. Its transferability and contribution to industrial decarbonisation require further empirical assessment.

Keywords

Energy Clusters, Innovation Ecosystems, Open Innovation, Ecosystem Orchestration, CleanTech, Sustainability Transition, Public-Private Collaboration, Knowledge Transfer, Net-Zero Industry Act, CECV

1. Introduction

The transition towards a net-zero economy has become the organising principle of European industrial policy. The European Green Deal set the objective of climate neutrality by 2050 (European Commission, 2019), the New Industrial Strategy for Europe placed the twin green and digital transitions at the core of competitiveness (European Commission, 2020), and the Net-Zero Industry Act (NZIA) established a framework to scale up the manufacturing capacity of strategic net-zero technologies within the Union (Regulation (EU) 2024/1735, 2024). These frameworks share a common premise: decarbonisation will not be achieved through isolated technological breakthroughs, but through the coordinated development, demonstration and adoption of clean technologies (hereafter, CleanTech) across entire industrial systems.

The subsequent evolution of EU industrial policy further clarifies this coordination challenge. The Competitiveness Compass identifies closing the innovation gap, decarbonisation and the reduction of strategic dependencies as interconnected priorities (European Commission, 2025a). The Clean Industrial Deal subsequently links industrial decarbonisation with competitiveness and the creation of lead markets for cleaner products (European Commission, 2025b). Read together, these policy documents provide an additional rationale for examining intermediary organisations capable of connecting technology providers, industrial users and public institutions. They do not, however, establish that any specific cluster programme has achieved the outcomes envisaged by these strategies.

This premise has important organisational implications. CleanTech solutions (solar generation, energy storage, renewable hydrogen, circularity, resource valorisation or industrial digitalisation) are typically complex, capital-intensive and dependent on complementary assets that no single organisation controls (Gaddy et al., 2017; Jacobides et al., 2018). Their deployment requires the combination of specialised technological knowledge held by start-ups and research organisations, the industrial capabilities and demand of large corporations, the agility of SMEs and the regulatory and financial support of public institutions (Doblinger et al., 2019; Huang et al., 2016). Open innovation, understood as the purposive use of inflows and outflows of knowledge across organisational boundaries, has therefore become a central strategy for firms engaged in the energy transition (Bogers et al., 2017; West & Bogers, 2014). Yet open innovation at the level of an ecosystem raises a governance problem: who convenes the actors, aligns their heterogeneous objectives, builds trust and turns a loose network into a functioning system of collaboration (Adner, 2017; Dhanaraj & Parkhe, 2006)?

While the technological dimension of the CleanTech transition has been studied extensively through the lenses of technological innovation systems and sustainability transitions (Hekkert et al., 2007; Markard et al., 2012), comparatively little attention has been devoted to the governance mechanisms that enable innovation ecosystems to emerge and scale. In particular, the role of *cluster organisations* (the institutional entities that manage and animate industrial clusters) remains undertheorised in the open innovation literature. Traditional cluster theory emphasises

the benefits of geographical concentration, specialised suppliers and knowledge spillovers (Delgado et al., 2014; Porter, 1998), and European cluster policy positions cluster organisations as facilitators of collaboration, networking and learning, and as providers or channels of specialised innovation support, particularly for SMEs (European Cluster Collaboration Platform [ECCP], n.d.-b). However, empirical research has repeatedly cautioned that proximity alone does not guarantee effective knowledge exchange (Boschma, 2005; Giuliani, 2007; Lee, 2009). This raises the question of what cluster organisations actually do to convert co-location into collaboration, technological adoption and scalable innovation.

This paper addresses that gap by examining the CECV CleanTech Open Innovation +LATAM-Caribe programme, promoted by the Cluster de Energía de la Comunitat Valenciana (CECV, the Energy Cluster of the Valencian Community, Spain), as an exploratory qualitative case study of a cluster-led open innovation ecosystem. The study is guided by two research questions:

- Q1. How do industrial cluster organisations orchestrate collaboration among large corporations, SMEs, start-ups, research organisations and public institutions to accelerate the development and adoption of CleanTech solutions?
- Q2. Which governance mechanisms enable a cluster-led open innovation ecosystem to align with European net-zero policy objectives and to scale across regions and countries?

The paper makes three contributions. First, it provides empirical evidence of how cluster organisations act as *institutional orchestrators* that connect policy, industry, research and entrepreneurship within a shared innovation ecosystem, extending the literature on innovation intermediaries (Howells, 2006; Kivimaa et al., 2019a) and network orchestration (Dhanaraj & Parkhe, 2006; Reypens et al., 2021) to the CleanTech domain. Second, it identifies four orchestration functions (knowledge exchange, reduction of coordination barriers, mobilisation of complementary capabilities and policy alignment) and integrates them into a three-layer governance framework. Third, it discusses the transferability of this framework to emerging CleanTech ecosystems in Latin America, building on previous work by the authors on public-private partnerships and cluster internationalisation in China (Irún et al., 2020, 2022a, 2022b).

The remainder of the paper is organised as follows. The next Section (Section 2) reviews the literature on open innovation ecosystems, clusters, innovation intermediaries and public-private governance in the CleanTech transition. Section 3 describes the methodology. Section 4 presents the case. Section 5 reports the findings, Section 6 discusses them and introduces the governance framework, and Section 7 concludes with limitations and avenues for future research.

2. Theoretical Background

2.1. Open Innovation and Innovation Ecosystems

Open innovation research has evolved from a firm-centric perspective, focused on how individual organisations source, integrate and commercialise external

knowledge (West & Bogers, 2014), towards a multilevel perspective that includes dyads, networks, ecosystems, regions and policy (Bogers et al., 2017). At the ecosystem level, the unit of analysis is no longer the focal firm but the set of interdependent actors whose joint contributions are necessary for a value proposition to materialise. Adner (2017) conceptualises the ecosystem as an *alignment structure* of the multilateral set of partners that need to interact for a focal value proposition to materialise, while Jacobides et al. (2018) argue that ecosystems are characterised by non-generic, unique or supermodular complementarities that cannot be fully governed through markets or hierarchies. Granstrand and Holgersson (2020) synthesise this literature by defining an innovation ecosystem as an evolving set of actors, activities and artifacts, together with the institutions and relations (both complementary and substitute) that matter for the innovative performance of an actor or population of actors.

Two complementary views coexist in this literature. The *ecosystem-as-structure* view emphasises the configuration of roles, positions and flows among partners, whereas the *ecosystem-as-coevolution* view emphasises how actors and their environment change together over time (Hou & Shi, 2021). Research on Chinese innovation ecosystems illustrates both dimensions. Xu et al. (2018), studying 3D printing in China, show that innovation ecosystems span scientific, technological and business subsystems whose coupling is neither automatic nor simultaneous, and Xie and Wang (2020) demonstrate, through a configurational analysis of Chinese firms, that different combinations of open innovation ecosystem modes can lead to high product innovation performance. For CleanTech, where the scientific, technological and market subsystems are often poorly synchronised (Gaddy et al., 2017), these insights suggest that ecosystems require deliberate coordination, rather than emerging spontaneously from market interactions.

2.2. From Agglomeration to Orchestration: Rethinking Clusters

Since Porter (1998) defined clusters as geographic concentrations of interconnected companies and institutions in a particular field, a large body of research has documented their economic effects. Delgado et al. (2014) show that industries located within strong regional clusters exhibit higher employment and patenting growth, and that new regional industries are more likely to emerge where a strong cluster environment is already present. The OECD (2007, 2009) has similarly highlighted clusters as vehicles for regional competitiveness, innovation and entrepreneurship, which explains their prominence in European regional and industrial policy.

The technological contribution of clusters is linked to their capacity to facilitate knowledge circulation between heterogeneous actors. Chyi et al. (2012), analysing the Hsinchu high-technology cluster in Taiwan region, find that external R&D spillovers are statistically significant in explaining firm net sales. Bathelt et al. (2004) argue that cluster dynamism results from the combination of *local buzz* (the dense, spontaneous exchange of information among co-located actors) and *global*

pipelines that connect the cluster with external sources of knowledge. In the CleanTech context, this mechanism is particularly relevant because the deployment of complex solutions frequently requires the combination of specialised technological knowledge, industrial capabilities and market experience distributed across corporations, SMEs, start-ups and research organisations.

At the same time, the benefits of clustering should not be interpreted as an automatic consequence of geographical or sectoral proximity. Lee (2009), using multi-country and multi-industry evidence, argues that proximity alone does not necessarily generate effective R&D knowledge spillovers and highlights the importance of mechanisms such as collaborative R&D and structured knowledge exchange. Boschma (2005) shows that geographical proximity is neither necessary nor sufficient for interactive learning, which also depends on cognitive, organisational, social and institutional proximity, and warns that excessive proximity may produce lock-in. Giuliani (2007) adds that knowledge networks within clusters are selective and uneven, concentrating among firms with stronger knowledge bases. Hervás-Oliver et al. (2021) show that SME innovation in European regions depends largely on firm-level drivers rather than on regional context alone, which reinforces the need for mechanisms that connect SMEs with external knowledge sources. Taken together, these qualifications suggest that the value of clusters in the CleanTech transition depends not only on bringing actors together, but on the existence of governance and orchestration capabilities that actively reduce coordination barriers and convert proximity into effective collaboration.

2.3. Innovation Intermediaries and Network Orchestration

The intermediary function of cluster organisations provides a theoretical explanation for their potential impact. Howells (2006) defines innovation intermediaries as organisations that act as agents or brokers in any aspect of the innovation process between two or more parties, and identifies functions that include foresight and diagnostics, scanning and information processing, knowledge processing and combination, gatekeeping and brokering, testing and validation, accreditation, regulation, protection of results, commercialisation and evaluation. Within industrial clusters, Zeng et al. (2010), using survey data from Chinese manufacturing SMEs, find that cooperation with other firms, intermediary institutions and research organisations is positively associated with SME innovation performance, which underlines the value of intermediated collaboration for smaller firms.

The literature on network orchestration complements this view by focusing on how a hub actor deliberately manages a network without hierarchical authority. Dhanaraj and Parkhe (2006) identify three orchestration processes (managing knowledge mobility, innovation appropriability and network stability) through which hub firms create and extract value from innovation networks. Batterink et al. (2010), studying innovation brokers in the agri-food sector, show that orchestration unfolds through the phases of innovation initiation, network composition

and innovation process management, and that brokers are particularly valuable for SMEs with limited absorptive capacity. Klerkx and Aarts (2013) demonstrate that orchestration is often distributed among multiple champions whose roles may conflict or complement each other, while Reypens et al. (2021) introduce the concept of *hybrid orchestration* to describe practices that mobilise multiple and diverse stakeholders across organisational boundaries in multi-stakeholder innovation networks.

In the field of sustainability transitions, Kivimaa et al. (2019a) propose a typology of transition intermediaries—systemic, regime-based, niche, process and user intermediaries—and emphasise that intermediaries not only connect actors but also articulate visions, aggregate lessons and contribute to destabilising incumbent regimes. This typology is relevant to cluster organisations, which may simultaneously represent established industrial interests and sponsor niche experimentation with new technologies.

A further distinction concerns the stage of transition at which intermediation occurs. Kivimaa et al. (2019b) examine how intermediary functions evolve across phases of sustainability transitions, including vision-building, networking, institutional support and capacity development. This temporal perspective suggests that the orchestration functions identified in the present study should not necessarily be treated as static: the relative importance of brokering, experimentation and support for scaling may vary as an innovation initiative matures. This is a theoretically informed proposition rather than a longitudinal finding established by the present case.

2.4. Public-Private Collaboration and Governance in the CleanTech Transition

CleanTech innovation is characterised by long development cycles, high capital requirements and regulatory uncertainty, features that make the venture-capital model poorly suited to the sector (Gaddy et al., 2017). Public actors therefore play a crucial role, not only as funders but also as partners. Doblinger et al. (2019) show that alliances between CleanTech start-ups and government partners are associated with higher innovation outcomes and follow-on financing, while Huang et al. (2016) attribute China's rise to leadership in solar photovoltaics to the interplay between entrepreneurial activity, market formation and sustained government support within a technological innovation system. From a policy perspective, mission-oriented approaches (Mazzucato, 2018) and transformative innovation policy (Schot & Steinmueller, 2018) call for instruments that provide directionality, articulate demand and coordinate across policy domains, thereby addressing the transformational system failures identified by Weber and Rohracher (2012).

The governance of public-private collaboration is, however, complex. In earlier work, Irún et al. (2020) show, using data from 180 agents involved in public-private partnership projects in China, that network market orientation acts as a relational governance mechanism that reduces the risk perceived by private

participants, with inter-organisational trust playing a central role. Monferrer et al. (2021) further show that network market orientation and entrepreneurial orientation foster international performance through ambidextrous dynamic capabilities. These findings suggest that relational governance (based on trust, shared information and coordinated responses to stakeholder needs) may be as important as contractual arrangements for sustaining multi-actor collaboration. The triple helix model (Etzkowitz & Leydesdorff, 2000) and the spatial perspective on sustainability transitions (Coenen et al., 2012) likewise emphasise that the interaction between universities, industry and government is embedded in specific regional institutional contexts, which is precisely where cluster organisations operate.

More recent EU policy explicitly recognises barriers between technological experimentation and market expansion. The EU Startup and Scaleup Strategy highlights difficulties associated with access to finance, markets, talent, infrastructure, networks and services, and proposes measures to address these constraints (European Commission, 2025c). This policy diagnosis strengthens the case for examining whether cluster-level intermediation can ease access to industrial partners and demonstration opportunities. It should nevertheless be distinguished from evidence that a particular intermediary has causally improved firm-level scaling outcomes.

2.5. Analytical Framework

Building on the preceding review, this study adopts an analytical framework that combines three bodies of literature: open innovation ecosystems, which define the *object* to be governed; innovation intermediation and network orchestration, which describe the *functions* performed by the orchestrator; and public-private relational governance, which explains the *conditions* that allow orchestration to be accepted as legitimate by heterogeneous actors. The framework guides the analysis towards four sensitising categories derived from the literature: 1) knowledge exchange and brokering (Bathelt et al., 2004; Howells, 2006); 2) reduction of coordination barriers (Dhanaraj & Parkhe, 2006; Lee, 2009); 3) mobilisation of complementary capabilities (Adner, 2017; Jacobides et al., 2018); and 4) policy alignment and directionality (Mazzucato, 2018; Weber & Rohracher, 2012).

3. Methodology

3.1. Research Design

Given the exploratory nature of the research questions and the limited theorisation of cluster-led orchestration in CleanTech ecosystems, the study adopts a qualitative single case study design (Eisenhardt, 1989). Case studies are particularly appropriate for answering *how* questions about contemporary phenomena embedded in their real-life context, and for building theory where existing frameworks are incomplete. The study follows an abductive logic: the sensitising categories identified in Section 2.5 informed data collection and analysis, while remaining open to emergent themes, following the recommendations of Gioia et al.

(2013) for qualitative rigour in inductive research.

3.2. Case Selection

The CECV CleanTech Open Innovation +LATAM-Caribe programme was selected as a revelatory case for three reasons. First, it is explicitly designed as a cluster-led open innovation programme that brings together large corporations, SMEs, start-ups, research organisations and public institutions around CleanTech challenges. Second, it is framed within the European net-zero policy architecture (the European Green Deal, the NZIA, the EU Strategy for Sustainable and Circular Textiles and the European Industrial Strategy) which allows examination of how orchestration connects ecosystem activities with policy objectives. Third, it extends a sequence of cluster programmes focused on internationalisation to Chinese mainland and Hong Kong SAR, open innovation in the agri-food sector (CECV, 2022) and artificial intelligence for sustainable transformation in energy-intensive sectors (CECV, 2025; Bayonne et al., 2025), which provides historical context for examining the evolution of the cluster's orchestration capabilities.

3.3. Data Sources

The study draws on three complementary sources of evidence, which are summarised in **Table 1**. The combination of documentary evidence, stakeholder engagement and direct observation allows data triangulation and reduces the risk of relying on a single perspective.

Table 1. Data sources used in the case study.

Source	Description	Use in the analysis
Programme documentation	Programme design documents, calls for challenges and solutions, presentations, reports of previous CECV programmes (2022, 2025), policy documents (European Green Deal, NZIA). n = 50 documents	Reconstruction of programme architecture, objectives and policy framing
Stakeholder engagement	Meetings, working sessions and informal interviews with cluster staff, challenge owners, start-ups, SMEs, research organisations and public representatives. n = 150 interactions; period 2020-2026	Identification of orchestration practices, perceived barriers and value of the cluster's role
Direct observation	Participant observation of ecosystem activities: challenge workshops, matchmaking sessions, pitch events, pilot follow-up meetings and dissemination events. n = 10 events	Observation of interactions in real time; triangulation of documentary and stakeholder evidence

3.4. Data Analysis

The analysis proceeded in three stages. First, programme documents and field notes were read repeatedly and coded into first-order concepts that described

orchestration activities in the participants' own terms (for example, "defining the challenge with the corporate", "pre-selecting start-ups", "preparing a pilot agreement"). Second, first-order concepts were grouped into second-order themes informed by the sensitising categories of the analytical framework. Third, second-order themes were aggregated into theoretical dimensions that constitute the building blocks of the governance framework presented in Section 6 (Gioia et al., 2013). To enhance trustworthiness, the emerging interpretation was discussed among the four authors, contrasted across data sources and shared with programme managers for member checking.

For analytical transparency, the distinction between evidence of orchestration activities and evidence of their effects is especially important. Documentary records and observations may establish that matchmaking, challenge definition or pilot facilitation took place; claims concerning additional investment, emissions reductions, commercial adoption or sustained internationalisation require corresponding outcome indicators and an appropriate observation period. Consequently, the functions described below are interpreted primarily as process-level findings, not as estimates of the programme's causal impact.

4. The Case: CECV CleanTech Open Innovation + LATAM-Caribe

4.1. The Energy Cluster of the Valencian Community

The Cluster de Energía de la Comunitat Valenciana (CECV, the Energy Cluster of the Valencian Community) is an industrial business association that brings together companies, technology centres, universities and other organisations linked to the energy value chain in the Valencian region of Spain. Its mission is to accelerate industrial decarbonisation, strengthen regional competitiveness and foster international collaboration between Europe and other regions, including Latin America and the Caribbean. Like other European cluster organisations, the CECV combines networking, collective services and innovation support for its members, in line with the definitions promoted by the European Cluster Collaboration Platform (ECCP, n.d.-a). Its activities are partly funded through the Generalitat Valenciana's calls for grants supporting non-economic activities that promote the reindustrialisation of the Valencian Community.

4.2. Evolution of the Cluster's Orchestration Capabilities

The programme analysed here builds on a sequence of cluster initiatives that progressively expanded the scope of the CECV's orchestration role. In 2021, the cluster developed a programme to generate new business opportunities for energy companies in the markets of Chinese mainland and Hong Kong SAR through innovation and sustainability strategies. This experience, analysed in previous work by the authors, highlighted the key role of European clusters as innovation ecosystems in the international promotion of member companies in strategic Chinese sectors such as net-zero technologies, smart cities, smart ports and smart factories,

particularly in the provinces of Guangdong and Hainan (Irún et al., 2022a, 2022b). In 2022, the CECV4SUSTAGRIFOOD programme applied open innovation strategies to promote collaborative projects and environmental sustainability in the agri-food sector (CECV, 2022). In 2025, the CECVImpulsaIA360 programme addressed the impact of artificial intelligence on the sustainable and digital transformation of energy-intensive sectors, structuring the orchestration process into sequential phases that run from prospecting and needs diagnosis to pilot design and impact evaluation (Bayonne et al., 2025; CECV, 2025).

4.3. Programme Architecture

The CECV CleanTech Open Innovation +LATAM-Caribe programme extends this trajectory by establishing a cluster-led open innovation ecosystem focused on CleanTech solutions aligned with EU net-zero priorities (solar generation, storage, hydrogen, circularity, digitalisation and resource valorisation) in sectors such as energy, agri-food, environmental services and energy-intensive industries. The programme connects demand-side actors (large corporations and industrial SMEs that formulate decarbonisation challenges) with supply-side actors (start-ups, technology-based SMEs and research organisations that propose solutions), while public institutions provide funding, regulatory guidance and policy legitimacy. Its international dimension links Valencian cluster members with CleanTech ecosystems in Latin America and the Caribbean.

The programme is organised into successive phases, each associated with deliverables and key performance indicators (KPIs). Throughout the cycle, the cluster organises dissemination events and facilitates access to information on relevant public funding instruments.

5. Findings

The analysis reveals that the CECV performs a strategic orchestration role that goes well beyond the traditional networking function associated with cluster organisations. Four orchestration functions were identified, together with a cross-cutting role as a trusted institutional intermediary. **Table 2** summarises the functions, the mechanisms through which they are enacted and their correspondence with the literature.

5.1. Facilitating Knowledge Exchange

The first function consists of facilitating the circulation of knowledge between actors that would otherwise rarely interact. The challenge-definition phase proved particularly important: by working with corporate and industrial partners to translate generic decarbonisation needs into well-specified technical challenges, the cluster made tacit industrial knowledge explicit and accessible to potential solution providers. Conversely, scouting and matchmaking activities exposed corporations to emerging technologies developed by start-ups and research organisations. This bidirectional brokering corresponds to the knowledge processing and gatekeeping

Table 2. Orchestration functions identified in the case.

Orchestration function	Mechanisms observed	Related literature
F1. Knowledge exchange	Challenge definition with corporates; scouting; matchmaking; dissemination events; international linkages	Bathelt et al. (2004); Howells (2006); Chyi et al. (2012)
F2. Reduction of coordination barriers	Standardised process; templates for challenges and pilot agreements; pre-screening; neutral negotiation space	Dhanaraj & Parkhe (2006); Lee (2009); Zeng et al. (2010)
F3. Mobilisation of complementary capabilities	Assembling start-ups, SMEs, research organisations, industrial testbeds and public support around each challenge	Adner (2017); Jacobides et al. (2018); Batterink et al. (2010); Doblinger et al. (2019)
F4. Policy alignment	Prioritising NZIA strategic technologies; framing results as decarbonisation impact; dialogue with policymakers	Mazzucato (2018); Schot & Steinmueller (2018); Weber & Rohracher (2012)
Cross-cutting: trusted intermediary	Neutrality; collective representation; legitimacy with regional government; continuity across programmes	Irún et al. (2020); Kivimaa et al. (2019a); Reypens et al. (2021)

functions described by Howells (2006), and illustrates how a cluster organisation can complement the *local buzz* of the regional ecosystem with *global pipelines* (Bathelt et al., 2004) connecting it to European and Latin American networks. It is consistent with the evidence that external R&D spillovers within clusters contribute to firm performance (Chyi et al., 2012), but shows that such spillovers are actively curated rather than spontaneous.

5.2. Reducing Coordination Barriers

The second function concerns the reduction of the transaction and coordination costs that typically hinder collaboration between large corporations and small innovators. Participants described asymmetries in size, time horizons, procurement procedures and risk tolerance as major obstacles to piloting new technologies. The cluster addressed these barriers by providing a standardised process, common templates for challenge descriptions and pilot agreements, pre-screening of candidate solutions and a neutral space for negotiation. These mechanisms reduce the uncertainty associated with knowledge mobility and appropriability, two of the core orchestration processes identified by Dhanaraj and Parkhe (2006), and support the argument of Lee (2009) that structured mechanisms, rather than proximity alone, are required to activate effective knowledge spillovers.

5.3. Mobilising Complementary Capabilities

The third function involves assembling, around each challenge, the combination of capabilities necessary to develop and demonstrate a solution. CleanTech pilots

typically required technological know-how from start-ups or research organisations, testing infrastructure and operational data from industrial partners, engineering and installation capacity from SMEs, and funding or regulatory support from public bodies. The cluster acted as the architect of these temporary configurations, which corresponds to Adner's (2017) view of the ecosystem as an alignment structure and to the role of innovation brokers in network composition (Batterink et al., 2010). This function was especially relevant for SMEs and start-ups, whose limited resources and legitimacy make it difficult for them to access industrial partners on their own (Zeng et al., 2010), and is consistent with the finding that alliances with public partners support CleanTech start-up innovation (Doblinger et al., 2019).

5.4. Aligning Innovation Initiatives with Net-Zero Policy Objectives

The fourth function concerns the alignment of ecosystem activities with the policy objectives established under the NZIA and related European frameworks. The cluster used the categories of strategic net-zero technologies to prioritise challenges, framed pilot results in terms of their contribution to industrial decarbonisation, and acted as an interlocutor between firms and regional and European policymakers. In this way, the orchestration process provided *directionality* to bottom-up open innovation, a function that transformative innovation policy considers essential to address directionality and coordination failures (Schot & Steinmueller, 2018; Weber & Rohracher, 2012). This also illustrates how mission-oriented objectives (Mazzucato, 2018) can be translated into concrete, firm-level collaborative projects at the regional scale.

The scope of policy alignment also requires differentiation. Regulation (EU) 2024/1735 establishes a specific framework for strengthening EU net-zero technology manufacturing, including provisions for strategic projects, while the Competitiveness Compass and the Clean Industrial Deal are broader Commission policy communications (Regulation (EU) 2024/1735, 2024; European Commission, 2025a, 2025b). Alignment with their objectives should therefore be assessed at the level of the relevant challenge or pilot, rather than inferred merely from the use of CleanTech terminology. This distinction matters when evaluating whether cluster activities support manufacturing capacity, industrial deployment or more general collaboration.

5.5. Clusters as Trusted Institutional Intermediaries

Across the four functions, a cross-cutting theme emerged: the effectiveness of orchestration depended on the cluster's position as a *trusted institutional intermediary*. Unlike a commercial broker or a single corporate hub, the cluster organisation was perceived as a neutral actor that represented the collective interest of the regional energy ecosystem, which facilitated the disclosure of challenges and the sharing of sensitive information. Its relationships with the regional government conferred legitimacy and convening power, while its membership base provided

continuity beyond individual projects. This relational foundation is consistent with the role of network market orientation and inter-organisational trust as relational governance mechanisms in public-private collaboration (Irún et al., 2020), and with the view that transition intermediaries derive their influence from their capacity to connect multiple levels of the system (Kivimaa et al., 2019a).

6. Discussion

6.1. A Three-Layer Governance Framework for Cluster-Led Open Innovation

The findings can be integrated into a governance framework composed of three interdependent layers (**Figure 1**). The *strategic alignment layer* connects the ecosystem with European and regional policy frameworks and provides directionality. The *ecosystem governance layer* comprises the relational and institutional conditions (neutrality, trust, shared rules and legitimacy) that allow the cluster to be accepted as orchestrator. The *operational orchestration layer* comprises the four functions identified in Section 5, which are enacted throughout the open innovation cycle. The framework links five types of actors to four intended outcomes: CleanTech adoption, industrial decarbonisation, regional competitiveness and internationalisation; and incorporates a feedback loop through which the evaluation of pilots informs new challenges, policy dialogue and inter-cluster cooperation.

From the framework, four propositions can be derived for future testing:

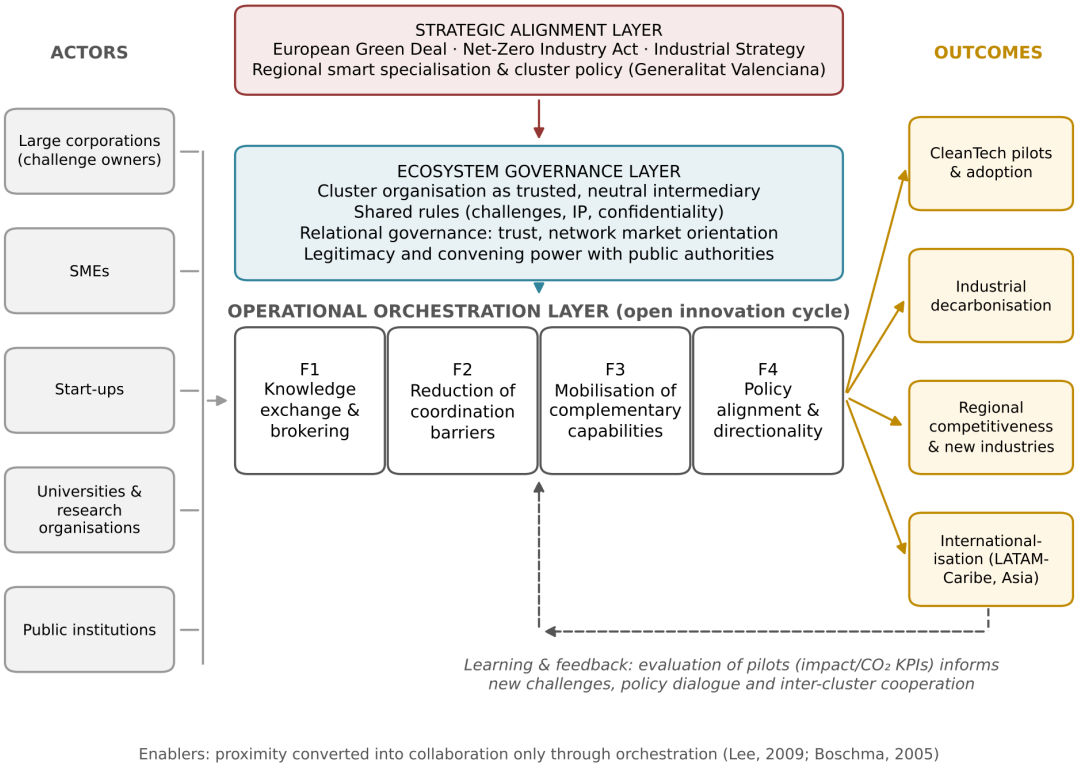


Figure 1. Three-layer governance framework for cluster-led open innovation in the CleanTech transition. Source: authors' elaboration.

- P1. The contribution of clusters to CleanTech innovation increases with the intensity of active orchestration, rather than with the mere density of co-located actors.
- P2. Cluster organisations perceived as neutral and trusted intermediaries are more effective in reducing coordination barriers between large corporations and small innovators than single-firm hubs.
- P3. Orchestration that explicitly aligns open innovation challenges with net-zero policy priorities increases the likelihood that pilots attract public support and progress towards scaling.
- P4. Inter-cluster and international linkages (global pipelines) increase the diversity of solutions available to regional challenge owners and the replicability of successful pilots.

6.2. Theoretical Contributions

The study contributes to the literature on open innovation ecosystems in three ways. First, it shifts the focus from the focal firm or platform leader as orchestrator (Dhanaraj & Parkhe, 2006; Jacobides et al., 2018) towards an *institutional* orchestrator whose legitimacy derives from its collective, non-commercial nature. This complements research on hybrid and distributed orchestration (Klerkx & Aarts, 2013; Reypens et al., 2021) by showing how a cluster organisation can combine the roles of broker, convenor and policy interlocutor. Second, the findings support the growing body of research that conceptualises industrial clusters as ecosystem orchestrators capable of enabling systemic innovation beyond firm-level collaboration, and specify the mechanisms through which proximity is converted into collaboration, addressing the qualifications raised by Boschma (2005), Giuliani (2007) and Lee (2009). Third, by connecting intermediation with relational governance (Irún et al., 2020; Monferrer et al., 2021), the study highlights that the effectiveness of orchestration rests on trust and network market orientation, and not only on formal programme design.

6.3. Economic Development Implications

From an economic development perspective, the relevance of cluster orchestration extends beyond the performance of individual firms. The evidence that industries located within strong regional clusters exhibit higher employment and patenting growth, and that new regional industries are more likely to emerge where a strong cluster environment is already present (Delgado et al., 2014), suggests that cluster-led innovation ecosystems may contribute simultaneously to technological dynamism, regional competitiveness and the development of new industrial activities. In the case analysed, the formation of cross-sectoral value chains linking energy, agri-food, environmental services and energy-intensive industries points to the potential of CleanTech orchestration to support related diversification within the regional economy. These results are consistent with European cluster policy, which positions cluster organisations as facilitators of collaboration,

networking and learning and as channels of specialised innovation support, particularly for SMEs (ECCP, n.d.-b; Hervás-Oliver et al., 2021).

6.4. Transferability to Emerging CleanTech Ecosystems in Latin America

The proposed governance framework provides an analytical basis for examining international collaboration; its scalability and transferability remain to be tested. The +LATAM-Caribe dimension of the programme shows how a regional cluster can act as a bridge between European and Latin American ecosystems, combining European policy frameworks with local industrial needs. The framework is also relevant for emerging CleanTech ecosystems in Asia. China's experience in solar photovoltaics shows that the combination of entrepreneurial experimentation, market formation and coordinated public support can rapidly scale a clean technology (Huang et al., 2016), while research on Chinese innovation ecosystems underlines the importance of coupling science, technology and business subsystems (Xu et al., 2018) and of configuring open innovation modes appropriately (Xie & Wang, 2020). The authors' previous work on public-private partnerships in China (Irún et al., 2020) and on the internationalisation of European cluster members in Guangdong and Hainan (Irún et al., 2022a, 2022b) indicates that relational governance and institutional intermediation are critical for European firms seeking to participate in Asian CleanTech ecosystems. Transfer should nevertheless be adaptive rather than mechanical, since the institutional, cognitive and organisational proximity that underpins orchestration differs across contexts (Boschma, 2005; Coenen et al., 2012).

The international dimension calls for a distinction between conceptual transferability and demonstrated external validity. The proposed framework offers categories with which to compare cluster programmes across jurisdictions, but its applicability in Latin American and Caribbean contexts will depend on such conditions as the mandate of intermediary organisations, access to industrial demonstration facilities, the continuity of public support and the ability to establish credible cross-border partnerships. Comparative evidence is therefore needed before concluding that similar orchestration practices will produce equivalent results across institutional settings (Boschma, 2005; Coenen et al., 2012).

6.5. Policy and Managerial Implications

For policymakers, the findings suggest that cluster policy should evolve from supporting generic networking activities towards funding and evaluating orchestration capabilities: challenge definition, matchmaking, pilot facilitation and impact assessment. Cluster organisations could be formally recognised as intermediaries in the implementation of the NZIA at regional level. For cluster managers, the findings highlight the importance of investing in neutrality and trust, of developing standardised yet flexible processes for corporate-start-up collaboration, and of measuring outcomes with environmental indicators that make the contribution of pilots

to decarbonisation visible. For firms, particularly SMEs and start-ups, participation in cluster-led ecosystems offers access to industrial partners, testing environments and international networks that would otherwise be difficult to obtain.

An evaluation agenda consistent with this argument would distinguish outputs, intermediate outcomes and longer-term impacts. Outputs could include documented challenges, screened solutions, facilitated meetings and initiated pilots; intermediate outcomes could include executed collaboration agreements, completed demonstrations and subsequent industrial adoption; longer-term impacts could include verified emissions reductions, repeat collaboration and commercial scaling. These are proposed evaluation dimensions, not newly measured results from the CECV programme. Where feasible, reporting should specify baselines, observation periods, the evidence source and the limitations of attributing outcomes to cluster orchestration alone.

7. Conclusions

This paper has examined how industrial clusters orchestrate open innovation ecosystems for the CleanTech transition, using the CECV CleanTech Open Innovation +LATAM-Caribe programme as an exploratory case. The findings show that the cluster performs four orchestration functions (facilitating knowledge exchange, reducing coordination barriers, mobilising complementary capabilities and aligning innovation initiatives with net-zero policy objectives) and suggest that these functions are supported by the cluster's position as a trusted institutional intermediary. Beyond their traditional networking function, clusters thus emerge as institutional orchestrators capable of strengthening governance, fostering public-private collaboration and enhancing regional innovation capacity. The three-layer governance framework proposed in this paper connects policy, industry, research and entrepreneurship within a shared ecosystem and provides an analytical model for examining how cluster orchestration may support industrial decarbonisation, regional competitiveness and international collaboration. These potential contributions require further outcome-based evaluation.

The study has limitations that suggest avenues for future research. First, as a single exploratory case study, its findings support analytical rather than statistical generalisation; comparative studies in other European regions, Latin America and Asia would help assess the framework's applicability across institutional contexts. Second, the study focuses on orchestration processes rather than long-term outcomes. Longitudinal research combining qualitative evidence with quantitative indicators is needed to assess industrial adoption, commercial scaling and verified environmental effects, and to distinguish the contribution of cluster orchestration from other influences. Finally, future research could examine how emerging technologies such as artificial intelligence modify the orchestration capabilities of cluster organisations, building on recent cluster programmes in energy-intensive sectors (Bayonne et al., 2025).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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