Collaborative Digital Innovation Ecosystems for a Just Energy Transition

Author & Presenter: P. MALEPE BTech Elec Eng, MBA – PhD Candidate at WBS
Co-author: N. OCHARA PhD (Information Systems) – Associate Professor at WBS

1. Introduction

The urgent need to address the multifaceted challenge of climate change has placed the energy sector at the forefront of global sustainability efforts prompting a paradigm shift towards the decentralization of energy systems. The rapid proliferation of digital technologies has led to digital innovation ecosystems, transforming business models which seeks to increase citizens participation in energy transition, and creating new opportunities for innovation. Therefore, the energy transition provides a suitable context for studying the development of innovation ecosystems (Kolloch & Dellermann, 2018). Digitalization plays a vital role in achieving adaptable, reliable, and sustainable energy systems by enabling real-time cross-sectoral coordination, leveraging data analytics, machine learning, and artificial intelligence for optimization and efficiency improvements.

Digital innovation ecosystems have the advantages of using digital resources to support innovation practices by facilitating collaboration among multiple stakeholders. However, the deployment of digital technologies is not without complexities and ambivalent impact on sustainability and social equity. Even with the presence of such complexities (Spigel, 2017), the digital innovation ecosystem is considered a significant factor in facilitating a shift towards a sustainable, just energy transition. However, there is a lack of a comprehensive and unified theoretical framework that explains how digitalisation can be effectively implemented and managed within the digital innovation ecosystem (Yingying Xu et al., 2023; Zhu et al., 2023).

The energy transition is not merely a technical or economic process; it is a significant social transformation. While essential for addressing climate change, it often risks exacerbating existing socio-economic inequalities, disproportionately affecting already vulnerable and disadvantaged communities. An exclusive focus on resource efficiency, for instance, may neglect to consider the social dimensions and potential risk for community marginalization. Consequently, there is an increasing imperative to ensure that energy transitions are just and inclusive, resulting in "just deep decarbonization" (Gantioler et al., 2023; Singh, 2023). This requires moving beyond a narrow technical perspective to consider the broader environmental and social impacts of energy transition and systems digitalisation.

Current research frequently emphasises the *what* and *where* of digitalization's influence on sustainability but pays little attention to the *how* and *why* (Pauliuk et al., 2022). To navigate and comprehend this complexity, the paper proposes a meta-theory framework for understanding Collaborative Digital Innovation Ecosystems for a Just Energy Transition. This framework integrates concepts from Critical Realism and Actor-Network Theory, underpinned by a system thinking approach. By integrating these theoretical lenses, we aim to provide a more thorough and perceptive comprehensive understanding of how the emergent ecosystems form, evolve, and can be steered towards just and sustainable outcomes. This integrated perspective acknowledges the dynamic interactions between diverse actors, both human and non-human, the underlying social structures that enable or constrain their actions, and the multi-scalar nature of energy transitions.

2. Theoretical Foundation

The paper is grounded in Critical Realism philosophy, specifically from Roy Bhaskar’s perspective of transcendental realism and ontological stratification. Critical Realism philosophical framework allows for the exploration of underlying causal mechanisms and structures that shape the interaction between actors (both human and non-human) within the digital innovation ecosystem, emphasising the coexistence of multiple layers of reality (Bhaskar, 2016; Geels, 2022; Stohr et al., 2024). To operationalise this approach, the paper adopts the Actor-Network Theory to analyse how socio-technical configurations, and the "scripts" embedded within digital technologies are co-created and interpreted by heterogeneous actors within the digital innovation ecosystem. The study aims to develop a meta-theory framework on how heterogeneous actors collaborate in shaping the digitalization process for just and sustainable energy futures.

The paper's contribution is twofold, encompassing both methodological and practical aspects. Methodologically, the paper enriches the Actor-Network Theory by providing a framework for analysing the dynamic co-evolution of digital artifacts and societal transitions. From a practical viewpoint, the paper contributes to the urgent need for integrated policy framework that promotes the multi-actor governance models for digital innovation ecosystems. The framework provides practitioners with a deeper understanding of the structural and causal mechanisms shaping the just energy transition programme in South Africa.

3. Literature Review

The following section of the study introduces the concept of digital innovation ecosystem design and its relevance to the energy transition through literature review.

3.1. Digital Innovation Ecosystems

Digital innovation ecosystems are created via the establishment of interactions among digital innovators. The significance of digital innovation ecosystems is emphasised, which refers to a comprehensive network consisting of organisations, individuals, technology, and processes that are involved in the development and implementation of digital innovations (Suseno et al., 2018; Y. Xu et al., 2023). As such Wang (2021) defines digital innovation ecosystem as "a loosely coupled set of independent actors involved in the development and implementation of innovations enabled by digital technologies."

Digital innovation ecosystems have the capacity and benefit of using digital resources to foster innovation practises by facilitating collaboration among multiple stakeholders. Accordingly, Wolsink (2024b) argues that the integration of Information and Communication Technologies into the energy systems has shown the possibility for real-time management, which can enable the incorporation of different variable energy sources into the grid. However, the validity of this assertion is largely contingent upon the way Information and Communication Technology is implemented, the individuals responsible for its deployment, and their intended objectives.

Moreover, Kindermann et al. (2022) argued that the mechanisms to orchestrate and govern innovation ecosystems are hence essential for digital innovation success. The authors further reiterate that executing such mechanisms often lies in the hands of a central actor, the orchestrator. The orchestrator is the ecosystem hub firm that, due to "individual attributes such as size, technological leadership, or unique resources and capabilities" (Giudici et al., 2018) possesses the prominence and power (Dhanaraj & Parkhe, 2006) to lead the process of aligning the various interests and activities of ecosystem members towards a common value proposition (Adner, 2017).

In summary, the proliferation of digital technologies has profoundly impacted various sectors, giving rise to digital platform ecosystems that serve as breeding grounds for innovative business ideas and models. These ecosystems are dynamic, multi-actor, and often multi-platform environments where diverse actors collaborate for the purpose of value creation and co-creation and value capture. The digital transformation can further lead to the emergence of meta-ecosystems, where different individual ecosystems collaborate to produce a joint value proposition for customers, rather than competing for the same customers. This signifies interconnected business models of multiple ecosystems, often coordinated by multiple orchestrators adding to the complexity of digital innovation ecosystems.

3.2. Role of Digitalization in Energy Transitions

According to Gantioler et al. (2023), digital technologies are considered a key driver of socio-technical and environmental transformation processes within the energy sector as summarized in table 1 below. This view is further supported by Diaz Valdivia (2023) who argued that digitalization in energy systems encompasses the increasing application of Information and Communication Technologies (Wolsink, 2024a), Artificial Intelligence, Internet of Things, and blockchain technology to govern physical infrastructures for energy production, transformation, transmission, distribution, consumption, and storage. This enables:

Table 1: The role of digitalization in energy transition

Role	Description
Enhanced Efficiency (Diaz Valdivia, 2023)	Using data analytics capabilities to uncover patters and predict demand and/or supply fluctuations, Machine Learning algorithms to automate decision-making and adapt to changing conditions, and Artificial Intelligence to optimise real-time operations.
Improved Coordination (Gantioler et al., 2023; Sareen, 2021; Sjödin et al., 2023)	Facilitate fair organisation of supply and demand in decentralised networks with multiple producers and consumers. Support coordination across diverse actors, technologies, and geographies. Enable transparent and just energy distribution critical for just oriented energy transition.
Development of New Business Models (Diaz Valdivia, 2023; Wittmayer et al., 2022)	Digital platforms enable the development of new market models, actor configurations, and institutional settings for social innovation in energy.
Improved Governance and Transparency (Hojnik et al., 2023; Wolsink, 2024a)	Digitalization can enhance transparency, control, and manageability of technological innovations, reducing energy consumption and environmental impact.

3.3. Collaboration and Challenges in Digital Innovation Ecosystems

As stated in the preceding section, collaboration is considered a key driver of innovation in digital ecosystems, often prioritizing collaborative efforts over competitive strategies (Oliver et al., 2025). However, it also faces its own significant challenges such as those highlighted in table 2 below.

Table 2: Challenges of collaboration in digital innovation ecosystems

Challenge	Description
Complexity Management (Sjödin et al., 2024)	Promoting continuous value co-creation and sustainable development with nonlinear interactions among actors can be complex, requiring effective ecosystem management capabilities, including strategic foresight, integration, and governance.
Systemic Vulnerabilities (Ungureanu et al., 2025)	In digital ecosystems, particularly those leveraging nascent technologies like blockchain, failures can undermine the reputation of the core technology and the survival of the ecosystem.
Power Imbalance (Chung et al., 2025)	Policy discussions often *'prioritize grand'* narratives that value energy as a commodity, potentially disregarding pathways that emerge from valuing energy as a common good.
Social Exclusion (Sareen, 2021)	Despite the promise, the benefits of energy transition are not always fairly distributed, often exacerbating existing social disparities.
Unintended Consequences	Rebound Effects and Disregard for Diverse Narratives.

In essence, successful collaborative digital innovation ecosystems for just energy transition require careful navigation of technological advancements, economic incentives, and social implications through collaborative efforts, robust governance mechanisms, and an awareness of potential pitfalls.

3.4. The Actor-Network Theory

According to Caprotti et al. (2020), the dynamic nature of South Africa's energy landscape is seen when a conceptual lens informed by Actor-Network Theory is deployed. Unsing the Actor-Network Theory, the authors found a shifting patterns of agency, power dynamics and actor networks. As such, the Actor-Network Theory offers a powerful methodological lens for analysing the development and dynamics of socio-technical systems, particularly relevant for understanding complex phenomena like energy transitions and digital innovation ecosystems.

To understand the stakeholders, a two-dimensional matrix (Eden & Ackermann, 1998) that uses power and interest to map actor classifications for sustainable energy projects is utilized as depicted in figure 1 below. Actor-Network Theory views realities as networked and unstable, discursively and materially constructed and performed through the interactions of heterogeneous actors (Berrou & Soulier, 2023).

High influence, low interest (High substantial power with no strong interest in energy transition.)	**High influence, high interest** (Significant power to affect the outcome of energy transition and vested interest in the outcome.)
Low influence, low interest (Minimal impact on and concern for energy transition.)	**Low influence, high interest** (Highly interested in the outcome of energy transition but lacks the influential power to significantly influence it.)

Figure 1: Two-Dimensional power-interest matrix for stakeholder mapping (Eden & Ackermann, 1998)

3.5. Understanding Energy Transition and Digitalization through CR Perspective

Applying a Critical Realist lens to collaborative digital innovation ecosystems for just energy transition involves the following:

Table 3: Application of Critical Realism paradigm to energy transition

Elements	Description
Uncovering Causal Mechanisms	Critical Realism helps identify how digitalization, rather than being a neutral force, interacts with existing power structures and institutional arrangements to produce specific outcomes in energy transitions. For example, policy developments and instruments are assumed to shape technological innovation and consumer behavior. Critical Realism would interrogate the underlying mechanisms through which these policies actually exert their influence, considering potential unintended consequences (Gantioler et al., 2023).
Addressing Normative Considerations and Value Systems	Critical Realism enables a deeper exploration of normative considerations, worldviews, and value systems that shape deep deliberative transformations in energy policy. It recognizes that debates on deep decarbonization involve competing "grand narratives", one valuing energy as a commodity and another valuing energy as a common good.

Elements	Description
Contextual Sensitivity	Critical Realism emphasizes that mechanisms operate differently in various contexts (Csedő et al., 2025; Gantioler et al., 2023; Kruger & Steyn, 2024; Speich & Ulli-Beer, 2023). The success of digital innovation in energy is highly dependent on the geographical, political, cultural, and industry structures in which it is embedded. For instance, a policy in one region might have different effects than in another due to historical path dependencies or specific local political cultures.
The Interplay of Agency and Structure	The framework of strong structuration theory provides a conceptualization that integrates agency (actors' intentions and actions) and structure (the social rules and resources that enable or constrain action). It recognizes that collective agency, characterized by "shared intentions," is shaped by both individuals' internal psychological structures and the institutional and material structural environment. This is crucial for understanding how governance actors develop capacities for transformative change in regional energy transitions (van Dijk et al., 2025).

3.6. A Conceptual Meta-Theory Framework Structure

Table 4: A Conceptual Meta-Theory framework structure

Component	**Description**
Actor Collaboration	Cross-sector and cross-functional partnerships including community participation.
Adaptability	Framework flexibility for regional customization.
Complexity	
Digital Economy Integration	Repurpose existing infrastructure and optimise operations. Information flows enabling reallocation enhancing governance mechanisms.
Digital Technologies	Data analytics, Machine Learning, Artificial Intelligence, Internet of Things, etc.
Governance	Effective coordination structures, address power imbalances.
Just Transition Principles	Inclusive value co-creation and benefit distribution.
Open Innovation	Key drivers of systemic transformation – Joint ventures and cross-sector platforms.
Policy & Institutional Support	Power imbalances, incentives and regulations.
Socio-Technical System	Systemic transformation, knowledge network and institutional logic.

By adopting Critical Realism, the meta-theory framework moves beyond merely describing the "what" of collaborative digital innovation ecosystems for just energy transition to critically examine the "how" and "why," revealing the generative mechanisms and underlying structures that shape outcomes and identifying points of leverage for achieving a more just and sustainable energy future.

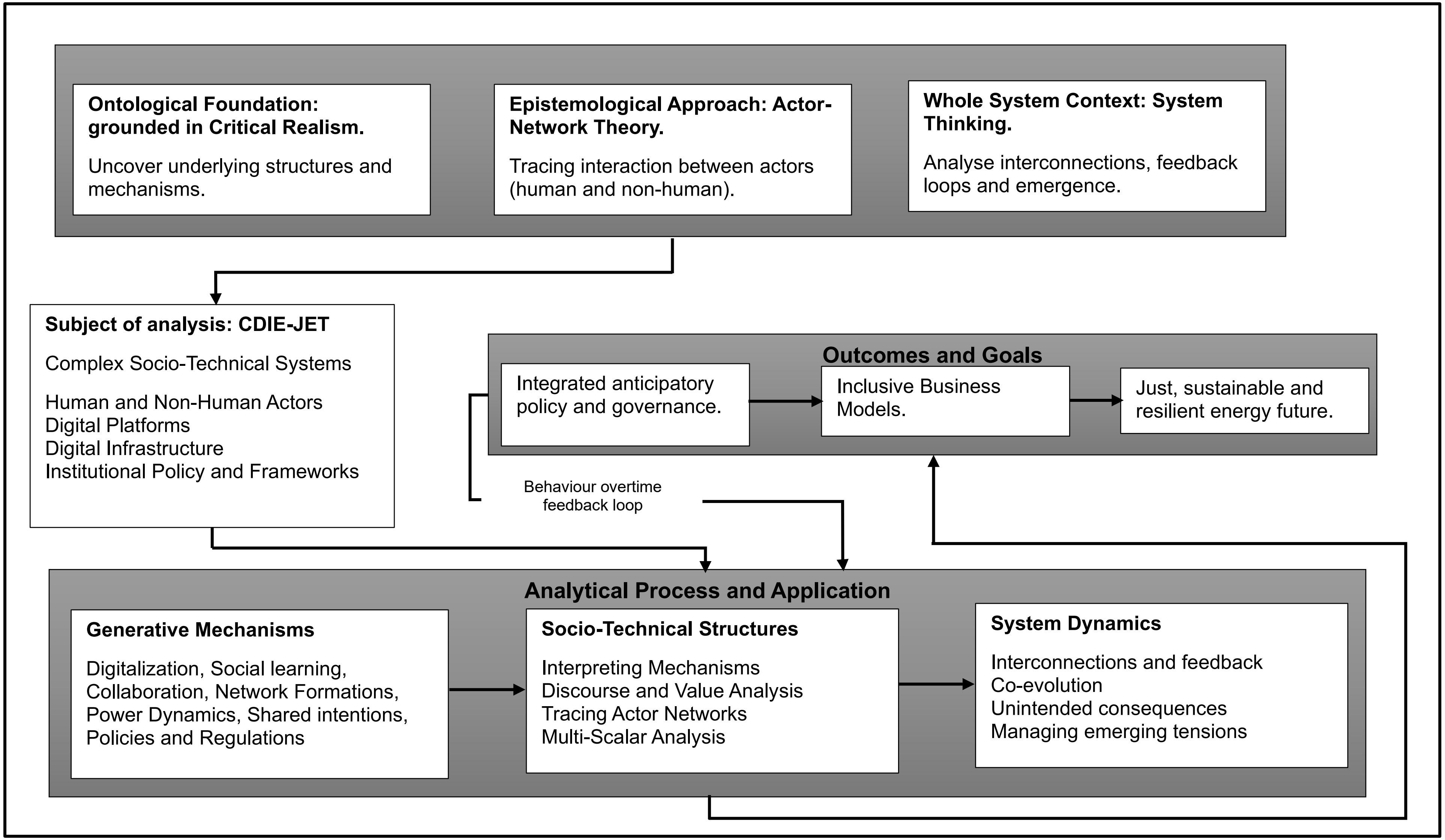

Figure 2:Conceptual Meta-Theoretical Framework

4. The proposed Meta-Theory Framework

The proposed conceptual meta-theory framework for collaborative digital innovation ecosystem for a just energy transition is summarised by figure 2. The framework synthesizes the strengths of Critical Realism and Actor-Network Theory, integrated through a system thinking approach. It provides a multi-dimensional understanding of how these complex socio-technical systems emerge, function, and can be purposively steered towards just and sustainable energy futures. This integration moves beyond a fragmented view to offer a more coherent and robust analytical lens.

4.1. Structures and Mechanisms

From a Critical Realist perspective, digital innovative ecosystems are understood as emergent phenomena underpinned by deeper, often unobservable, structures and mechanisms (Heymann et al., 2025). Actor-Network Theory helps to empirically map the actual manifestations of these structures as networks of heterogeneous actors (Berrou & Soulier, 2023).

a) **Generative Mechanisms:**

- **Digitalization:** According to Gantioler et al. (2023), there is an increasing application of Information and Communication Technologies, Artificial Intelligence, Internet of Things, and Blockchain technologies. This acts as a powerful generative mechanism, enabling new forms of energy production, distribution, consumption, and governance. This mechanism facilitates the creation of platforms, data flows, and automated processes (Diaz Valdivia, 2023).
- **Collaboration and Network Formation:** The collaborative mechanisms of digital innovation ecosystems are driven by the inherent need for diverse actors to co-create value in complex socio-technical transitions (Oliver et al., 2025). The Actor-Network Theory's concept of translation explains how these networks are formed and maintained. Critical Realism further probes the underlying social and power structures that enable or constrain these translations (Sjödin et al., 2024).
- **Institutional Frameworks and Policies:** Regulatory environments, policy incentives, and governance capacities of public actors are crucial structures that enable or constrain the emergence and direction of digital innovation ecosystems. These institutional mechanisms can promote or impede innovation and the just distribution of benefits (Colovic et al., 2025; Speich & Ulli-Beer, 2023; van Dijk et al., 2025).
- **Shared Intentions and Social Learning:** The development of collective agency among diverse actors, rooted in "shared intentions," is a key mechanism for developing capacities for transformative change (van Dijk et al., 2025). This is reinforced by social learning processes through which actors collectively respond to challenges, learn from past experiences, and systematically question underlying assumptions (Csedő et al., 2025).

b) **Emergent Structures and Pathways:** According to Speich and Ulli-Beer (2023) digital innovation ecosystems are not simply collections of elements but complex adaptive systems where interactions at the micro-level dynamically reconfigure meso-level socio-technical regimes and contribute to macro-level sustainability transformations.

4.2. Tracing Networks and Discourses

The meta-theory framework adopts an epistemological approach that combines Actor-Network Theory's detailed tracing of socio-technical networks with Critical Realism's interpretive depth, enabling a comprehensive analysis from the empirical to the real.

a) **Tracing Actant-Networks (ANT):** The study by Berrou and Soulier (2023), found that the emergence of localised ecosystem networks can be analysed through Actor-Network Theory modelling, identifying "Socio-Energetic Nodes" and the relationships between various actors.

b) **Interpreting with Critical Realism:** Critical Realism then provides the means to interpret these observed networks and their dynamics by referring to deeper generative mechanisms (Gantioler et al., 2023; Heymann et al., 2025). For example, tracing digital servitization business models in ecosystems (actual) allows for an understanding of how digital capabilities (real mechanism) mediate venture growth and performance (Kamble et al., 2023; Shen et al., 2023).

c) **Discourse Analysis and Value Systems:** The framework emphasizes uncovering and making visible the "grand narratives" and associated value systems that define pathways (Gantioler et al., 2023). This involves analysing how these narratives are iterated and reinforced in discourses, shaping the capacity to act and the structuring of institutions and policies. This directly links the empirical (discourse) to the real (underlying values and structures).

d) **Multi-Scalar Analysis:** The framework explicitly considers multi-scalar dynamics, recognizing that energy transitions unfold across local, regional, national, and global scales (Sareen, 2021; Schmidt-Scheele & Mattes, 2025). Actor-Network Theory helps to trace the translation of agendas and policies across these scales, while Critical Realism allows for identifying how structural conditions at different scales exert causal influence on local outcomes (van Dijk et al., 2025).

4.3. Interconnections and Feedback Loops

System thinking provides the overarching perspective, emphasizing the interconnectedness of elements, feedback loops, and emergent properties within the digital innovation ecosystem.

a) **Holistic View of Ecosystems:** According to Speich and Ulli-Beer (2023), digital innovation ecosystems are viewed as dynamic webs of entities with interlinked business models, a pool of resources, and orchestration processes (Shen et al., 2023). Digital platforms, in this context, function as shared resources and orchestrators, facilitating collaboration and value co-creation. The framework acknowledges the "eco" in innovation ecosystem, recognizing that actors operate within complex adaptive systems (Yingying Xu et al., 2023).

b) **Feedback Loops and Co-evolution:** The framework highlights the co-evolutionary aspects of digital innovation ecosystems, where systemic innovations require contributions and adaptations from various actors, co-evolving with institutions, infrastructure, and industry structure (Speich & Ulli-Beer, 2023). Feedback loops exist between technological advancements, social practices, and institutional settings, constantly shaping and reshaping the system (Cerchione et al., 2025; Csedő et al., 2025). This means that the impact of digital servitization, for example, is not linear but involves complex interactions between resources, processes, and outcomes (Sassenou et al., 2025; Sjödin et al., 2024).

c) **Managing Paradoxical Tensions:** Within digital innovation ecosystems, companies face paradoxical tensions between flexibility and efficiency, control and autonomy, and standardization and customization (Shen et al., 2023). Effective ecosystem management involves developing solutions to navigate these tensions.

d) **Addressing Unintended Consequences:** System thinking necessitates a holistic approach to address unintended consequences and "rebound effects" of digitalization and circular economy initiatives (Cerchione et al., 2025). This requires developing holistic assessment tools that evaluate environmental, social, and economic factors to identify and mitigate negative impacts early in a project's lifecycle (Chung et al., 2025). It also calls for participatory governance models that maximize social capital and minimize environmental impact (Chung et al., 2025).

In sum, the integrated meta-theory framework of Critical Realism, Actor-Network Theory, and system thinking provides a powerful analytical scaffold. It allows for a deep understanding of digital innovation ecosystems by revealing the underlying causal structures, mapping the dynamic networks of human and non-human actors, acknowledging multi-scalar interactions, interpreting competing discourses and value systems, and recognizing the co-evolutionary and feedback-driven nature of these complex socio-technical systems.

5. Conclusion

The transition to a sustainable and decarbonised energy system is a complex socio-technical transformation that demands a comprehensive and integrated understanding. This paper has presented a conceptual meta-theory framework for digital innovation ecosystems for a just energy transition drawing on the complementary insights of Critical Realism and Actor-Network Theory, grounded in Systems Thinking.

By applying Critical Realism paradigm, we emphasize the importance of moving beyond empirical observation to uncover the underlying causal mechanisms and social structures that shape the development and outcomes of digital innovation ecosystems. This perspective allows for a nuanced understanding of why certain phenomena occur and how deep decarbonisation pathways are shaped by these deeper realities.

The Actor-Network Theory provides the methodological tools to empirically trace the dynamic, heterogeneous networks of human and non-human actors that constitute these ecosystems. It highlights the process of translation through which actors are enrolled, and interests are aligned (or misaligned) revealing the emergent nature of these socio-technical systems across multiples scales.

Integrated through Systems Thinking, the framework underscores the interconnectedness, co-evolutionary dynamics, feedback loops, and emergent properties inherent in digital innovation ecosystems. It highlights how digital platforms function as a critical orchestrator and shared resource, while also drawing attention to the paradoxical tensions and unintended consequences that arise from digitalisation. The framework provides holistic view, acknowledging that these ecosystems are not merely technical constructs but deeply embedded in social, cultural, and political contexts.

Ultimately, the proposed meta-theory framework offers a robust conceptual tool for academics, policymakers, and practitioners to better understand, analyse and actively promote digital innovation ecosystems.

REFERENCES

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of management*, *43*(1), 39-58.

Berrou, Y., & Soulier, E. (2023). A Methodology to Analyze the Development of Local Energy Communities Based on Socio-Energetic Nodes and Actor-Network Theory. *Procedia Computer Science*, *219*, 439-446.

Bhaskar, R. (2016). *Enlightened common sense: The philosophy of critical realism*. Routledge.

Caprotti, F., Essex, S., Phillips, J., de Groot, J., & Baker, L. (2020). Scales of governance: Translating multiscalar transitional pathways in South Africa's energy landscape. *Energy Research & Social Science*, *70*, 101700.

Cerchione, R., Morelli, M., Passaro, R., & Quinto, I. (2025). Balancing sustainability and circular justice: The challenge of the energy transition. *Journal of Cleaner Production*, *494*, 144942. https://doi.org/https://doi.org/10.1016/j.jclepro.2025.144942

Chung, L., Tan, K. H., & Yoshie, O. (2025). Sustainable circular economy: Unpacking the unintended consequences of digital transformation in Japanese SMEs. *Technological Forecasting and Social Change*, *221*, 124335. https://doi.org/https://doi.org/10.1016/j.techfore.2025.124335

Colovic, A., Caloffi, A., Rossi, F., & Russo, M. (2025). Institutionalising the digital transition: The role of digital innovation intermediaries. *Research policy*, *54*(1), 105146. https://doi.org/https://doi.org/10.1016/j.respol.2024.105146

Csedő, Z., Zavarkó, M., Sára, Z., & Pörzse, G. (2025). Exploring the role of transdisciplinary research in accelerating sustainability transition: an empirical analysis of environmental innovation drivers in Central European energy sector. *Energy Research & Social Science*, *127*, 104222. https://doi.org/https://doi.org/10.1016/j.erss.2025.104222

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating innovation networks. *Academy of Management Review*, *31*(3), 659-669.

Diaz Valdivia, A. (2023). Between decentralization and reintermediation: Blockchain platforms and the governance of 'commons-led' and 'business-led' energy transitions. *Energy Research & Social Science*, *98*, 103034. https://doi.org/https://doi.org/10.1016/j.erss.2023.103034

Eden, C., & Ackermann, F. (1998). *Making strategy: The journey of strategic management*. Sage.

Gantioler, S., Balest, J., Tomasi, S., Voltolini, F., & DellaValle, N. (2023). Transformative disruptiveness or transition? Revealing digitalization and deep decarbonization pathways in the Italian smart electricity meter roll-out. *Energy Research & Social Science*, *106*, 103309. https://doi.org/https://doi.org/10.1016/j.erss.2023.103309

Geels, F. W. (2022). Causality and explanation in socio-technical transitions research: Mobilising epistemological insights from the wider social sciences. *Research policy*, *51*(6), 104537.

Giudici, A., Reinmoeller, P., & Ravasi, D. (2018). Open-system orchestration as a relational source of sensing capabilities: Evidence from a venture association. *Academy of Management Journal*, *61*(4), 1369-1402.

Heymann, F., Küfeoğlu, S., & Galus, M. (2025). Digitalization, autonomy and the future of energy policy. *Energy Research & Social Science*, *127*, 104167. https://doi.org/https://doi.org/10.1016/j.erss.2025.104167

Hojnik, J., Ruzzier, M., Konečnik Ruzzier, M., Sučić, B., & Soltwisch, B. (2023). Challenges of demographic changes and digitalization on eco-innovation and the circular economy: Qualitative insights from companies. *Journal of Cleaner Production*, *396*, 136439. https://doi.org/https://doi.org/10.1016/j.jclepro.2023.136439

Kamble, S., Rana, N. P., Gupta, S., Belhadi, A., Sharma, R., & Kulkarni, P. (2023). An effectuation and causation perspective on the role of design thinking practices and digital

capabilities in platform-based ventures. *Technological Forecasting and Social Change*, *193*, 122646. https://doi.org/https://doi.org/10.1016/j.techfore.2023.122646
Kindermann, B., Salge, T. O., Wentzel, D., Flatten, T. C., & Antons, D. (2022). Dynamic capabilities for orchestrating digital innovation ecosystems: Conceptual integration and research opportunities. *Information and Organization*, 100422.
Kolloch, M., & Dellermann, D. (2018). Digital innovation in the energy industry: The impact of controversies on the evolution of innovation ecosystems. *Technological Forecasting and Social Change*, *136*, 254-264.
Kruger, S., & Steyn, A. A. (2024). Developing breakthrough innovation capabilities in university ecosystems: A case study from South Africa. *Technological Forecasting and Social Change*, *198*, 123002. https://doi.org/https://doi.org/10.1016/j.techfore.2023.123002
Oliver, P. G., Mora, L., & Zhang, J. (2025). Collaboration before competition: How smart city entrepreneurs co-create temporary ecosystems to build capacity for learning. *Technological Forecasting and Social Change*, *214*, 124046. https://doi.org/https://doi.org/10.1016/j.techfore.2025.124046
Pauliuk, S., Koslowski, M., Madhu, K., Schulte, S., & Kilchert, S. (2022). Co-design of digital transformation and sustainable development strategies-What socio-metabolic and industrial ecology research can contribute. *Journal of Cleaner Production*, *343*, 130997.
Sareen, S. (2021). Digitalisation and social inclusion in multi-scalar smart energy transitions. *Energy Research & Social Science*, *81*, 102251. https://doi.org/https://doi.org/10.1016/j.erss.2021.102251
Sassenou, L.-N., Olivieri, L., Kotnarovsky, G., Longo, D., & Olivieri, F. (2025). Companion modelling for energy transition: A participatory approach to design positive energy districts in Mediterranean cities. *Energy Research & Social Science*, *127*, 104175. https://doi.org/https://doi.org/10.1016/j.erss.2025.104175
Schmidt-Scheele, R., & Mattes, J. (2025). Unravelling the relationship between digitalisation and sustainable energy transitions using socio-technical-ecological scripts. *Environmental Innovation and Societal Transitions*, *56*, 100994.
Shen, L., Sun, W., & Parida, V. (2023). Consolidating digital servitization research: A systematic review, integrative framework, and future research directions. *Technological Forecasting and Social Change*, *191*, 122478. https://doi.org/https://doi.org/10.1016/j.techfore.2023.122478
Singh, M. K. (2023). What is state capacity and how does it matter for energy transition? *Energy Policy*, *183*, 113799.
Sjödin, D., Liljeborg, A., & Mutter, S. (2024). Conceptualizing ecosystem management capabilities: Managing the ecosystem-organization interface. *Technological Forecasting and Social Change*, *200*, 123187. https://doi.org/https://doi.org/10.1016/j.techfore.2023.123187
Sjödin, D., Parida, V., & Kohtamäki, M. (2023). Artificial intelligence enabling circular business model innovation in digital servitization: Conceptualizing dynamic capabilities, AI capacities, business models and effects. *Technological Forecasting and Social Change*, *197*, 122903. https://doi.org/https://doi.org/10.1016/j.techfore.2023.122903
Speich, M., & Ulli-Beer, S. (2023). Applying an ecosystem lens to low-carbon energy transitions: A conceptual framework. *Journal of Cleaner Production*, *398*, 136429. https://doi.org/https://doi.org/10.1016/j.jclepro.2023.136429
Spigel, B. (2017). The relational organization of entrepreneurial ecosystems. *Entrepreneurship theory and practice*, *41*(1), 49-72.
Stohr, A., Ollig, P., Keller, R., & Rieger, A. (2024). Generative mechanisms of AI implementation: A critical realist perspective on predictive maintenance. *Information and Organization*, *34*(2), 100503.

Suseno, Y., Laurell, C., & Sick, N. (2018). Assessing value creation in digital innovation ecosystems: A Social Media Analytics approach. *The Journal of Strategic Information Systems*, *27*(4), 335-349.

Ungureanu, P., Bellesia, F., & Cochis, C. (2025). Dealing with blame in digital ecosystems: The DAO failure in the Ethereum blockchain. *Technological Forecasting and Social Change*, *215*, 124096. https://doi.org/https://doi.org/10.1016/j.techfore.2025.124096

van Dijk, J. G., Wieczorek, A. J., Gevers, J. M., & Groenleer, M. L. (2025). Developing governance capacities for regional energy transition: The case of Eindhoven Metropolitan Region. *Environmental Innovation and Societal Transitions*, *55*, 100968.

Wang, P. (2021). Connecting the parts with the whole: Toward an information ecology theory of digital innovation ecosystems. *MIS quarterly*, *45*(1).

Wittmayer, J. M., Hielscher, S., Fraaije, M., Avelino, F., & Rogge, K. (2022). A typology for unpacking the diversity of social innovation in energy transitions. *Energy Research & Social Science*, *88*, 102513. https://doi.org/https://doi.org/10.1016/j.erss.2022.102513

Wolsink, M. (2024a). Conceptualizations of smart grids–anomalous and contradictory expert paradigms in transitions of the electricity system. *Energy Research & Social Science*, *109*, 103392.

Wolsink, M. (2024b). Conceptualizations of smart grids –anomalous and contradictory expert paradigms in transitions of the electricity system. *Energy Research & Social Science*, *109*, 103392. https://doi.org/https://doi.org/10.1016/j.erss.2023.103392

Xu, Y., Sun, H., & Lyu, X. (2023). Analysis of decision-making for value co-creation in digital innovation systems: An evolutionary game model of complex networks [Article]. *Managerial and Decision Economics*, *44*(5), 2869-2884. https://doi.org/10.1002/mde.3852

Xu, Y., Sun, H., & Lyu, X. (2023). Analysis of decision-making for value co-creation in digital innovation systems: An evolutionary game model of complex networks. *Managerial and Decision Economics*, *44*(5), 2869-2884.

Zhu, Z.-Y., Xie, H.-M., & Chen, L. (2023). ICT industry innovation: Knowledge structure and research agenda. *Technological Forecasting and Social Change*, *189*, 122361. https://doi.org/https://doi.org/10.1016/j.techfore.2023.122361