

---

# A Review of Socio-Technical Transition Theory Frameworks and their Applications in Energy Transition Studies

---

**Ahmed Ibrahim Butu**  
**Bukar Zanna Waziri**

Department of Business Administration, Yobe State University, Nigeria

Department of Accounting, University of Maiduguri, Nigeria

[butuahmed@ysu.edu.ng](mailto:butuahmed@ysu.edu.ng)

[bukarwaziri@unimaid.edu.ng](mailto:bukarwaziri@unimaid.edu.ng)

## **Abstract**

Socio-technical transition theory has become a cornerstone in sustainability and energy research, offering insights into how complex systems such as energy, mobility, and food transform over time. This paper reviews three major frameworks: Multi-Level Perspective (MLP), Transition Management (TM), and Strategic Niche Management (SNM)—and critically evaluates their application to energy transition studies. While these frameworks provide powerful conceptual tools for understanding the dynamics of system change, they also face significant criticisms, including conceptual ambiguities, Eurocentrism, and limited applicability to Global South contexts. The review highlights how transition theory has been mobilised to analyse low-carbon energy transitions in Europe, China, and beyond, and how more recent scholarship integrates concerns with justice, power, and geopolitics. It argues that transition studies must evolve towards more inclusive, multi-scalar, and politically attuned frameworks, capable of addressing urgent global challenges such as net-zero decarbonisation, digitalisation, and energy poverty. The paper concludes by proposing a research agenda that bridges theoretical developments with practical governance in diverse socio-political settings, particularly in developing countries where transitions unfold under different constraints and opportunities.

**Keywords:** Multi-Level Perspective (MLP), Transition Management (TM), Strategic Niche Management (SNM), Socio-technical transitions, Energy transition frameworks.

---

## **1. Introduction**

The concept of “transition” denotes a movement or evolution from one state to another. In socio-technical systems research, transitions have been defined as long-term, multi-dimensional processes that transform the structures, cultures, and practices underpinning essential societal functions such as energy, food, mobility, and communication (Rotmans et al., 2001; Elzen and Wieczorek, 2005; de Haan and Rotmans, 2011). A socio-technical transition typically unfolds over decades, involves co-evolutionary interactions between technologies, institutions, and social practices, and results in the emergence of new system equilibria.

Transition studies emerged in the early 2000s as an interdisciplinary response to sustainability challenges, bringing together insights from evolutionary economics, science and technology studies, governance, and innovation policy (Rip and Kemp, 1998; Geels, 2002). Since then, the field has expanded considerably, becoming a central framework for analysing sustainability pathways in both academic and policy contexts (Markard et al., 2012; Köhler et al., 2019). Recent global events—including the Paris Agreement, the COVID-19 pandemic, and the 2022 energy crisis triggered by geopolitical conflict—have further elevated the

importance of transition frameworks in explaining and guiding socio-technical change (Sovacool, 2021; IPCC, 2022).

Three theoretical approaches dominate the field: the Multi-Level Perspective (MLP), Transition Management (TM), and Strategic Niche Management (SNM). The MLP conceptualises transitions as non-linear processes shaped by interactions between niches (spaces of radical innovation), regimes (dominant socio-technical systems), and landscapes (exogenous pressures) (Geels, 2002; Geels and Schot, 2007). TM, meanwhile, offers a governance framework for steering long-term system change through participatory visioning, experimentation, and reflexive learning (Loorbach, 2010). On the other hand, SNM provides strategies for nurturing and protecting niche innovations until they can challenge or integrate into dominant regimes (Kemp et al., 1998; Schot and Geels, 2008). Together, these frameworks form the conceptual backbone of transition studies.

Despite their influence, these approaches face several criticisms. Scholars highlight persistent conceptual ambiguities, particularly around the definitions of “niche” and “regime,” as well as difficulties in operationalisation (Raven et al., 2010; Geels, 2011). Transition theory has also been critiqued for its Eurocentric focus, limited engagement with politics and power, and insufficient attention to Global South contexts (Lawhon and Murphy, 2012; Newell, 2020). Moreover, while transitions are typically conceptualised as slow and incremental, urgent sustainability challenges such as climate change demand accelerated transformations, raising questions about the adequacy of existing frameworks (Sovacool, 2021).

This paper contributes to the ongoing debate by providing an updated review of transition theory frameworks and their applications to energy studies. It offers three main contributions. First, it revisits the conceptual foundations of MLP, TM, and SNM, tracing their development and interconnections. Second, it surveys empirical applications of transition theory to energy systems across diverse geographical and socio-political contexts. Third, it critically engages with emerging debates around justice, inclusivity, and the political economy of transitions, proposing avenues for strengthening the analytical and practical utility of transition frameworks. By situating the discussion within the pressing realities of decarbonisation, energy access, and geopolitical disruption, the paper seeks to bridge theoretical insights with the governance of sustainability transitions in both developed and developing country contexts.

## **2. Stages of Socio-Technical Transition**

Transitions are often conceptualised as long-term, multi-phase processes involving the gradual destabilisation of existing socio-technical systems and the emergence of new ones. Rotmans et al. (2001) describe four broad phases: (i) *predevelopment*, characterised by experimentation and weak signals of change; (ii) *take-off*, when innovations begin to diffuse and structural tensions accumulate; (iii) *acceleration*, marked by wider adoption, institutional reconfiguration, and economic scaling; and (iv) *stabilisation*, when a new socio-technical regime becomes dominant.

These stages are useful for illustrating the temporal dynamics of transitions, but scholars caution against interpreting them as rigid or linear sequences. Empirical research shows that transitions are often cluttered, path-dependent, and subject to reversals, with phases overlapping or unfolding at different speeds across sectors and regions (Geels and Schot, 2007; de Haan and Rotmans, 2011). For example, renewable energy technologies such as solar photovoltaics have rapidly progressed through take-off and acceleration phases in some contexts (e.g., Germany, China), while remaining in predevelopment or early diffusion in others, particularly in parts of Sub-Saharan Africa (Eberhard et al., 2017).

Recent scholarship further complicates stage-based models by emphasising the role of crises, shocks, and tipping points in shaping transitions. The COVID-19 pandemic, the Russia–Ukraine war, and the resulting global energy price volatility have demonstrated how exogenous

disruptions can accelerate or derail transition pathways (Goldthau and Hughes, 2020; IPCC, 2022). In such cases, transitions do not necessarily follow gradual evolutionary logics but may instead feature abrupt reconfigurations and contested political struggles.

Moreover, transitions rarely occur in isolation within a single system. Interactions between multiple systems—such as energy, mobility, housing, and digital infrastructure—create complex interdependencies that cannot be captured by linear stage models alone (Raven and Verbong, 2009; Köhler et al., 2019). For instance, the electrification of transport simultaneously transforms both the energy and mobility systems, while digitalisation shapes demand-side flexibility in electricity networks.

In summary, stage models provide a heuristic entry point into understanding socio-technical transitions, but they must be applied flexibly and critically. They are most effective when combined with frameworks such as the Multi-Level Perspective (MLP), which conceptualises the interplay between innovation niches, incumbent regimes, and broader landscape pressures. The following section explores the MLP in detail, highlighting its contributions and limitations in analysing sustainability transitions.

### **3. The Multi-Level Perspective (MLP)**

The Multi-Level Perspective (MLP) is the most widely used framework in transition studies. It conceptualises socio-technical transitions as dynamic interactions across three analytical levels: *niches*, *regimes*, and the *landscape* (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007).

- Niches are protective spaces where radical innovations can emerge and develop, shielded from market selection pressures. They provide the experimental environments in which new technologies, practices, and business models can mature.
- Regimes represent the dominant socio-technical systems that structure production, consumption, regulation, and cultural expectations. Regimes are deeply embedded and resistant to change due to lock-in mechanisms such as sunk investments, vested interests, and cognitive routines.
- The landscape encompasses broader exogenous pressures, including macro-economic trends, cultural shifts, demographic change, environmental pressures, and geopolitical shocks. Unlike niches and regimes, landscape factors are largely beyond the control of actors within the system.

Transitions occur when landscape pressures destabilise incumbent regimes, creating opportunities for niche innovations to diffuse and eventually reconfigure or replace the regime. This dynamic underscores the non-linear and contested nature of system change.

The MLP has made several significant contributions to transition theory. First, it provides a meso-level heuristic that integrates technological innovation with institutional and cultural dynamics. Second, it offers a historical and evolutionary lens, enabling scholars to trace long-term system changes such as the shift from sailing ships to steamships or from coal to oil-based energy systems (Geels, 2005). Third, it has been widely applied across empirical domains, including renewable energy (Verbong and Geels, 2007), mobility (Hickman, 2012), agriculture (Elzen et al., 2012), and waste management (Van Berkel, 2007).

Despite its widespread influence, the MLP has also attracted extensive critique. Three main lines of criticism can be identified:

1. Conceptual ambiguity: The boundaries between niches, regimes, and landscapes are often blurred, making empirical application challenging (Raven et al., 2010; Genus and Coles, 2008). For example, some argue that large-scale renewable energy projects can simultaneously operate as niche experiments and regime-level infrastructures.
2. Overly structural and deterministic: Critics argue that the MLP risks portraying transitions as evolutionary and incremental processes, downplaying the roles of agency,

politics, and power struggles (Smith et al., 2005; Avelino and Grin, 2017). In practice, transitions often involve conflicts between incumbents and challengers, lobbying, resistance, and governance failures.

3. **Eurocentrism and limited global relevance:** Much MLP scholarship has focused on European case studies, raising questions about its applicability in the Global South where state capacity, infrastructure, and socio-economic conditions differ markedly (Lawhon and Murphy, 2012; Newell, 2020). In African energy transitions, for example, informal markets, donor dependence, and infrastructure deficits shape system dynamics in ways not easily captured by the MLP.

More recent work seeks to address these criticisms. Scholars have called for integrating the MLP with perspectives from political economy, social justice, and global development (Köhler et al., 2019; Sovacool et al., 2020). There is growing attention to multi-regime interactions, recognising that transitions rarely occur within a single domain but rather span interconnected systems such as energy, transport, and digitalisation (Raven and Verbong, 2009; Geels et al., 2017). Others highlight the need to analyse accelerated transitions, where urgent climate imperatives and geopolitical crises compress temporal dynamics (Sovacool, 2021).

In sum, the MLP remains a powerful heuristic for studying socio-technical change, but it must be applied critically and adapted to account for power, politics, and diversity across contexts. The next section turns to Transition Management (TM), a framework that shifts attention from descriptive analysis to prescriptive governance strategies for steering sustainability transitions.

#### **4. Transition Management (TM)**

While the Multi-Level Perspective (MLP) provides a descriptive framework for analysing how transitions unfold, Transition Management (TM) offers a normative and prescriptive governance approach designed to actively steer transitions toward sustainability (Rotmans et al., 2001; Loorbach, 2010). Developed primarily in the Netherlands in the early 2000s, TM emerged from the recognition that sustainability challenges require long-term, systemic change that cannot be achieved through incremental policy adjustments alone.

TM is based on several key principles that distinguish it from conventional policy-making (Loorbach, 2010; Rotmans and Loorbach, 2009):

1. **Long-term orientation:** TM emphasises forward-looking visioning, typically over 25–50 years, to provide direction for short- and medium-term actions.
2. **Multi-actor participation:** It encourages inclusive processes involving policymakers, businesses, civil society, and researchers in co-producing transition pathways.
3. **Experimentation and learning:** TM promotes pilot projects, living labs, and policy experiments as ways to test new ideas under real-world conditions.
4. **Reflexivity and adaptability:** Continuous monitoring and reflection are integral, enabling adjustment of strategies in response to evolving dynamics and unexpected developments.

Operationally, TM is often described as a cyclical process with four phases: (i) problem structuring and envisioning, (ii) development of transition agendas and coalitions, (iii) experimentation through projects and instruments, and (iv) evaluation, learning, and adaptation (Rotmans and Loorbach, 2009).

TM has been applied most prominently in Dutch sustainability initiatives, including energy, waste, and mobility transitions (Kemp and Loorbach, 2006). It has also inspired experimentation in other European contexts, such as city-level climate governance and regional energy strategies (Loorbach et al., 2017). More recently, TM principles have informed urban sustainability labs, mission-oriented innovation policies, and climate adaptation planning (Mazzucato, 2018; Hölscher et al., 2019).

The strength of TM lies in its ability to bridge long-term visions with short-term action, bringing together diverse actors in structured processes of co-creation. It provides a governance framework that explicitly recognises uncertainty, complexity, and the need for iterative learning. By fostering experimentation, TM can help scale niche innovations into broader regime transformations.

Despite its appeal, TM has faced several critiques:

1. **Democratic legitimacy:** Critics argue that TM processes often involve a narrow set of stakeholders (typically experts, policymakers, and large firms), raising concerns about inclusivity and representation (Shove and Walker, 2007; Hendriks, 2009).
2. **Over-reliance on technocracy:** TM risks privileging technical expertise and managerial control over political deliberation, potentially sidelining contentious social and political dimensions (Meadowcroft, 2009).
3. **Context specificity:** Much of the empirical grounding of TM comes from the Dutch context, raising questions about its transferability to other governance systems, particularly in the Global South where institutional capacity and participation structures differ (Lawhon and Murphy, 2012; Newell, 2020).
4. **Incrementalism vs. urgency:** While TM is designed as a gradual and iterative process, urgent global challenges such as climate change and biodiversity loss demand more rapid and transformative action (Sovacool, 2021).

Recent scholarship seeks to adapt TM to these critiques by linking it with broader frameworks of polycentric governance, justice-oriented transition planning, and mission-driven innovation policy (Mazzucato, 2018; Köhler et al., 2019). There is also growing attention to the role of cities and regions as laboratories of transition governance, and to how TM can be tailored for contexts with weaker institutions but pressing sustainability needs (Hölscher et al., 2019).

In short, TM advances the transition studies field by offering tools for steering and governing systemic change, but its practical application requires careful attention to inclusivity, power dynamics, and contextual diversity. The next section examines Strategic Niche Management (SNM), a framework that focuses more specifically on how radical innovations can be nurtured and scaled in transition processes.

## **5. Strategic Niche Management (SNM)**

Strategic Niche Management (SNM) is a framework developed in the 1990s to explain how radical innovations can emerge and eventually challenge established socio-technical regimes (Kemp et al., 1998; Schot and Geels, 2008). SNM emphasises the importance of creating protected spaces - so-called “niches” where new technologies, practices, and business models can be tested without being immediately exposed to mainstream market selection pressures. SNM identifies three interrelated processes that are crucial for the development and diffusion of niche innovations (Raven, 2005; Schot and Geels, 2008):

1. **Articulation of expectations and visions:** Clear and credible expectations help align actors, attract resources, and guide experimentation.
2. **Building social networks:** The involvement of diverse stakeholders—including firms, policymakers, users, and civil society—facilitates resource mobilisation and learning.
3. **Learning processes:** Niche experiments generate technical, social, and institutional learning that can inform broader regime change.

These processes are mutually reinforcing robust visions attract networks, networks facilitate learning, and learning in turn strengthens expectations.

SNM has been applied across a wide range of sectors, including renewable energy technologies, electric mobility, waste management, and sustainable agriculture (Raven, 2024; Smith and Raven, 2012). In the energy domain, SNM has been particularly influential in understanding the development of wind power in Denmark, solar photovoltaics in Germany

and China, and more recently off-grid solar in Africa and South Asia (Geels et al., 2016; Ahlborg and Sjöstedt, 2015). These cases illustrate how niches can evolve from small-scale experiments to mainstream technologies, especially when supported by favourable policy frameworks and socio-political coalitions.

More recent applications of SNM extend beyond technology to encompass social and organisational innovations, such as community energy projects, cooperative housing models, and sustainable consumption practices (Seyfang and Smith, 2007; Hargreaves et al., 2013). In this sense, SNM has evolved into a broader framework for understanding experimentation in sustainability transitions. The strength of SNM lies in its actor-centred and process-oriented approach. Unlike the more structural MLP, SNM zooms in on how concrete experiments and actor strategies can shape long-term transitions. It provides practical insights for policymakers and practitioners interested in designing interventions to nurture radical innovations.

SNM is not without limitations. Several critiques have been raised:

1. **Scaling challenges:** While SNM explains how niches emerge, it is less clear on how they scale up to transform regimes, especially when incumbents actively resist change (Smith and Raven, 2012).
2. **Power and politics:** Similar to the MLP, SNM has been criticised for insufficiently engaging with power struggles, vested interests, and political contestation in niche development (Avelino and Grin, 2017).
3. **Overemphasis on protection:** Some argue that excessive protection can create “niche enclaves” that fail to connect with mainstream systems, limiting broader transformative potential (Smith and Raven, 2012).
4. **Global South applicability:** SNM has primarily been developed in European contexts, raising questions about its transferability to developing countries where niches often emerge in informal, resource-constrained settings (Lawhon and Murphy, 2012; Newell, 2020).

Recent scholarship has advanced SNM in several directions. First, researchers have explored the role of experimentation and living labs as platforms for scaling sustainability innovations (Evans et al., 2016). Second, there is growing attention to innovation ecosystems and transition experiments that go beyond single niches to foster systemic learning (Sengers et al., 2019). Third, the concept of empowerment has been introduced to capture how niches can both “fit and conform” to existing regimes or “stretch and transform” them (Smith and Raven, 2012). Finally, scholars have highlighted the importance of contextualising niche development in the Global South, where energy access challenges, donor dependence, and local community dynamics fundamentally shape experimentation (Ahlborg and Sjöstedt, 2015; Ockwell and Byrne, 2017).

In short, SNM contributes a micro-level perspective on how innovations emerge and mature, complementing the meso-level governance lens of TM and the macro-structural perspective of the MLP. Taken together, these frameworks provide a rich conceptual toolkit for analysing and guiding socio-technical transitions. The next section reviews how these frameworks have been applied in energy transition studies, with a focus on diverse geographical and sectoral contexts

## **6. Applications in Energy Transition Studies**

Energy systems have been among the most prominent domains for applying socio-technical transition frameworks, reflecting the centrality of energy to climate change mitigation, sustainable development, and economic competitiveness. Studies drawing on the MLP, TM, and SNM have illuminated how renewable energy technologies, infrastructures, and governance arrangements evolve and how they interact with incumbents and wider socio-political contexts.

### **6.1 Renewable Energy Transitions in Europe**

European countries have been at the forefront of applying transition theory to energy systems. In Denmark, the development of wind power has often been analysed as a successful niche-to-regime transition, facilitated by long-term policy support, cooperative ownership models, and strong socio-political coalitions (Karnøe and Garud, 2012; Andersen and Markard, 2020). In Germany, the Energiewende has been studied as a case of multi-level dynamics in which landscape pressures (climate policy, anti-nuclear movements) and niche innovations (solar PV and wind) destabilised the fossil-nuclear regime, leading to systemic transformation (Lauber and Jacobsson, 2016; Geels et al., 2016). In the United Kingdom, transition studies have examined the contestations around offshore wind, nuclear power, and smart grids, highlighting how incumbents negotiate and reshape regime change (Kern and Rogge, 2016).

### **6.2 Emerging Powers and Asia**

Transition frameworks have also been applied in rapidly industrialising contexts. In China, scholars have analysed how state-led industrial policies, global supply chains, and domestic market scaling accelerated the diffusion of solar photovoltaics, enabling China to become the world's largest producer and consumer of solar energy (Urban and Nordensvärd, 2018; Zhao et al., 2022). In India, socio-technical transition theory has been used to understand decentralised solar and microgrid experiments, particularly in rural electrification, where niche innovations interact with governance challenges and questions of equity (Ahlborg and Sjöstedt, 2015; Gupta, 2020). Japan and South Korea have also featured in studies on hydrogen innovation systems and smart grid transitions, often framed through SNM and TM (Lee et al., 2020; Zusman et al. 2014).

### **6.3 Transitions in the Global South**

In the Global South, transition theory has increasingly been applied to contexts where energy transitions are not only about decarbonisation but also about energy access, poverty alleviation, and development (Lawhon and Murphy, 2012; Newell, 2020). In Sub-Saharan Africa, for example, SNM has been applied to analyse off-grid solar and mini-grid projects, many of which are donor-supported and community-based (Ockwell and Byrne, 2017). These cases highlight the challenges of scaling in resource-constrained environments, where niches must often operate in parallel to, rather than in direct competition with, dominant regimes. In Latin America, studies have examined energy transitions in contexts of political contestation, such as the expansion of renewables in Brazil alongside continued reliance on hydropower and fossil fuels (de Oliveira and McCauley, 2017).

## **7. Conclusion and Research Agenda**

Socio-technical transition theory has become a cornerstone in the study of sustainability transformations, offering powerful conceptual tools to analyse how innovations emerge, diffuse, and reshape entrenched systems. Frameworks such as the Multi-Level Perspective (MLP), Strategic Niche Management (SNM), and Transition Management (TM) have illuminated the complex interplay between niches, regimes, and landscapes, providing insights into both historical and contemporary transitions. Applications in energy systems, mobility, housing, and digitalisation demonstrate the value of these approaches across diverse geographies.

Yet, as the critiques in this paper underscore, transition theory is not without its limitations. Persistent challenges include conceptual ambiguities, Eurocentric biases, insufficient attention to power and politics, and limited engagement with justice and equity. Furthermore, the frameworks have sometimes underplayed the significance of crises, tipping points, and global interdependencies that shape transition pathways.

To advance the field, future research should move in several directions:

1. **Context-Sensitive Theorising:** Transition frameworks must be adapted to the realities of the Global South, where transitions are deeply entangled with issues of energy access, informality, and uneven development. Comparative and postcolonial perspectives are particularly valuable in this regard.
2. **Power, Politics, and Justice:** Building on the literature on energy justice and just transitions, future work should explicitly examine who wins and who loses from transitions, how power is exercised, and how inclusivity and democracy can be enhanced.
3. **Multi-System and Cross-Sectoral Dynamics:** Researchers should expand beyond single-system analyses to study the interdependencies between energy, mobility, food, water, and digital systems, which increasingly co-evolve and co-constitute sustainability outcomes.
4. **Policy and Governance for Transformation:** Transition studies should continue to inform policy by linking conceptual advances with practical experimentation, co-creation, and governance innovation. The emerging field of Transformative Innovation Policy (TIP) offers a promising bridge between research and practice.

In conclusion, socio-technical transition theory remains a vibrant and evolving field, uniquely positioned to address the grand challenges of sustainability. By embracing critiques, expanding geographical scope, and engaging with questions of power, justice, and disruption, scholars can ensure that transition studies remain relevant not only as an analytical framework but also as a transformative resource for guiding sustainable futures.

## References

- Ahlborg, H. and Sjöstedt, M. (2015) 'Off-grid solar power in Africa: How the power of agency and institutional context shape the adoption of innovations', *Energy Research & Social Science*, 10, pp. 87–97.
- Avelino, F., and Grin, J. (2017). Beyond deconstruction. a reconstructive perspective on sustainability transition governance. *Environmental Innovation and Societal Transitions*, 22, 15-25.
- de Haan, J.H. and Rotmans, J., (2011). Patterns in transitions: Understanding complex chains of change. *Technological Forecasting and Social Change*, 78(1), pp. 90-102
- Eberhard, A., Gratwick, K., Morella, E., and Antmann, P. (2017). Accelerating investments in power in sub-Saharan Africa. *Nature Energy*, 2(2), 1-5.
- Elzen, B. and Wieczorek, A., (2005). Transitions towards sustainability through system innovation. *Technological forecasting and social change*, 72(6), pp. 651-661
- Elzen, B., Barbier, M., Cerf, M., and Grin, J. (2012). Stimulating transitions towards sustainable farming systems. In *Farming Systems Research into the 21st century: The new dynamic* (pp. 431-455). Dordrecht: Springer Netherlands.
- Evans, J., Karvonen, A. and Raven, R. (2016) *The experimental city*, Routledge, London.
- Geels, F.W. and Schot, J., (2007). Typology of sociotechnical transition pathways. *Research policy*, 36(3), pp. 399-417
- Geels, F.W., (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, 31(8), pp. 1257-1274
- Geels, F.W., (2005). *Technological transitions and system innovations: A co-evolutionary and socio-technical analysis*. University of Manchester, UK: Edward Elgar Publishing.
- Geels, F.W., (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1(1), pp. 24-40



- Geels, F.W., Schot, J., Köhler, J. and Markard, J. (2016) 'The dynamics of low-carbon transitions: A multi-level perspective', *Annual Review of Environment and Resources*, 41, pp. 405–432.
- Genus, A., and Coles, A. M. (2008). Rethinking the multi-level perspective of technological transitions. *Research policy*, 37(9), 1436-1445.
- Goldthau, A. and Hughes, L. (2020) 'The geopolitics of the energy transition: How the global shift to renewable energy will affect energy dependence, green wars, and international relations', *Foreign Affairs*, 99(1), pp. 114–124.
- Gupta, A. (2020) 'Energy transition experiments in rural India: pathways, agency and equity issues', *Energy Policy*, 139, 111346.
- Hargreaves, T., Hielscher, S., Seyfang, G. and Smith, A., (2013). Grassroots innovations in community energy: The role of intermediaries in niche development. *Global Environmental Change*, 23(5), pp. 868-880
- Healy, N. and Barry, J. (2017) 'Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition"', *Energy Policy*, 108, pp. 451–459.
- Hickman, R. (2012). Automobility in Transition. A Socio-Technical Analysis of Sustainable Transport. *Transport Reviews*, 33(1), 128–129.
- Hölscher, K., Frantzeskaki, N. and Loorbach, D. (2019) 'Shaping transformations in practice: Intermediate actors and strategies for transition governance', *Environmental Innovation and Societal Transitions*, 31, pp. 58–72.
- IPCC (2022) *Climate Change 2022 Mitigation of Climate Change, Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge.
- Jenkins, K.E.H., Sovacool, B.K., Mouter, N., Hacking, N., Burns, M.-K. and McCauley, D. (2021) 'The methodologies, geographies, and technologies of energy justice: a systematic and comprehensive review', *Environmental Research Letters*, 16(4), 043009.
- Kemp, R. and Loorbach, D. (2006). Transition management: A reflexive governance approach. In: VOSS, J.P., Bauknecht, D. and Kemp, R. (eds.). *Reflexive governance for sustainable development*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, pp. 103-130
- Kemp, R., Schot, J. and Hoogma, R., (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, 10(2), pp. 175-198
- Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sandén, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D. and Wells, P. (2019) 'An agenda for sustainability transitions research: State of the art and future directions', *Environmental Innovation and Societal Transitions*, 31, pp. 1–3
- Lawhon, M. and Murphy, J.T. (2012) 'Socio-technical regimes and sustainability transitions; Insights from political geography', *Progress in Human Geography*, 36(3), pp. 354–378.
- Loorbach, D., (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance*, 23(1), pp. 161-183
- Loorbach, D., Frantzeskaki, N., and Avelino, F. (2017). Sustainability transitions research: transforming science and practice for societal change. *Annual review of environment and resources*, 42, 599-626.
- Markard, J., Raven, R., and Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research policy*, 41(6), 955-967.
- Mazzucato, M. (2018) *Mission Economy: A Moonshot Guide to Changing Capitalism*, Allen Lane, London.

- Meadowcroft, J. (2011) 'Engaging with the politics of sustainability transitions', *Environmental Innovation and Societal Transitions*, 1, pp. 70–75.
- Mercure, J.-F., Pollitt, H., Bassi, A., Viñuales, J.E., Edwards, N.R., (2015) Modelling complex systems of heterogeneous agents to better design sustainability transitions policy, *Environmental Innovation and Societal Transitions*, 17, pp. 166–185
- Newell, P. (2020) *The Global Political Economy of Energy Transitions*, *Global Transitions Journal*, special issues.
- Ockwell, D. and Byrne, R. (2017) 'Informal recognition and formal regulation: The politics of off-grid solar innovation in Africa', *Energy Research & Social Science*, 34, pp. 162–170.
- Raven, R. and Verbong, G. (2009) 'Multi-regime interactions in transitions: Mobility, energy and feeding systems', *Technological Forecasting & Social Change*, 76(4), pp. 431–447.
- Raven, R., (2005). *Strategic niche management for biomass: A comparative study on the experimental introduction of bioenergy technologies in The Netherlands and Denmark*. Eindhoven University Press: Netherlands
- Raven, R., van den Bosch, S. and Weterings, R., (2010). Transitions and strategic niche management: towards a competence kit for practitioners. *International Journal of Technology Management*, 51(1), pp. 57-74
- Rip, A. and Kemp, R., (1998). Technological Change. In: Rayner, S. and Malone, E.L., (eds.) *Human choice and climate change: An international assessment*. Washington DC: Battelle Press.
- Rotmans, J. and Loorbach, D., (2009). Complexity and transition management. *Journal of Industrial Ecology*, 13(2), pp. 184-196
- Rotmans, J., Kemp, R. and van Asselt, M., (2001). More evolution than revolution: Transition management in public policy. *Foresight*, 3(1), pp. 15-31
- Schot, J. and Geels, F.W., (2008). Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, 20(5), pp. 537-554
- Schot, J. and Steinmueller, W.E. (2018) 'Three frames for innovation policy: R&D, systems of innovation and transformative change', *Research Policy*, 47(9), pp. 1554–1567
- Smith, A. and Raven, R., (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, 41(6), pp. 1025-1036
- Smith, A., Stirling, A. and Berkhout, F., (2005). The governance of sustainable socio-technical transitions. *Research policy*, 34(10), pp. 1491-1510
- Sovacool, B.K. (2021) 'Decarbonisation and its discontents: A critical justice perspective on four low-carbon transitions', *Energy Research & Social Science*, 77, 102092.
- Sovacool, B.K., Burke, M., Baker, L., Kotikalapudi, C.K., and Wlokas, H. (2017) 'New frontiers and conceptual frameworks for energy justice', *Energy Policy*, 105, pp. 677–691.
- Van Berkel, R. (2007). Eco-Innovation: opportunities for advancing waste prevention. *International Journal of Environmental Technology and Management*, 7(5-6), 527-550.
- Verbong, G. and Geels, F., (2007). The ongoing energy transition: lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy policy*, 35(2), pp.1025-1037.
- Waziri, B. Z., Hassan, A., & Kouhy, R. (2018). The effect of transitioning to renewable energy consumption on the Nigerian oil and gas exports: an ARDL approach. *International Journal of Energy Sector Management*, 12(4), 507-524. <https://doi.org/10.1108/IJESM-11-2017-0010>
- Waziri, B. Z. (2016). *An empirical investigation of the impact of global energy transition on Nigerian oil and gas exports* (Doctoral dissertation, Abertay University).