# THE TRANSITION TOWARDS DESIGN FOR DISASSEMBLY IN THE CONSTRUCTION SECTOR

**Ann Kristin Kvellheim[1*], Phuc Hong Huynh Evertsen[1] and Marit Thyholt[2]**

[1] Dpt of Architecture, Building materials and Construction, SINTEF Community, Trondheim, Norway
[2] Skanska teknikk, Skanska, Oslo, Norway

*E-mail: ann.kristin.kvellheim@sintef.no

**Abstract.** The construction sector is notably resource-inefficient and contributes significantly to resource depletion. One promising strategy to combat this is to implement Design for Disassembly. Design for Disassembly is a design approach created in response to diminishing material and energy resources and the increasing volume of waste. It facilitates the easy dismantling of buildings so that materials and components can be reused, repurposed, or recycled, thereby minimizing waste and reducing the environmental impact of construction activities. Despite the long-standing awareness of Design for Disassembly principles, their implementation has been slow.

This article explores DfD in the Norwegian construction sector in the context of the Multiple Level Perspective transition theory framework. Although transition theory has been widely applied to study systemic changes across different industries, such as energy, mobility, food, and carbon capture and storage, its application for the construction industry has been limited. This perspective therefore represents a contribution to current research and also has practical implication to the implementation of Design for Disassembly.

This study is part of the SirkBygg research project, led by the construction and development company Skanska. Data was collected through interviews with key stakeholders and a literature review. The analysis focuses on the research question: What key factors enable Design for Disassembly to transition from a niche innovation to a widely adopted industry standard? Findings indicate that the most important factors are knowledge development and pilot projects to learn from, as well as supportive business models. This should be followed by standardization and risk reduction measures, targeted support and incentives, clear and concise regulations, and a change of attitude in the market. The transition will require a coordinated approach, balancing policy enforcement, economic drivers, and industry innovation to mainstream Design for Disassembly as a standard practice.

## 1. Introduction

The building and construction sector is a major consumer of resources: about 50 % of raw materials, 36% of the global final energy used (1) and about a third of the total waste generated in the EU (2). Also in Norway, the construction sector is responsible for a substantial portion of the country's waste, contributing to environmental degradation and resource scarcity (5). One effective strategy to reduce this consumption is to develop solutions for Design for Disassembly (DfD). DfD is a design approach created in response to diminishing material and energy resources and the increasing volume of waste. The construction industry is at a pivotal juncture, transitioning from traditional linear economic models to more sustainable circular economy practices. This shift is also evident in Norway, where the principles of DfD are gaining traction. DfD is an approach that facilitates the easy dismantling of buildings so that materials and components can be reused, repurposed, or recycled, thereby minimizing waste and reducing the environmental impact of construction activities. Historically, the construction industry has operated on a linear "take, make, dispose" model, which has led to significant resource depletion and waste generation. The transition to a circular economy, which emphasizes the reuse and recycling of materials, is seen as a crucial step towards achieving sustainability goals.

Despite the long-standing awareness of DfD principles, their implementation has been slow. Recent examples of DfD highlight its growing adoption and innovative applications worldwide. In the United States, cities like Seattle and Pittsburgh have implemented deconstruction ordinances requiring older buildings to be carefully dismantled rather than demolished, significantly reducing construction waste (3). In Europe, projects such as the EDGE Suedkreuz Berlin Offices in Germany and the Beyond Building at Dutch Design Week showcase advanced DfD techniques, emphasizing the reuse of materials and modular construction (4). Also in Norway, projects like Hasle Tre[1] and HABiO[2] are demonstrating the principles of DfD. These initiatives reflect a broader trend towards integrating DfD into urban planning and construction practices, aiming to enhance sustainability and resource efficiency. However, implementation at a broader scale is still depending on reduction of key barriers as well as supporting business models (BMs) (5). Despite the acknowledged impact of BMs in sustainability transitions, there is a lack of understanding of what impacts their adoption (6).

One of the most prevalent theoretical frameworks in sustainability transition studies is the multi-level perspective (MLP), which emphasizes a non-linear transition process at the three analytical levels: niche, regime and landscape (7). At the niche level, DfD represents a radical innovation that challenges traditional construction practices. Within the socio-technical regime, established norms and regulations are gradually adapting to incorporate DfD principles, promoting more sustainable building practices. Finally, at the socio-technical landscape level, broader societal and environmental pressures are driving the construction sector towards sustainability, making DfD an essential strategy for achieving long-term environmental goals (8).

This study is part of the SirkBygg[3] research project, led by the construction and development company Skanska. This paper aims to answer the following research question: What key factors enable Design for Disassembly (DfD) to transition from a niche innovation to a widely adopted industry standard? By the analysis of DfD as a radical niche in the MLP-framework, we aim to analyse the transition towards material reuse and DfD as well as which factors are supporting the

1 https://www.arkitektur.no/prosjekter/naering/hasletre/
2 HABiO experience report (Norwegian)
3 About the research project SirkBygg (Norwegian)

transition. Although transition theory has been widely applied to study systemic changes across different industries, such as energy, mobility, food, and carbon capture and storage, its application for the construction industry has been limited. This perspective therefore represents a contribution to current research and also has practical implication to the implementation of DfD.

## 2. Research theory and method

*2.1 Research theory*

The Multi-Level Perspective (MLP) is a widely used framework in sustainability transition studies, offering insights into systemic change across socio-technical systems such as energy, mobility, and waste. It integrates technological, social, economic, and institutional dynamics, addressing environmental challenges like climate change and resource depletion (7,9). At its core, MLP analyses transitions through three levels: landscape (external pressures), regimes (dominant structures), and niches (protected spaces for radical innovations) (10). Niches foster green innovations that may disrupt regimes in response to landscape pressures, such as policy shifts or societal demands (11). Smith et al. (12) highlight MLP's ability to structure transition narratives, linking experimental niche activities to macro-level transformations. MLP aids in analysing both historical and future transitions, identifying patterns that facilitate or hinder systemic change (7). It is particularly useful in evaluating the scaling potential of niche innovations like circular construction practices.

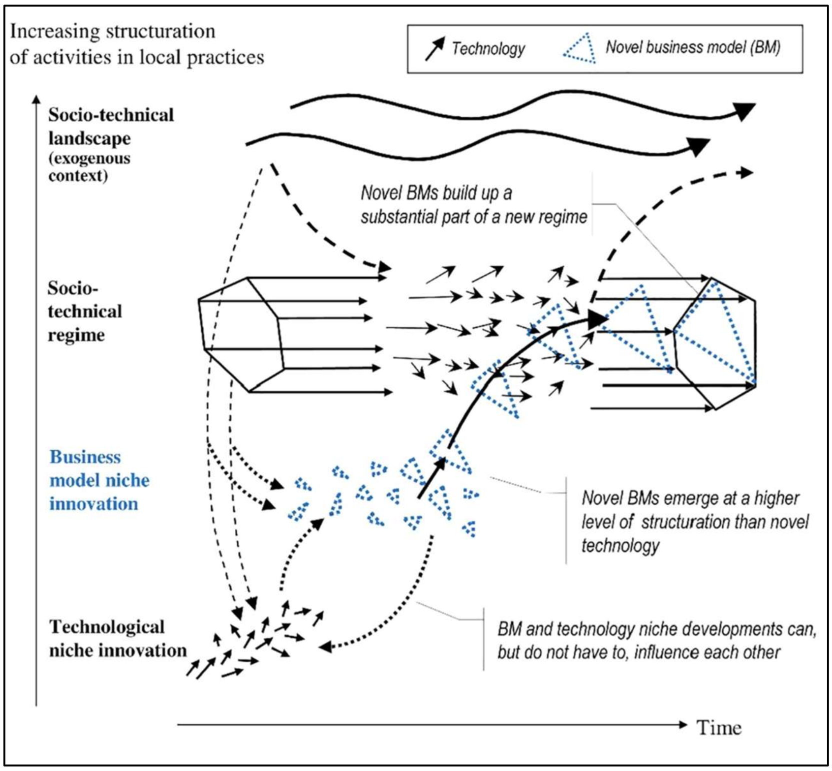


**Figure 1.** The MLP framework, highlighting business models as non-technological niche innovations ((13) based on (14))

MLP encompasses a dynamic interplay of actors, institutions, and innovations (12), driven by interactions between niches, regimes, and landscapes (14). Niches incubate novel technologies, shielded from mainstream constraints, where pioneering actors push radical innovations (7,15). Niche innovations often emerge through research, experimentation, and early market adoption (16), aiming to disrupt entrenched systems. Regimes constitute the meso-layer of socio-technical systems, maintaining stability through regulations, cognitive routines, and established structures (14). Policy changes or evolving consumer preferences can create openings for niche innovations (16). Landscapes exert external pressures—such as climate policies or market shifts—impacting regimes and facilitating transitions. Successful niches can align with or disrupt regimes, gradually reshaping socio-technical systems.

The sustainable transition to the circular economy and DfD requires companies to rethink their value chains and BMs (13). The primary aim of a BM is to create and capture value, and BMs have gradually been recognized as a source of market disruption. Technological innovations must be complemented by non-technological ones to drive structural change and transitions towards sustainability (17). Business models can be seen as non-technological niche innovation (13) and emerge at a higher level of structuration than novel technologies as illustrated in figure 1. Innovative BMs are needed in order to combat the prevailing unsustainable BMs.

Transition pathways outline how radical niche innovations evolve through distinct stages, interacting with niches, regimes, and landscapes. There are four stages of transition: 1) **Experimentation**: Innovations emerge through research projects and urban living labs (18)(19). Early adoption faces high failure rates, market uncertainty, and user resistance, especially for costly green technologies. 2) **Stabilization**: Successful innovations spread, benefiting from knowledge sharing, learning, and standardization. Innovation agencies act as intermediaries, facilitating adoption. 3) **Diffusion/Disruption**: Innovations enter mainstream markets, improving performance and economies of scale. However, they face competition with incumbents and conflicts over policy, taxation, and cultural perceptions. External pressures can destabilize progress. 4) **Institutionalization**: The old socio-technical system is replaced, embedding new standards, norms, technologies, and institutions (20). Radical innovations must overcome economic, political, and cultural resistance to achieve systemic change.

Sustainability transitions, including the circular economy, rely on radical innovation to disrupt entrenched socio-technical systems. This "creative destruction" helps shift long-established industries, such as construction, which face path-dependence and lock-in effects due to economic, social, and political barriers (21)(22). Lock-in mechanisms—such as sunk investments, conservative mindsets, and policies favouring incumbents—often hinder change. Radical innovation breaks these patterns, enabling transformation. It typically originates in niche markets, led by startups, entrepreneurs, and activists (20), and takes various forms such as technological innovations (e.g., DfD, electric cars), business model innovation (e.g., disassembly services, car-sharing over ownership), social innovation (e.g., community-based material reuse networks), infrastructure innovation (e.g., smart building systems including digital tracking).

Due to their novelty, radical innovations diverge from traditional market trajectories, interacting with broader socio-technical landscapes to achieve mainstream adoption (20). Their success depends on overcoming systemic resistance and fostering widespread acceptance.

*2.2 Research method*

This paper adopts a mixed-method, qualitative approach based on interviews and a limited literature study. We did interviews with key stakeholders in the construction industry, member organisations and public entities selected due to their experience and/or engagement in DfD. In the interviews we asked questions about drivers and barriers, policy measures and business models that might be significant to the more widespread implementation of DfD. Interviews were conducted in person or on Teams and lasted from 45-60 minutes. Subsequently, the interviews were transcribed and colour coded according to key aspects of investigation. During data collection, we focused on peer-reviewed journal and conference papers, excluding grey literature. Search terms included "design for disassembly" OR "design for deconstruction" AND "construction" OR "building" OR "built environment", applied to titles, abstracts, and keywords. To ensure accuracy, we restricted results to English-language publications and excluded non-academic works. In the table below, an overview of interview objects is provided.

**Table 1.** Overview of the interview objects.

| | Actor | Role |
|---|---|---|
| 1 | Construction City Cluster | Innovation cluster for the construction industry |
| 2 | The Norwegian Building Authority (DiBK) | Directorate in charge of building regulations |
| 3 | Höegh Eiendom | Building developer, owner and manager |
| 4 | Mustad Eiendom | Building developer, owner and manager |
| 5 | Skanska | Construction and development company |
| 6 | Snøhetta | Architect and advisor |
| 7 | Spenncon | Supplier of precast concrete elements |
| 8 | Statsbygg | Building developer, owner and manager |

The interviewees have been anonymised when quoted in the text. In the next section, the findings from the qualitative studies conducted are presented.

## 3. Empirical findings

*3.1 Niche innovation*

DfD is a radical niche emergence that deviates from traditional architect and engineering practices. This new practice requires radical products, services and methods. In the Norwegian context, most of the radical niche innovations are financially supported by innovation research funds agencies such as Enova and Innovation Norway and led by forefront actors such as developers (e.g., Höegh Eiendom, Mustad Eiendom), contractors and suppliers (e.g., Skanska, Spenncon) and architects (e.g., Snøhetta). A significant number of new products and solutions have been developed as a result of innovation processes related to the first demonstration projects. However, main parts such as hollow-core slabs, have been largely the same over time. Reuse has resulted in the development of a Norwegian standard describing the disassembly and testing of used hollow-core slabs. As a part of the SirkBygg project, Spenncon and Heidelberg Materials Prefab are developing precast concrete elements designed for deconstruction, based on standard hollow-core slabs. Recently, the architect Snøhetta has, with support from Innovation Norway, invented an innovative, prefabricated concrete element called E-slab systems. These slabs are made from low-carbon concrete and feature a ribbed design that provides strength through form rather than thickness. The design includes open channels on both the top and bottom, allowing for integrated technical installations such as electrical wiring and ventilation. This system is particularly suited for office buildings, offering flexibility and the potential to add an extra floor for every seven floors due to reduced floor heights. Additionally, the slabs are demountable and reusable, contributing to sustainability in construction. Mustad Eiendom made the first order of the E-slab system, meant for Vollsveien 11, but due to increased financial costs, the project has been postponed. There is a need to test the system in a full-scale project to learn and further develop it. Potentially, the E-slab system could be a competitor to the predominant hollow-core slabs provided by incumbent actors. The E-slab system has met some scepticism in the market while others believe strongly in the qualities of the new product:

*"The product is* one *competitor to hollow-core slabs, but it doesn't have the same beneficial properties when it comes to being part of the stiffening system that hollow-core slabs provide. I believe that less concrete can be used, and the optimal solution would be to use a traditional DT element—a double-tee element, which has a similar structure. This slab concept is essentially the same approach, so I wonder… is it fair to say that E-slab is "The Emperor's New Clothes"?"* (Interview object y)

*"E-slab can replace hollow-core slabs. There are some prerequisites that must be in place. The challenge is to get the design team to be open to new ideas."* (Interview object c)

This can be understood as a result of little experience with the E-slab system or observed deficiencies. It can also be understood as a technological innovation that is perceived as a threat to incumbent actors in the industry. If a technological innovation, such as E-slab, is seen as beneficial to more actors at the regime level, the incumbents generally have greater capacity to drive transitions (6). In any case, the E-slab system is an example of innovative product development that is addressing some of the barriers towards DfD and might be advancing the speed of implementation.

*3.2 Regime*

As illustrated above, niches often struggle to become part of the regime. Conflicts between the existing regime of linear construction and the new regime of circular construction are expected. Below, we have made a comparison of characteristics of the traditional regime versus how a new regime based on circular principles, would look like.

**Table 2**: A comparison between a traditional and a new regime.

| Dimension | Traditional regime:<br>Traditional design, construction and demolition | New regime:<br>Design for disassembly, circular construction and material reuse |
|---|---|---|
| Market | Large market segments of the traditional regime: virgin materials that are much easier to access can be cheaper. | Small market segments of secondhand materials, often with risks such as project delays, higher costs, and safety concerns. |
| Techniques | Traditional fastening methods that make dismantling difficult. | Different fastening methods like mechanical connections, modularity, and prefabricated components to enable dismantling. Focus on fewer and easily disassemblable materials. |
| Design approach | Generally involves permanent and complex assemblies. | Focuses on design strategies that prioritize disassembly, reuse, and adaptability for future uses. |
| Material flow | Linear flow: materials are used and discarded as waste. | Circular flow: materials are reused, recycled, or repurposed. |
| End-of-life | Demolition typically leads to materials being either recycled, used for energy recovery or sent to landfills. | Disassembly allows for material recovery and reuse. |
| Economic Model | Cost efficiency driven by virgin material use in design. | May induce higher upfront costs but potential for long-term savings through material reuse and reduced waste disposal costs. |

The old regime is well established and strongly rooted in the mindset, behaviour and culture of actors in the sector. Changing behaviour is significantly one of the keys to breaking the lock-in and shifting the regime. This requests a shift in the mindset and methodology to a more holistic and systematic approach, as strongly emphasised by most of the interviewees (e.g., Höegh Eiendom, Statsbygg, Mustad Eiendom) illustrated by this quote:

"*..., it's about doing this systematically—going through the table and addressing the building layer by layer. This ensures a conscious approach to the project. What kind of project is it? Is it a building where large parts should be designed for disassembly, or is it more like an opera house where most of it is intended to remain in place for a very long time?"* (Interview object x)

There has been increased interest from developers, but it still lacks knowledge and experience among actors on how to adopt and implement the new regime. Changing to a holistic mindset also requires knowledge sharing and research collaboration. Leading actors with technical expertise (e.g., OsloTre in design with new connection techniques of timber and steel) can transfer their knowledge when jointly developing and implementing the DfD construction projects. Research knowledge through workshops/training and research collaboration with academic organisations is significant in breaking the path of dependence and enabling the feasibility of niche innovations and radical technologies such as using AI in design, deconstruction, and material identification. Forefront actors are vital to penetrating the existing regime and breaking the paths by leading the examples of successful cases in DfD and material reuse.

There is typically a path dependence of small municipalities, large incumbents and SME contractors. This is a key mechanism that holds socio-technical systems in their current development trajectories (22). Path dependence can also be understood as a synonym to the manifold barriers towards sustainability transitions.

*3.3 Landscape*

The construction sector is increasingly influenced by growing awareness among policymakers, consumers, and companies about environmental and societal issues. This heightened focus has prompted a shift toward sustainable practices such as DfD and material reuse. Political and consumer landscapes are evolving rapidly, with significant emphasis placed on climate action and waste reduction. European directives have positioned construction waste reduction as a priority, with DfD and material reuse recognised as essential strategies to achieve this goal.

Recent changes in regulatory frameworks highlight a shift in the pace of transition, challenging the landscape effects on established regimes. New regulations are already influencing construction practices, particularly in pioneering projects that adopt DfD principles. Economic measures, such as increasing costs for CO2 emissions tied to virgin materials, also contribute to reshaping market dynamics. Over time, these pressures are expected to reinforce adopting sustainable practices, particularly as stricter regulations and market mechanisms continue to evolve. However, the practical implementation of DfD faces significant challenges. Although there is a growing demand for its adoption, existing regulations often lack clarity and enforceability. Industry professionals have noted that while DfD requirements exist within building codes, they are not sufficiently concrete or actionable to drive widespread change.

*"There is a requirement in the building regulations, but it's not framed clear enough to be followed in practice. What's missing is something that makes it concrete and applicable."* (Interview object x)

Economic factors further complicate the adoption of DfD. At a macroeconomic level, fluctuations in central bank policy rates, mortgage rates, and commercial loan costs increase the financial burden on construction projects. These factors can delay or reduce investments in innovative and sustainable construction approaches, such as DfD. Simultaneously, project-level costs of high material prices and labour expenses to compliance and risk mitigation costs create a risk-averse environment that discourages engagement in uncertain or experimental projects. Uncertain market conditions compound the financial pressures on developers. Higher costs and limited incentives make it challenging for developers to prioritize DfD.

*"There are so many projects almost ready to go, but the uncertainty in the market keeps them on hold. Developers are reluctant to take risks in the current environment."* (Interview object z)

Institutional and regulatory frameworks play a critical role in overcoming these barriers. Strengthened regulations, combined with targeted funding mechanisms and clearer requirements, are essential to fostering the adoption of DfD and material reuse. Stakeholders emphasize the importance of comprehensive measures that include economic incentives, capacity building, and streamlined public procurement processes.

*"For public procurement to succeed, we need to know exactly what to ask for and evaluate. This clarity has been lacking."* (Interview object x)

Efforts to advance DfD also require alignment between regulatory ambitions and practical implementation. Clearer guidelines and evaluation criteria are critical to ensuring that regulatory requirements translate into actionable practices.

*"We've required DfD in contracts, but it hasn't been clear enough what is needed to meet the requirement."* (Interview object x)

Addressing these challenges will require a coordinated approach, combining regulatory rigour, financial incentives, and innovation in practice. Pilot projects and experimental initiatives, supported by funding and institutional backing, can play a pivotal role in demonstrating the feasibility and benefits of DfD.

*"A combination of funding support schemes and other measures, such as prioritization in case processing, can make a significant difference."* (Interview object w)

This chapter has elaborated on DfD as a radical niche innovation in a MLP framework, based on findings from the interviews and literature study. In the next chapter the findings will be further discussed, implications are made and a conclusion is drawn.

## 4. Discussion and conclusion

This article aims to answer the following research question: What key factors enable DfD to transition from a niche innovation to a widely adopted industry standard? A MLP transition framework has been utilized to illustrate how these innovations evolve from niche applications to mainstream practices in response to policy changes, societal expectations, and climate-related concerns.

The DfD approach represents a paradigm shift in construction, transitioning from linear material consumption to a circular economy model that prioritizes reuse and adaptability. Transition pathways outline how radical niche innovations evolve through distinct stages. DfD is currently in an early stage of development, **experimenting** and building a knowledge base as part of research projects like SirkBygg. In this stage, expanding the number of pilot initiatives, backed by innovation-focused funding, will generate valuable insights for the broader industry. Moreover, successful case studies from developers such as Höegh Eiendom and Mustad Eiendom can set precedents that encourage widespread adoption. Our study confirms the lack of innovative BMs to support the transition. There is a need for technological as well as BM innovations to emerge in the niches such as deconstruction services, prefabrication production, material reuse services etc. Some advancements to prefabricated hollow-core slabs are made as part of the SirkBygg project.

In addition to innovative BMs, advancing from experimentation to **stabilization** necessitates comprehensive knowledge sharing, learning, and standardization. The trend towards reuse has earlier resulted in a Norwegian standard for reuse of hollow-core slabs to be made. This significantly reduces risk for the actors involved. SirkBygg has contributed to knowledge building and risk reduction by developing criteria for DfD as well as calculation rules for greenhouse gas emissions accounting during DfD.

The next step on the transition pathway is **disruption**, meaning the radical niche has entered the regime level, and structural changes can be seen. Despite growing awareness and regulatory shifts toward sustainability, DfD faces significant barriers in the construction sector. Regulatory clarity remains a challenge, as existing building codes lack concrete, enforceable guidelines for DfD implementation, limiting widespread adoption. Economic pressures, including rising material costs, interest rate fluctuations, and financial risks, create a market environment where developers are hesitant to invest in innovative, resource-efficient construction methods. Overcoming these challenges will require stronger regulatory frameworks, targeted financial incentives, and DfD criteria clear enough to be utilized in public procurement, ensuring that sustainable practices become both viable and scalable. The ultimate step becoming an industry standard is **institutionalization**. This implies that the linear system of construction is replaced by circular principles, embedding new standards, norms, technologies, and institutions relevant to the circular principles of construction (20).

The transition from traditional construction methods to DfD as an industry standard demands systemic changes across market behavior, regulation, financial frameworks, and technological advancements. Strengthening collaboration, economic incentives, and regulatory enforcement will be fundamental in accelerating this shift. By addressing these key factors, DfD has the potential to become a mainstream practice, supporting sustainability goals while redefining the future of construction.

## 5. Acknowledgement

The authors thankfully acknowledge the support from the Research Council of Norway as well as the SirkBygg partners Skanska Norway, Spenncon and Heidelberg Materials Prefab.

## 6. References


1. IEA U. Global status report for buildings and construction 2019 [Internet]. 2019. Available from: https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019
2. Norouzi M, Chàfer M, Cabeza LF, Jiménez L, Boer D. Circular economy in the building and construction sector: A scientific evolution analysis. Journal of Building Engineering. 2021 Dec 1;44:102704.
3. Augustine-Marceil W. Which Buildings are "Worth" Disassembling? An Analysis of American Deconstruction Ordinances. 2023.
4. De Wolf C, Çetin S, Bocken NMP, editors. A Circular Built Environment in the Digital Age [Internet]. Springer Nature; 2024 [cited 2025 May 25]. Available from: https://library.oapen.org/handle/20.500.12657/86890
5. Försterling G, Orth R, Gellert B. Transition to a Circular Economy in Europe through New Business Models: Barriers, Drivers, and Policy Making. Sustainability. 2023 Jan;15(10):8212.
6. Rezaeian M, Pinkse J, Rigby J. Transforming titans: The role of policy mixes in business model adaptation strategies for sustainability transitions. Energy Research & Social Science. 2024 Jun 1;112:103499.
7. Geels FW. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research policy. 2002;31(8–9):1257–74.
8. Ahmadov T, Durst S, Gerstlberger W, Kraut E. SMEs on the way to a circular economy: insights from a multi-perspective review. Manag Rev Q. 2025 Feb 1;75(1):289–322.
9. Loorbach D, Frantzeskaki N, Avelino F. Sustainability Transitions Research: Transforming Science and Practice for Societal Change. Annual Review of Environment and Resources. 2017 Oct 17;42(Volume 42, 2017):599–626.
10. Rip A, Kemp R. Technological change. In: Human choice and climate change: Vol II, resources and technology. Battelle Press; 1998. p. 327–99.
11. Schot J, Geels FW. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. In: The Dynamics of Sustainable Innovation Journeys. Routledge; 2011.
12. Smith A, Voß JP, Grin J. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Research policy. 2010;39(4):435–48.
13. Bidmon CM, Knab SF. The three roles of business models in societal transitions: New linkages between business model and transition research. Journal of Cleaner Production. 2018 Mar 20;178:903–16.
14. Geels FW, Schot J. Typology of sociotechnical transition pathways. Research Policy. 2007 Apr 1;36(3):399–417.
15. Kemp R, Schot ,Johan, and Hoogma R. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technology Analysis & Strategic Management. 1998 Jan 1;10(2):175–98.
16. Smith A, Raven R. What is protective space? Reconsidering niches in transitions to sustainability. Research Policy. 2012 Jul 1;41(6):1025–36.
17. Fagerberg J. Mission (im) possible? The role of innovation (and innovation policy) in supporting structural change & sustainability transitions. Centre for Technology, Innovation and Culture, University of Oslo; 2018.
18. Bulkeley H, Coenen L, Frantzeskaki N, Hartmann C, Kronsell A, Mai L, et al. Urban living labs: governing urban sustainability transitions. Current opinion in environmental sustainability. 2016;22:13–7.
19. Sengers F, Wieczorek AJ, Raven R. Experimenting for sustainability transitions: A systematic literature review. Technological Forecasting and Social Change. 2019;145:153–64.
20. Geels FW. Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. Current Opinion in Environmental Sustainability. 2019 Aug 1;39:187–201.
21. Fuenfschilling L, Truffer B. The interplay of institutions, actors and technologies in socio-technical systems—An analysis of transformations in the Australian urban water sector. Technological Forecasting and Social Change. 2016;103:298–312.
22. Apajalahti EL, Kungl G. Path dependence and path break-out in the electricity sector. Environmental Innovation and Societal Transitions. 2022;43:220–36.