URBAN SUSTAINABILITY TRANSITIONS TOWARDS ASBESTOS-FREE MUNICIPALITIES

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The phase-out of asbestos in urban environments represents a complex challenge across European municipalities. Despite European Union targets to achieve asbestos-free cities, implementation remains uneven because municipalities face fragmented regulations, differing inspection and disclosure requirements, limited funding, technical constraints, and variable public awareness. The paper identifies key barriers, including regulatory heterogeneity, inadequate disposal infrastructure, and financing gaps, as well as enabling factors such as harmonized policies, innovative treatment technologies, capacity-building programs, and community engagement. Based on these insights, a typology of municipal transition pathways is developed, including compliance-driven, retrofit-integrated, innovation-led, community-driven, and market-based approaches. The findings also underline equity considerations, emphasizing the need to prevent disadvantaged communities from remaining disproportionately exposed to asbestos hazards. By framing asbestos removal as a material legacy transition within broader urban sustainability transitions, the paper contributes both to theoretical understanding of socio-technical and ecosystem dynamics and to practical guidance for policymakers and urban planners.

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1 Introduction

Asbestos remains one of the most persistent environmental and public health hazards in European cities, despite longstanding bans on its use (Curado et al., 2024). Its widespread application in historical construction has left a legacy of ageing buildings and infrastructure containing asbestos-containing materials (abbreviation: ACMs) that continue to pose risks when deteriorated or improperly removed (Butkevics & Atstaja, 2025). Exposure to asbestos is linked to serious diseases, including mesothelioma, lung cancer, and asbestosis, often decades after initial contact (Klebe et al., 2024). While the European Union has set an ambitious target for asbestos-free cities by 2032, progress across municipalities remains uneven because rules on asbestos inspection, disclosure during property transactions, removal obligations, financing eligibility, and waste handling differ across jurisdictions, while limited financing, insufficient technical capacity, and low public awareness further constrain implementation. Local contexts (such as institutional capacity, economic resources, public attitudes, and existing infrastructure) significantly influence the pace and effectiveness of removal programs (Vincenten et al., 2017).

Current research often focuses on technical removal methods, waste management, or health risks, but less attention has been paid to treating asbestos elimination as a systemic urban sustainability transition (Durczak et al., 2024). Cities function as complex urban ecosystems (Bódizs et al., 2025), where infrastructure, institutions, and communities interact to shape both environmental risks and sustainability transitions. This paper addresses this gap by applying a systemic ecosystem framework that integrates institutional, technological, economic, social, and infrastructural dimensions to analyse municipal asbestos phase-out. The research identifies barriers and enablers, maps distinct transition pathways, and examines how path dependencies shape implementation strategies. By combining theoretical insights from sustainability transitions with comparative observations drawn from policy documents, regulatory frameworks, municipal strategies, and academic literature on European municipalities, it provides actionable guidance for policymakers, urban planners, and industry stakeholders. The paper positions asbestos removal not only as a technical or regulatory task, but as a multidimensional challenge central to achieving sustainable, resilient, and equitable urban futures.

2 Theoretical Background

Sustainability transitions research aims to understand how complex socio-technical systems evolve toward more sustainable configurations involving intertwined technological, institutional, economic, and social change processes (Andersson et al., 2024). A dominant analytical lens in this field is the Multi-Level Perspective (abbreviation: MLP), which conceptualizes transitions as emerging from dynamic interactions among niches (protected spaces for innovation), regimes (stable configurations of institutions, practices, and technologies), and landscape pressures (broad socio-economic and cultural forces) that together enable or impede systemic change (F. W. Geels, 2011). Traditionally, MLP has been applied to energy, transport, and resource systems, revealing how novelty emerges in sheltered spaces, destabilizes incumbent regimes under external pressures, and eventually reshapes socio-technical configurations (F. Geels, 2024). However, sustainability transitions research increasingly recognizes that meaningful transformation often requires governance and institutional change (Nagy-Rádli et al., 2025), addressing entrenched path dependencies and lock-in effects that are not reducible to technological innovation alone (van Wijk & Fischhendler, 2025). Complementing MLP, innovation ecosystem thinking emphasizes the systemic interdependencies among heterogeneous actors, funding flows, organizational networks, and enabling institutions, enabling a richer understanding of how transition processes unfold across multiple domains beyond individual technologies or policies (Sultana & Turkina, 2023).

This perspective highlights that transitions emerge not only from niche innovations but also from co-evolutionary processes that involve learning, collaboration, and coordination among diverse stakeholders (Winkler-Portmann et al., 2025). In parallel, institutional theory contributes insights into how regulatory capacity, governance norms, and policy frameworks shape actors' capabilities to enact change (Brammer et al., 2012). Institutional arrangements influence both the distribution of authority and the allocation of resources necessary to support systemic transition processes, including regulatory harmonization, enforcement mechanisms, and mechanism design for equitable cost sharing (Radtke & Renn, 2024). This paper treats asbestos phase-out as a material-legacy transition, a form of sustainability transition that is driven by decommissioning and remediation of hazardous infrastructures rather than only by the diffusion of environmentally beneficial

technologies. The integrated ecosystem framework developed here captures cross-domain interactions among institutional, technological, economic, social, and infrastructural elements, providing a holistic lens to analyse how municipal actors negotiate barriers and harness enabling conditions for urban sustainability transitions.

To synthesize the theoretical perspectives discussed above, Figure 1 applies the multi-level perspective to municipal asbestos phase-out as a material legacy transition. The figure illustrates how landscape-level pressures, including public health imperatives and EU policy targets, interact with regime-level municipal governance structures, infrastructure systems, and regulatory frameworks. At the niche level, emerging removal technologies, pilot projects, and innovative governance arrangements create protected spaces for experimentation and learning. The framework highlights that transition dynamics are driven not by technological diffusion alone, but by the coordinated reconfiguration of institutional, economic, technological, and social elements. More specifically, institutional rules shape which technologies can be adopted and financed, while social acceptance, contractor capabilities, and public communication influence whether removal programmes are implemented effectively. This conceptualization provides the analytical foundation for the methodological approach and comparative analysis presented in the following sections.

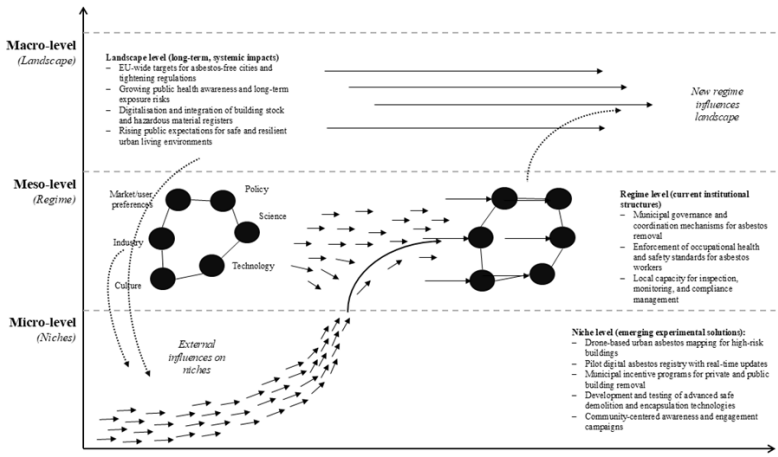

Figure 1: Multi-level perspective applied to municipal asbestos phase-out
Source: author's own elaboration.

3 Methodology and Research Design

This paper adopts a qualitative, comparative research design to examine asbestos phase-out as an urban sustainability transition at the municipal level in Europe. Municipalities are selected as the unit of analysis because they represent the primary arena where regulatory implementation, infrastructure management, and public engagement intersect. The analysis focuses on European urban contexts in which asbestos use is banned, but significant legacy stocks of asbestos-containing materials remain.

The paper applies an ecosystem-based analytical framework integrating institutional, technological, economic, social, and infrastructural dimensions. Data sources include policy documents, regulatory frameworks, municipal strategies, and peer-reviewed academic literature that document recurring implementation conditions, governance arrangements, and removal challenges across European municipalities. These materials are analysed using qualitative content analysis, combining deductive coding informed by sustainability transition theory with inductive identification of emergent patterns, illustrative implementation scenarios, and recurring cross-case mechanisms. A comparative logic is employed to identify recurring transition pathways across municipalities while accounting for local contextual variation; rather than presenting full case studies, the paper synthesizes recurring patterns reported across European contexts. The research emphasizes analytical rather than statistical generalization, focusing on mechanisms and configurations shaping removal outcomes. Limitations include uneven data availability and reliance on secondary sources, which are mitigated by a focus on cross-case patterns and systemic insights.

4 Results and Discussion

The results demonstrate that achieving asbestos-free urban environments is not primarily a technical challenge but a systemic governance issue that unfolds across multiple interacting domains. Municipal progress depends on the coordinated alignment of institutional frameworks, financial instruments, technological capacities, social engagement, and infrastructural conditions. Isolated policy measures or technological solutions are insufficient to trigger sustained removal dynamics. Instead, effective implementation emerges where multiple levers are activated simultaneously within a coherent policy mix.

Institutional arrangements appear as the most influential factor shaping municipal asbestos phase-out trajectories. Municipalities with clear allocation of responsibilities, standardized asbestos registries, and enforcement capacity are better positioned to plan, prioritize, and sequence removal activities. Registries function not only as technical tools but also as governance instruments that enhance transparency, enable targeted financing, and support risk-based prioritization. In this context, fragmented regulations refer to situations in which inspection duties, disclosure requirements in property transactions, financing eligibility, and waste-management procedures are distributed unevenly across administrative levels or jurisdictions. For example, one municipality may require an asbestos assessment before renovation or sale, while another may rely mainly on general construction compliance, leading to markedly different implementation pathways. Incomplete data systems and fragmented competencies therefore generate inertia even in contexts with formal regulatory bans.

Economic constraints constitute a second major barrier. Asbestos removal, transport, and disposal remain significantly more expensive than conventional renovation activities, placing a disproportionate burden on municipalities and low-income households. A retrofit-integrated pathway refers to situations in which asbestos removal is embedded in broader building renovation, energy-efficiency upgrading, or urban regeneration programmes, allowing municipalities and property owners to combine funding streams, administrative procedures, and construction works. In such cases, implementation can accelerate through cost-sharing and administrative synergies. However, without explicit equity mechanisms, such integrated approaches risk privileging better-resourced property owners.

Technological capacity forms a third critical axis. Conventional manual removal and controlled landfill disposal remain the dominant practices, yet they generate large volumes of hazardous waste and long-term disposal liabilities. Emerging alternatives offer potential pathways to reduce landfill dependence and support circular economy objectives. From a transition perspective, these technologies operate as experimental niches rather than immediate substitutes, with their diffusion contingent upon regulatory adaptation, risk governance, and public acceptance. Municipalities can play an active role as niche sponsors by enabling pilot projects, facilitating learning, and negotiating regulatory flexibility.

Social dynamics significantly influence compliance and legitimacy. Municipalities that invest in public awareness campaigns, contractor training, and transparent communication experience lower rates of illegal disposal and higher participation in removal programs. Infrastructural legacies and path dependencies further shape implementation strategies. Concentrated asbestos stocks in public buildings enable economies of scale, while diffuse private holdings require mass inspection, subsidy schemes, and long-term engagement strategies. Sequencing approaches that prioritize high-risk public assets and use them as demonstration projects have proven effective in building capacity and trust, thereby catalysing broader private-sector uptake.

These findings reveal distinct municipal transition pathways, ranging from compliance-driven strategies to retrofit-integrated, innovation-led, community-driven, and market-based approaches. These pathways emerge from different combinations of institutional capacity, technological readiness, financing arrangements, and social engagement rather than from a single policy instrument or technological solution. These pathways differ in speed, equity, and scalability, highlighting that no single model is universally optimal. Rather, asbestos phase-out success depends on adaptive governance capable of aligning institutional, economic, technological, and social dimensions in response to local conditions. The results reinforce broader sustainability transition insights emphasizing policy coherence, learning-oriented implementation, and the strategic management of material legacies.

The research provides actionable insights for municipal policymakers. Effective asbestos phase-out requires multi-domain coordination, aligning regulatory enforcement, dedicated funding, and technical capacity to accelerate removal outcomes. Transparent asbestos registries, as promoted in EU guidance and national frameworks, are critical for identifying high-risk buildings, planning interventions, and building public trust. Funding mechanisms should ensure equitable access; combining asbestos removal with EU-supported renovation or energy-efficiency programs can reduce costs while avoiding exclusion of vulnerable populations. Sequencing interventions by prioritizing public assets such as schools and hospitals helps build technical capacity and encourages subsequent private-sector uptake. Pilot projects for advanced technologies, including thermal treatment, vitrification, or chemical stabilization, enable learning and regulatory adaptation. Integrating removal with urban regeneration or energy retrofits generates co-benefits and

reduces administrative burdens. Participatory approaches that involve communities and contractors improve compliance, trust, and long-term sustainability. Altogether, these lessons emphasize that effective asbestos phase-out requires adaptive, learning-oriented governance that balances technical feasibility, social equity, and institutional capacity.

5 Conclusions

This paper demonstrates that asbestos phase-out in European municipalities represents a complex sustainability transition requiring coordinated action across multiple domains. Effective removal depends on the alignment of institutional arrangements, financing mechanisms, technological capacities, social engagement, and infrastructural management. Municipalities adopt distinct transition pathways (compliance-driven, retrofit-integrated, innovation-led, community-driven, and market-based), each with differing speed, equity, and scalability. Early interventions in high-risk public assets build technical capacity, reduce perceived risk, and catalyze broader participation in private housing programs. Municipalities that support pilot projects for advanced treatment technologies facilitate safe, innovative, and circular approaches to asbestos management.

Policy packages combining harmonized regulation, dedicated funding, transparent registries, and community engagement consistently outperform isolated measures. Equity considerations are central, ensuring vulnerable populations are not disproportionately exposed. Demonstration projects, capacity-building initiatives, and public awareness campaigns strengthen compliance and long-term program success. The paper provides both theoretical contributions to sustainability transition research and practical guidance for urban governance, highlighting the need for integrated, adaptive, and socially responsive strategies to achieve asbestos-free urban futures.

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