

From Systems Thinking to Project Decisions: Bridging the Gap in Building Practice

Azam Khan and Simon Breslav

Trax

azam.khan@trax.co and simon@trax.co

Abstract

Housing systems are increasingly understood as complex, interconnected systems shaped by economic, social, technical, and regulatory forces. Despite growing awareness of this complexity, outcomes across the housing sector remain inconsistent. Some housing builders develop innovative best practices and thrive despite increasing regulatory burdens, while others seem to be disconnected from these advances and cannot adapt their businesses accordingly. We suggest that the core challenge is not a lack of knowledge, but the difficulty of translating knowledge into consistent decisions across the lifecycle of a building project. Drawing on prior work in system dynamics, recent research on data supply chains, and advances in construction informatics, we explore the gap between understanding housing systems and operationalizing that understanding in practice. We propose that a building systems-first, decision-centered perspective is required to bridge this gap and improve outcomes in building delivery.

Introduction

The housing system is widely recognized as a complex adaptive system in which outcomes emerge from the interaction of economic, social, technical, and regulatory factors. In recent years, significant progress has been made in identifying best practices for improving housing performance, including energy efficiency, emissions reduction, and construction innovation. However, despite this growing body of knowledge, project outcomes remain inconsistent.

This discrepancy suggests that the central challenge facing housing systems is no longer solely one of knowledge generation, but of knowledge application i.e., how to apply the right knowledge for a specific project at the right time. While research, policy, and industry have converged on various solutions, these solutions are not consistently realized in practice. We examine the structural reasons for this gap and explore how a whole systems-oriented approach can support more reliable decision-making in building practice.

From System Dynamics to Housing Practice

Prior work (Khan 2021; Marzouk and Hosny 2016; Dianati and Ryan-Collins 2023) has explored housing systems using system dynamics modeling, demonstrating how variables such as housing supply, population growth, financing,

and investment interact through reinforcing and balancing feedback loops. Rather than treating housing outcomes as the result of isolated decisions, this approach frames them as emergent properties of interconnected systems.

These systems can represent historical data and can model scenarios of future outcomes based on specific policy interventions (Future Cities Institute 2026; Urban Data Research Center 2026; Urban Predictive Analytics Lab 2026). To validate that these outcomes can be realized, they need to be based on mature data sets of high quality (Fox, Gajderowicz, and Lyu 2025) and must be connected to construction supply chain data, in the future, as that field matures (Josa and Borrión 2025).

This perspective reveals a key limitation in current policy-making and research, specifically that data-driven economic forces are not modeled in practice by governing bodies and research to connect these models to construction innovations is not available.

The Implementation Gap

Even when best practices are well understood, their implementation is often inconsistent. For example, in energy retrofit projects, technologies such as heat pumps are widely recognized as essential components of decarbonization strategies. However, these systems may not be properly sized or integrated, due to gaps in information, communication, or coordination among stakeholders.

Had this process been reversed, where building systems had been specified based on energy modeling and the procurement of code-compliant components had been determined up front, these best practices could help optimize costs and minimize downstream failures.

The Innovation Paradox

The adoption of innovative building systems introduces a recurring paradox. To implement new technologies, project teams must verify that products are compliant with building codes, meet local by-law requirements, are available within regional supply chains, and can be maintained over time. When this analysis is delayed, projects often encounter late-stage redesign or must accept low performance outcomes, resulting in schedule risk and increased cost (Paulson 1976).

This dynamic reflects a broader structural issue: innovation is constrained not by a lack of ideas, but by the diffi-

culty of aligning regulatory, technical, and logistical considerations early in the design process.

Top-Down Goals and Bottom-Up Decisions

As a best practice, a building systems-first strategy suggests that these challenges can be mitigated by integrating top-down goals with bottom-up feasibility analysis. Top-down goals, such as costs, emissions targets, or performance requirements, define desired outcomes, while bottom-up analysis ensures that these outcomes are achievable within real-world constraints.

Early identification of viable materials, systems, and equipment can reduce uncertainty in specification and procurement, thereby lowering costs and improving delivery timelines. This approach reframes decision-making as a continuous process across phases, rather than a sequence of isolated steps.

From Data to Decisions

The increasing availability of urban and building-scale data presents new opportunities to better understand housing systems. However, recent work on Canada's AI strategy highlights that data alone is insufficient. Instead, the development of structured data supply chains is required to transform raw data into actionable insight (Sen 2026).

In the housing domain, data exists across multiple sources, including design models, product specifications, building codes, and operational data. Yet these datasets are rarely integrated in ways that support consistent decision-making. Froese et al. have demonstrated pragmatic ways to integrate relevant data sets at the building level using Building Information Modeling (BIM) to support integrated decision-making across the building lifecycle (Froese 2010). In an academic context, Gerber et al. propose the extension of the digital twin concept to foster data-driven building research in a living lab paradigm (Gerber et al. 2025).

BPIBS's Collaborative Intelligence Vision (CIV) represents an important step toward addressing this challenge by combining large language models with structured ontologies and graph-based knowledge systems. To close the loop, these best practices could result in data sets, or data streams from digital twins, that could act as new validation inputs for knowledge integration, or as characterized data sets into the CIV graph database.

Leading with Innovative Building Systems

The central challenge, therefore, is not only to align knowledge across the housing system, but to ensure that this knowledge is optimally applied in practice based on project context. This requires a shift in perspective from viewing knowledge as static information to understanding it as an active component of decision-making.

It should be expected that innovation in building systems will continue and when new best practices replace previous ones, or outcome data sets revise best practice knowledge, the entire community can benefit immediately via the CIV system.

Building the right housing can only be achieved when starting from the right approved, available, and maintainable building systems. By modeling the overall housing system, and modeling the building systems performance within these projects, evidence-based housing policy can directly benefit the entire industry.

Acknowledgments

We thank Lenny Kishi for the heat pump example regarding reliable information and Rod Nadeau for emphasizing the problems introduced when selecting components late in the design and construction process (personal communication during the BC Housing BPIBS Gathering: Bringing Together Voices and Perspectives on Housing Futures).

References

- Dianati, K.; and Ryan-Collins, J. 2023. The London Housing Market: A System Dynamics Analysis. *SSRN Electronic Journal*. Working paper.
- Fox, M. S.; Gajderowicz, B.; and Lyu, D. 2025. A Maturity Model for Urban Dataset Metadata. *International Journal of Digital Curation*, 19(1): 1–27.
- Froese, T. M. 2010. The Impact of Emerging Information Technology on Project Management for Construction. *Automation in Construction*.
- Future Cities Institute. 2026. University of Waterloo: Advancing Best Practices in Urban Development and Building Systems. <https://uwaterloo.ca/future-cities-institute/>.
- Gerber, D.; McGlashan, N.; Breslav, S.; and Khan, A. 2025. Living Lab Digital Twin: Case Study of the Development of a Research-Oriented Digital Twin in a LEED Platinum Academic Building. In *Symposium on Simulation for Architecture and Urban Design (SimAUD 2025)*, ANNSIM '25, 11. Madrid, Spain: Society for Modeling and Simulation International (SCS). Part of ANNSIM 2025.
- Josa, I.; and Borrion, A. 2025. Key indicators to assess construction supply chains from an environmental perspective: taxonomy and critical insights. *Sustainable Futures*, 10: 100824.
- Khan, A. 2021. Thinking Tools for Systems Thinking. *TAD: Technology — Architecture + Design*, 5(2): 134–139.
- Marzouk, M.; and Hosny, I. 2016. Modeling housing supply and demand using system dynamics. *Housing, Care and Support*, 19(2): 64–80.
- Paulson, B. C. 1976. Designing to Reduce Construction Costs. *Journal of the Construction Division*, 102(4): 587–592.
- Sen, A. 2026. The Missing Pillar of Canada's AI Strategy: Data Supply Chains.
- Urban Data Research Center. 2026. University of Toronto: Urban Data and Systems Modeling for Sustainable Cities. <https://urbandatacentre.com>.
- Urban Predictive Analytics Lab. 2026. UBC: Computational science for urban planning and decision-making. <https://www.urbanpredictiveanalytics.com/>.