

Data Silos in the Architecture, Engineering, and Construction Industry

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1. Introduction

The architecture, engineering, and construction (AEC) industry is among the world's largest economic sectors, projected to reach 16 trillion dollars by 2031 (Thorta, 2024) and accounting for nearly 13 percent of global GDP (McKinsey & Company, 2020, p. 3). The built environment is responsible for around 34 percent of global CO₂ emissions, and consumes about 32 percent of global energy, meaning that decisions in this sector directly impact long term climate outcomes (McLean, 2025), as increasingly scarce natural resources along with worsening environmental conditions are leading to a growing demand for sustainability within the built environment (U.S. EPA, 2017). When referring to sustainable construction or green building, this paper will use USGBC's definition of green building as “.. a process of continually improving design, construction, and operations practices to create lower impact, more sustainable, and ultimately regenerative built environments that support healthier communities and more efficient use of energy, water, and materials” (*An Introduction to LEED and Green Building* | U.S. Green Building Council, 2019). Despite its economic scale, the AEC industry has been one of the slowest major sectors to adopt digital tools (Ham et al., 2018, p. 2; Beck Technology, 2025). Recent data from Revizto's 2026 Digital Design & Construction Report shows that 92% of projects go over budget, and that poor communication and coordination are among the leading causes of rework which is the process of redoing or fixing parts of a project that either fail to meet specifications or was done incorrectly (Revizto, 2026). As of early 2026, 87% of firms reported significant cost overruns, half of which being over 11%. The same report describes the industry as having “effectively built in a tolerance for missing targets by around 10%,” which translates into billions in lost value across project cycles (Revizto, 2026). Beck Technology estimates that only 0.5% of construction data is used efficiently, and that bad or incomplete data has cost the industry over 1.84 trillion dollars globally, with millions in avoidable rework and thousands of hours spent trying to organize information (Beck Technology, 2025). While most construction firms now collect extensive

financial and project data, only around one third utilize their financial data to inform decisions (Peccalo, 2023). These numbers suggest that inefficiency in construction is a structural problem in how the industry manages data. On top of the large volume of technical and financial data necessary to deliver projects that the AEC sector already struggles with, reforms which intend to make building practices more sustainable add additional layers of complexity. In trying to define how sustainable construction should take place, numerous actors define “best practices” for materials and systems in slightly different ways and on different timelines. These layers act as parallel streams of information, so a single project must satisfy multiple, partially conflicting definitions of how the project must be configured to be considered sustainable. In practice, firms generally tend to manage each system in its own software environment or reporting environment, meaning those parallel definitions are also stored in parallel technical systems. As Turk observes, diverse software in the built environment is “unable to talk to each other and is resulting in islands of automation,” and this problem of digital information fragmentation has persisted for three decades despite extensive reporting and awareness (Turk, 2020). Butcher (2025, p. 1) similarly notes how data in the built environment is “dominated by centralized storage and management” which produces data silos and therefore directly sabotages efforts to support sustainability reforms. Slow progress in sustainable construction cannot be explained solely as a failure of markets to internalize externalities or as a mere lack of political will and cooperation, but rather is the result of the AEC’s difficulty with integrating dispersed knowledge across multiple poorly coordinated institutional and technical systems.

2. Coordination Failure and Market Limitations

Several economic accounts of underinvestment in low carbon and energy efficient technologies frame the problem as a coordination failure. Mielke and Steudle describe how “economies can become stuck in an inefficient equilibrium with a low level of economic activity, even

though a better equilibrium exists” suggesting that macro states can be understood as stag hunt situations in which actors stay in a “risk dominant” equilibrium despite the existence of a higher payoff alternative (Mielke and Steudle, 2018). In the context of the AEC industry, decentralized firms must make large and interdependent decisions about adopting sustainable construction practices, such as investing in less familiar materials and design processes. Because the benefits of these investments often depend on complementary actions by other actors such as manufacturers, clients, lawmakers, and regulatory agencies, individual firms have an incentive to “wait and see” whether others move first. This results in collective underinvestment and a stalled transition to sustainable practices, even though a more sustainable, energy efficient and cost efficient equilibrium is technically feasible. Maklan (n.d.) similarly discusses how decentralized actors lack enough incentives to invest in low carbon solutions without coordination more broadly across the industry. He uses the example of how infrastructure investments required for a national home heating solution are “likely beyond any supplier” and that, in the absence of credible government backing, capital markets are unwilling to finance them. Additionally, these investments require a co-development of complementary goods and services, such as tens of thousands of trained tradespeople and new generation transmission hardware. Suppliers will not invest ahead of demand, but demand will not materialize until these externalities are in place. Policymakers then interpret this economic impasse as evidence of market failure and respond by implementing standards intending to coordinate sustainability progress and mobilize investment. The stag hunt model and coordination failure theories can be a useful tool in understanding how even rational actors can remain stuck in inefficient outcomes like in the case of the AEC’s many inefficiencies as discussed above, and why some form of coordination might be necessary. They also provide context for why so many different institutions have attempted to create focal points for behavior through their own regulatory systems and certification schemes within sustainable development. However, these models are limited in two important ways for understanding the AEC

case. First, they tend to treat “the market” and “the government” as distinct and relatively coherent actors and focus on the question of whether the state can move the system from a bad equilibrium to a good one. In practice, sustainable construction involves a dense network of overlapping institutions, from intergovernmental organizations (UNEP, ISSB), and financial regulators to governmental authorities (e.g., federal agencies, state code councils, municipal planning boards), alongside third party certifiers (e.g., GBCI) and private industry stakeholders (e.g., investors, developers, manufacturers) to name a few. There is not one coordinating authority at the top of the pyramid, but rather a cluster of partially overlapping circles of bureaucracies with their own information and compliance requirements. Second, stag hunt models abstract away from the question of how information is communicated and utilized in specific organizational settings. They assume actors know the structure of the “game” and can observe or even infer others’ actions and payoffs. However, in the AEC most of the information professionals need to evaluate a sustainable design choice is dispersed throughout technical documents and data sources that are often heterogeneous in nature. No single actor can simultaneously see how a given design choice will affect direct costs and schedule, interact with site specific conditions (e.g., water stress or local climate risks), impact emissions throughout the building’s lifecycle, satisfy ever changing code and regulatory constraints, and be interpreted under different reporting standards, all while meeting project specific client and community preferences. Any coordination mechanism in sustainable construction therefore must operate under conditions of inherently partial, local information rather than full centralized knowledge. This exemplifies Hayek’s theory of dispersed knowledge, in which he argues that the knowledge relevant for coordination exists “solely as dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess” (Hayek 1945, p. 519). In chapter 2 of *Rules and Order* Hayek explains how price signals convey this dispersed knowledge and guide market decisions to help it continuously return to equilibrium (Hayek 1973). The modern financial sector is an example of this mechanism working as new information is

almost instantly incorporated into valuations which allows decentralized actors to adjust according to prices that already reflect the latest information. The AEC industry does not have an equivalent mechanism that could aggregate this dispersed knowledge into something that project stakeholders can utilize in real time, even though in principle a better institutional and technical architecture could theoretically give sustainable construction its own version of that coordinating function.

Within everyday industry practice during the construction process, this paper identifies the knowledge required for such coordination to instead be spread across three empirical “silos”: public regulatory and compliance systems, investment criteria, and operational project tools and workflows. The way each silo is organized and interacts shows that the same institutions intended to correct market failures often make coordination even more difficult and that this broader bureaucratic environment continues to constrain entrepreneurial innovations.

3. Regulatory and Compliance Systems

In principle, regulatory and compliance systems exist to correct market failures. Federal environmental regulations, state building and energy codes, local zoning ordinances, and municipal permitting procedures are all designed to encourage lower carbon emitting and more energy and water efficient outcomes than unregulated markets would feasibly allow. However, these systems do not easily integrate with project level workflows. The U.S. regulatory environment is highly disconnected, and environmental and energy policies operate at multiple jurisdictional levels where federal rules are layered on top of state codes and local ordinances. ESG (Environmental, social, and governance) refers to a set of standards and metrics used to evaluate how firms manage environmental impacts, especially for investment and disclosure purposes. Cross jurisdictional variation means that a firm working in two neighboring cities or states, and sometimes even towns might deal with different definitions of what counts as compliant performance or ESG related disclosure obligations attached

to public funding or different project types (Deltek, 2025). Jurisdictions can also choose to “overlay” codes such as the International Green Construction Code (IgCC), which is designed to help integrate with core model codes and align with green building pathways, but ends up introducing yet another variable in what qualifies as compliant, further slowing down workflows. Firms therefore must maintain multiple “internal knowledge bases” about numerous codes and funding conditions. The format in which regulatory knowledge is communicated in further reinforces these silos, since in many jurisdictions building control and permitting processes are still largely manual and only partially digitized. Inspectors and permitting staff often rely on checklists that may be digitized but frequently reside in isolated municipal applications which forces staff to reenter the same information across multiple systems and maintain parallel spreadsheets or tracking tools (MCCI, 2025). A building information modeling system does not automatically update when the state implements a new energy code last month, nor does a permitting database automatically see how a proposed change to wall material choice would affect project’s lifecycle carbon emissions. Human intermediates must manually translate between regulatory texts and project models, which adds time and opportunities for error (Fauth et al., 2023). In addition, there are third party rating frameworks—the most well known being LEED—designed to certify buildings that implement enough sustainable building practices. While these systems are not laws per se, they rely on similarly intensive documentation and review processes, making them function as additional “quasi regulatory” layers which, although valuable for informing project teams *what* to do and *how* to do it, they do not translate cleanly into the technical workflows in which project teams make decisions within the scope of their unique local conditions. When these rules are implemented through disconnected, static systems, they also create what is effectively a separate data silo. While regulatory and compliance systems do partially address the stag hunt problem by setting common baselines and in some cases shifting payoffs through incentives, they also

exemplify the limits of trying to solve coordination failures by adding more rules without redesigning the information channels through which those rules interact with local, project level knowledge.

4. Investment Pathways

The second major silo involves firms and capital markets; most notably, Environmental, Social, and Governance (ESG) reporting has evolved from a mostly voluntary pursuit into a major channel through which construction and real estate firms communicate with investors. OECD survey data shows that 72 percent of companies identify institutional investors and banks as the top users of their ESG reports, meaning that demand from financial markets is what primarily drives sustainability reporting efforts (OECD, 2025). In this sense, ESG frameworks are almost explicitly intended to address a perceived market failure through the act of embedding environmental and social considerations into financial decision making, for example requiring firms to disclose emissions profiles and green asset exposure so that investors can compare across portfolios. However, ESG systems have their own coordination challenges, a major issue being the divergence among ESG rating agencies. Research from MIT Sloan’s “Aggregate Confusion” project documents substantial disagreement between the ESG ratings of major agencies, due to differences in which indicators they include and even how they are measured and weighted (Berg et al., 2022). This means that the same construction or real estate firm can receive significantly different ESG scores depending on the rating agency, which makes it hard for companies to understand what behaviors are being rewarded making it difficult for developers to secure financing and align with sustainable capital mandates. ESG ratings also often focus on how companies manage internal processes rather than the actual climate impacts of their products (CFA Institute, 2024). So, at the top of the organization, sustainability and finance teams work with ESG ratings and disclosure documentation, while at the project level, professionals use governmental codes and local information to inform operation. There is no straightforward

communication between these levels, as reporting is not the same as decision making. ESG metrics may influence how firms talk about sustainability to capital providers, but they do not automatically dictate how a project engineer or architect should choose materials, assemblies, or systems on a given job. In coordination terms, ESG frameworks attempt to create a new payoff structure by rewarding firms that perform well on environmental and social dimensions, yet because the information they generate is top-down, periodic, and methodologically inconsistent, they often function as a separate coordination game between firms and capital providers, with only indirect and delayed connection to the project level design choices that determine actual emissions and resource use.

5. Operational Project Data and Workflows

The third silo comprises of operational tools and workflows through which buildings are actually designed on and which assist day to day decisions. This includes BIM platforms, CAD tools, cost estimation software, scheduling and project management systems, carbon calculators, and more recently, custom “vibe coded” tools in which firms utilize AI to speed up tedious tasks and adapt quicker to changing regulatory laws. Much of these tools consist of proprietary software, meaning they are controlled by individual vendors that use closed formats and licensing models which keep data inside specific products, so firms must repeatedly export and reenter information across several incompatible systems rather than working from a shared, open data layer (Infrared.city, 2025). Verneuille (2026) describes the AEC industry as experiencing “point solution fatigue,” with teams managing “hundreds of specialized software tools,” which is not only tedious but also multiplies coordination work every time data has to move from one application to another. Currently, BIM tools are the most promising, as in principle they can help overcome fragmentation. BIM environments support collaborative three-dimensional models linked to data about materials, systems, quantities, and costs, and studies have found that investments of just 0.23 percent of total project cost can

generate returns on investment exceeding 150–190 percent (Ham et al., 2018). These gains are especially important for sustainable construction because most of a building’s lifetime emissions and performance are effectively “locked in” by early-stage design decisions, yet at those stages “the availability of data is very poor and any assessment has to be based mainly on assumptions” about form, materials, and systems (Bragança et al., 2014). In principle, properly integrated BIM and analysis tools could surface reliable carbon and performance information early enough to change massing, structural systems, and envelope strategies. In practice, however, the majority of firms especially small and medium-sized firms are significantly less likely to implement BIM because of high upfront software and hardware costs and training requirements, as well as ongoing interoperability problems when trying to connect BIM with other proprietary tools and legacy workflows (Newforma, 2024). As Arman Gukasayan, CEO of Revizto, puts it, “Too many teams are running sophisticated digital strategies on top of fragmented workflows. Without solving coordination at scale, more technology alone will not fix project outcomes” (Revizto, 2025). Even the most advanced operational tools still sit inside their own silo, and while they can improve local efficiency, but they do not yet provide a common, reliable signal about sustainable performance that can connect early stage design choices to regulatory demands and capital market expectations.

6. Entrepreneurial Responses and Limits

In practice, entrepreneurs function less as inventors of entirely new technologies and more as coordinators who try to stitch together existing tools, standards, and data sources (Cooperative Computing, 2025). A BIM vendor, for example, might integrate with carbon calculators, cost databases, and scheduling software so that changes in one domain are reflected across the others. A project controls platform might pull in information from compliance systems and reporting frameworks to flag issues early. Decentralized data technologies, such as the peer-to-peer systems and

networks that Butcher analyzes, go a step further by rethinking how data is stored and governed in the first place, aiming to move away from rigid, centralized repositories toward more open and transparent architectures that support lifecycle information flows (Butcher, 2025, pp. 2–3). Yet even the most sophisticated entrepreneurial tools operate within the constraints set by regulatory, financial, and institutional systems they do not control. If ESG frameworks require particular metrics in specific formats, and those metrics are defined at the firm level rather than the project level, a platform can help collect and format the data but cannot change the underlying mismatch between how investors think and how projects are run. If permitting offices accept only static PDFs, a BIM-based workflow can generate those PDFs more reliably but cannot turn the permitting process itself into a live, interoperable data exchange. There is also the risk that each new tool essentially becomes a “micro silo” of its own because firms often adopt multiple platforms without a coherent strategy or the technical expertise required to utilize them seamlessly. Employees have to learn and maintain several interfaces, each with their own data structures and integration patterns. Revizto’s 2026 survey showed nearly half reporting that software costs are rising without clear, measurable value and calling for simpler tools and workflows that reduce training burdens (Revizto, 2026). In that sense, entrepreneurs have the same fundamental problem as regulators and rating agencies in that they are inadvertently adding another layer to the information silos.

York’s research on environmental entrepreneurs shows that such actors can be effective in promoting environmental certification adoption across both liberal and conservative regions, often more so than local government policies that fail to cross political divides (York 2018). This suggests that market based and entrepreneurial initiatives have real potential to diffuse sustainable practices where formal regulation is weak or contested. However, the persistence of massive inefficiencies today and a chronic underuse of available data indicates that these initiatives have not fundamentally transformed the information architecture of the sector.

7. A Possible Solution

It is evident that one of the most persistent constraints in the AEC industry, especially in the context of sustainable construction, is therefore the difficulty of moving information between systems in ways that directly assist early stage design decisions in a manner that is user friendly. While the ConTech market continues to produce more software solutions, what is missing is a sort of “decision intelligence layer” for early planning which behaves as a shared environment where regulatory constraints, ESG expectations, cost information, and performance metrics can be evaluated together as teams weigh design decisions. Instead of becoming yet another proprietary platform, this layer would sit on top of existing project tools and siloed data. Project teams could use it to toggle between a sets of plausible wall or envelope assemblies and see, in real time, how each option affects different project variables such as upfront and lifecycle costs, code compliance under current or even anticipated rules, environmental impact, and potential alignment with the firm’s or investor’s ESG targets. Now, the aim would not be to automate these decisions, but to make tradeoffs transparent and computable during the period where choices are still flexible. Again using the example of the finance industry, the Bloomberg Terminal does not centralize all information, nor does it eliminate regulation; however, it aggregates data from many sources and provides tools for querying, comparing, and acting on that information in near real time. but the terminal allows them to interpret and respond to dispersed signals with a degree of precision that would be impossible otherwise. A similar platform for sustainable construction would turn all three of the siloed data sources discussed above into inputs to a common decision space that instantly aggregates regulatory, financial, and technical variables into a working format that project teams can use with ease.

8. Analysis and Conclusion

Neither markets nor governments on their own are properly equipped to solve the data silos problem within sustainable construction. Instead of a continuously updated signal that condenses dispersed knowledge into something legible for decentralized actors, the AEC industry has accumulated layers of partial, delayed, and often contradictory signals that are in formats project teams cannot easily incorporate into workflows. The problem is not that we lack guidelines or tools, but that each new layer tends to make the coordination problem worse. Unlike in financial markets where price signals continuously aggregate dispersed knowledge into something legible and actionable, the built environment has no equivalent mechanism. Each new regulatory layer, rating framework, and software platform adds to the clutter of information without improving the channels through which that information reaches the people who need it. The AEC industry needs a deliberate redesign of the channels connecting these three silos discussed above on a into an overarching, real time basis for evaluating tradeoffs during the window when choices are still reversible. The Bloomberg Terminal made dispersed signals usable, and the built environment needs its equivalent.

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