

VISION PAPER · LOGISTICS REAL ESTATE

Future-proof logistics

A vision paper on whole-life value, energy hubs and sustainable logistics infrastructure

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Abstract

Logistics real estate is undergoing a structural shift. Warehouses are evolving from a covered storage space into a strategic infrastructure in which logistics processes, energy supply, automation, regulation, financeability and social responsibility converge. This paper analyses why future-proof warehousing requires more than energy-efficient installations or a favourable choice of materials. The central question is how logistics buildings can retain value when processes, technology, energy demand, reporting requirements and user profiles change faster than the physical structure of the building.

The paper adopts a life-cycle perspective. It distinguishes embodied carbon, the CO₂ impact of materials and construction processes, from operational carbon, the emissions generated during use. These two forms of carbon influence each other. Additional material can reduce operational emissions; excessive material reduction can undermine service life, functionality or reusability. Sustainability must therefore be assessed within clear system boundaries, with an appropriate functional unit and with explicit attention to scenarios over several decades.

The paper examines five interrelated transitions: the evolution of warehouses into process-driven platforms, the building as an energy hub, the tension between build-to-suit and build-to-last, the growing financial materiality of CO₂, and the need for measurable, auditable performance indicators. Its conclusion is that future-proof logistics is a systems challenge. Logistics real estate remains robust only when design, energy, technology, use, finance and regulation are considered together from the earliest project phase.

It therefore frames future-proof logistics as a whole-life value problem: a building should be assessed through life-cycle carbon, functional adaptability, energy resilience, operational evidence and financial materiality rather than through one isolated sustainability measure.

Executive summary

Warehousing and logistics real estate are often discussed as if they essentially consist of large, efficient buildings. That representation is rapidly losing explanatory power. The logistics sector is undergoing several transitions at once: e-commerce increases pressure on speed and granularity, returns logistics makes flows less linear, geopolitical uncertainty reinforces just-in-case inventories, automation changes the internal layout, transport electrification shifts energy demand to sites, and European reporting frameworks make CO₂ performance financially and strategically visible. As a result, a warehouse becomes a node in logistics, real estate, energy and data.

The central thesis of this paper is that future-proof warehousing is possible only when isolated optimisation is abandoned. A building with a low initial material footprint may prove less sustainable over its service life if it has insufficient clear height, inadequate floor loading, an unfavourable column grid or poor technical expandability. An energy-efficient installation can lose value if it is not scalable, replaceable or controllable. A build-to-suit building may appear economically attractive for the first occupier while creating residual-value risk if it is too closely tied to one process or tenant. Future-proof construction therefore requires a shift from project thinking to systems thinking.

The first dimension of this systemic thinking is functional. Modern warehouses are becoming process-driven. Automation through shuttles, conveyors, AGVs, robotic arms, sorting lines and high-bay solutions imposes different requirements on floor strength, clear height, fire safety, maintenance zones, data rooms and energy supply. The building increasingly follows the process, while the load-bearing structure must remain sufficiently generic to support future processes. The design question is not only which tenant enters the building today, but which scenarios the building must be able to accommodate in ten, twenty or thirty years.

The second dimension is energy. The warehouse is becoming an energy hub. It consumes electricity for lighting, HVAC, automation, charging infrastructure, data processing and internal logistics. At the same time, it can generate energy through PV, store it in batteries, control it intelligently through an Energy Management System (EMS) and reduce peak load through peak shaving. Grid congestion makes this role strategic. In several regions, available grid capacity is becoming a limiting factor for growth, automation and transport electrification. The question of the right connection capacity must therefore be replaced by an analysis of consumption profiles, peaks, flexibility, storage and local generation.

The third dimension concerns carbon over the life cycle. Embodied carbon includes emissions from raw materials, production, transport, construction, maintenance, replacement and end of life. Operational carbon includes emissions from energy and water consumption during operation. A credible assessment requires a Life Cycle Assessment (LCA) in accordance with standards such as ISO 14040, ISO 14044 and EN 15978. Life-cycle modules A1-A3, A4-A5, B1-B7, C1-C4 and module D show where emissions arise and which benefits fall outside the system boundary. For logistics buildings, the load-bearing structure, foundations, floor slabs, roof build-up and building envelope are often dominant emission sources. A Pareto analysis is therefore essential: not every material saving has the same impact, and not every additional material input is indefensible.

The fourth dimension lies in the relationship between build-to-suit and build-to-last. Build-to-suit optimises for the first user; build-to-last ensures that a building can serve several users, processes and technological generations. These two logics need not be mutually exclusive. Bespoke elements can fit within a long-term framework when they remain demountable, expandable or replaceable, and when the slow layers of the building, foundations, structure, envelope and energy backbone, are sufficiently robust. The challenge is to decide which components should be fixed and which should remain adaptable.

The fifth dimension is financial. Sustainability is shifting from a reputational issue to a valuation issue. The EU Taxonomy, CSRD, EPBD, Green Asset Ratio, SFDR, ESG due diligence and bank lending criteria all strengthen the demand for demonstrable performance. At the same time, the market is moving from a green premium to a brown discount: sustainable buildings may still command rental premiums or better occupancy rates, but buildings that do not evolve risk value loss, retrofit costs, higher financing costs or reduced lettable area. Economic analysis must therefore go beyond CapEx. It must include OpEx, TCO, maintenance, downtime, energy security, residual value, financeability and reporting value.

Research on green commercial and industrial buildings shows that sustainable buildings can involve higher initial costs while generating lower operational and maintenance costs. In the literature reviewed for this paper, with the necessary contextual caution, figures are mentioned such as construction costs up to approximately 30 % higher, operational savings of around 23%, maintenance savings of around 15% and a net life-cycle saving of 17%. For certification systems such as BREEAM and LEED, the literature reports rental premiums and energy savings, but these figures depend strongly on market context, building type and dataset. The conclusion is therefore not that every green building automatically pays off, but that the business case can become positive when sustainability is integrated into design, operation and financing.

Certification remains important, but it must not replace sustainability itself. BREEAM, LEED and WELL provide structure, evidence and market confidence. They help compare performance and substantiate claims. Yet a certificate remains an instrument, not an end in itself. A labelled building can perform poorly if it is used incorrectly; a non-certified building can perform strongly in a specific context when it is well designed, measured and managed. Certification must therefore be linked to LCA, energy data, maintenance data, CO₂ indicators and user performance.

The choice of KPIs requires particular attention. CO₂ per square metre is useful because it appears simple and comparable. In a logistics context, however, this metric can be misleading. A taller building with more pallet positions may appear heavier per square metre while performing better per logistics unit. Additional indicators are therefore needed, such as CO₂ per pallet position, per cubic metre of storage, per year of use, per logistics movement or per unit of operational throughput. The functional unit must correspond to the actual function of the building.

Finally, the human dimension remains essential. Automation does not arise only from technological ambition, but also from labour shortages, ageing workforces, safety requirements and changing employee expectations. Yet the social component of ESG is often underexposed in discussions about logistics real estate. Future-proof warehousing must address workability, safety, skills development, human-machine collaboration and the social legitimacy of land and energy use.

The core message is both simple and demanding: future-proof logistics emerges when developers, occupiers, funders, construction partners and policymakers treat the warehouse as a long-lived system with multiple use cycles. Those who design today do not merely fix a floor, roof and façade. They also determine the options for later automation, energy security, emissions reduction, reporting, lettability and residual value. Decision-making must therefore shift from “what does it cost today?” to “which choice remains functional, climate-responsible and financially defensible over the whole life cycle?”

For developers, occupiers, funders, construction partners and public authorities, the warehouse has consequently become a shared risk object. It influences reporting quality, energy security, operational continuity, financing conditions and residual value at the same time.

1. Introduction: why logistics real estate is at a turning point

For a long time, logistics real estate was the quiet infrastructure behind economic activity. Warehouses were often located at the edge of business parks, close to motorways or multimodal nodes, and were assessed mainly on accessibility, floor area, clear height, loading docks, rent and operational efficiency. These criteria remain relevant, but they are no longer sufficient to understand the value of a logistics building. The sector is moving into an environment in which goods flows, energy supply, digital infrastructure, CO₂ performance and financial reporting enter a single decision space.

The traditional real-estate logic starts from location, building quality and contractual cash flow. The new logistics logic adds a much broader set of questions. Can the building support automated processes? Can the site provide sufficient energy for electrification of internal transport, external charging infrastructure and advanced installations? Can the roof carry PV installations, both today and under future technology? Is there room for batteries, transformers and cable routes? Can the envelope be adapted to a new user without major demolition? Will the building remain lettable when regulation becomes stricter? Can the owner substantiate performance to banks, investors, occupiers and auditors?

These questions show that the warehouse can no longer be regarded merely as a building. It functions as a production asset, energy infrastructure, data carrier and financial asset. These four roles reinforce each other. A poorly chosen column grid can impede automation. An insufficient energy backbone can delay electrification. An incomplete LCA can narrow investment decisions to material choice alone. A building without measurable performance can lose financing or tenants when ESG reporting becomes stricter. The future resilience of logistics real estate therefore arises from the interaction between design, operation, governance and market.

The meaning of sustainability changes accordingly. In an earlier phase, sustainability was often understood as an addition to the building: solar panels, LED lighting, better insulation, green roofs, charging stations or a certificate. Today the emphasis is shifting towards system performance. A sustainable logistics building must remain functionally usable over its service life, control its material impact, limit operational emissions, support energy security, provide reporting data and retain economic value. This requires a sober but rigorous framework: life-cycle assessment, functional units, scenario thinking, clear system boundaries and transparent assumptions.

This requires a 360-degree view of logistics real estate. Processes, buildings, technology and energy can no longer be optimised as separate domains. A technically efficient building can underperform when the logistics process is poorly understood, just as a strong logistics concept can lose value when the building lacks the structural, energetic or digital capacity to support it over time.

The construction and real-estate sector also carries substantial climate responsibility. The literature reviewed for this paper indicates that buildings and construction were responsible in 2023 for more than one third of global CO₂ emissions and around 32% of total energy consumption (estimations tend to differ slightly depending the source). Such figures include both operational energy and embodied carbon in materials and construction processes. The implication for logistics real estate is specific: warehouses have large surfaces, heavy structures, high material volumes and increasingly complex installations. At the same time, their scale offers significant opportunities for energy generation, process optimisation and measurable CO₂ reduction.

This paper therefore moves away from an overly narrow question. It does not ask which material is the greenest, which certificate scores highest or which technology appears most innovative today. It examines how logistics real estate can retain value over several decades in a context of technological, energy-related, legal and economic uncertainty.

2. From storage space to strategic infrastructure

The transformation of warehousing begins with the logistics function itself. The traditional warehouse logic was based on storage, handling and distribution. Goods arrived, were registered, stored, picked and dispatched again. The main performance indicators related to space efficiency, error reduction, labour efficiency, throughput time and transport links. These elements remain relevant, but the sector has come under additional pressure from e-commerce, omnichannel retail, just-in-case inventories, returns logistics, nearshoring, mass customisation and higher service expectations.

The recent transition can be read as a sequence of pressures that now converge. E-commerce increased granularity and speed. Last-mile, same-day and next-day delivery compressed cut-off times. Return logistics made flows less linear. COVID-19 exposed the fragility of pure just-in-time models and gave more weight to buffer stocks and just-in-case thinking. Regulation, ESG scrutiny and data-driven management then turned the warehouse from a background asset into a visible performance node.

E-commerce has changed the nature of logistics processes. Whereas traditional distribution often involved relatively predictable flows to shops or business customers, e-commerce requires granular picking, rapid processing, flexible cut-off times, returns flows and variable peaks. The promise of same-day or next-day delivery increases process pressure. Returns logistics makes the system more complex because goods do not simply move forward through the chain; they also return, must be inspected, repackaged or reallocated.

The COVID-19 period exposed the vulnerability of just-in-time models. Many companies have since become more cautious in their thinking about buffer inventories, security of supply and strategic stock positions. This shift towards just-in-case does not mean that every company structurally needs more storage space, but it does mean that flexibility and resilience weigh more heavily in location and building decisions. Logistics real estate must be able to absorb peaks, uncertainty and process variation.

Automation is a second structural movement. Where mechanisation previously focused mainly on supporting manual processes, the new generation of systems makes more intensive use of robotics, sensors, WMS connections, AI-driven planning, automatic sorting lines, shuttles, AGVs and goods-to-person solutions. These systems change the building itself. They require flat floors, higher floor loading, reliable power, data connections, maintenance spaces, fire-safety concepts and sometimes different heights or spans. A building that is suitable today for racking storage may reveal limitations tomorrow when the user wants to automate.

Artificial intelligence strengthens this shift. The most relevant question is not whether warehouses will contain robots, but how intelligent systems, human operators, maintenance teams and warehouse management software will work together. If an inefficient process is automated without redesign, the inefficiency is merely locked into technology. Future-proof design therefore starts with process quality before it translates into robotics or layout.

Digitalisation reinforces this development. A modern warehouse runs on data: order flows, location data, energy measurements, process quality, temperature, occupancy, transport planning, stock levels and maintenance signals. The building acquires a digital layer. Sensors, cloud-based WMS systems, energy platforms and predictive maintenance connect real estate with operational data. As a result, the boundary between building and process shifts. The building is not only a space in which logistics takes place, but an infrastructure that actively supports processes.

Electrification adds a third layer. Internal vehicles, charging yards, vans, heavy trucks, cooling systems, batteries and automated installations increase electricity demand. The logistics site becomes a node in the energy transition. In the past, energy in many warehouses lay mainly in lighting, heating and limited technical installations. Today, energy can become the limiting factor for growth. Grid congestion, peak tariffs, variable energy prices and uncertainty about connection capacity make energy security a strategic issue.

External transport electrification reinforces the same logic. Last-mile delivery is already moving rapidly towards electric fleets, while heavier transport will increasingly require charging strategies at depots, warehouses and logistics campuses. The site boundary therefore becomes more permeable: the building, the yard, the vehicle fleet and the grid connection form one operational energy system.

These developments mean that logistics real estate can no longer be designed as a generic box. The building must be process-driven and at the same time remain sufficiently generic for later users. That paradox runs throughout this paper. A warehouse must efficiently support the first user, but it must not sacrifice its future usability. It must be robust enough for demanding processes, but it must not be blindly oversized. It must be prepared for energy requirements, but it need not lock every possible future demand into material and CapEx today.

The strategic meaning of warehouses therefore stems from their role in business continuity. Those who do not design goods flows, data and energy together create vulnerabilities. A warehouse with insufficient energy capacity can delay electrification. A building that is not prepared for automation can hinder operational innovation. A site without measurable CO² data can create reporting problems for occupiers. An overly specific building can lose value after the departure of the first user. The future of warehousing lies in the capacity to absorb several uncertainties at once.

3. Future-proof construction: designing for uncertainty

Future-proof construction means designing for a future that cannot be fully known. In logistics real estate, this uncertainty is particularly high because the service life of the building is much longer than the innovation cycle of logistics technology. Foundations, load-bearing structures, façades and roofs remain in place for decades. Automation systems, software, charging technology, energy prices and tenant profiles can change in much shorter cycles. The design discipline must therefore distinguish between slow and fast building layers.

The slow layers include location, load-bearing structure, foundations, floor slab, roof, envelope and primary energy backbone. These elements determine the structural possibilities of the building. They are difficult and costly to modify. The fast layers include fit-out, mezzanines, technical installations, software, robotics, racking, charging points and operational processes. These elements must be able to evolve without disrupting the slow layers. A future-proof building consciously fixes the slow layers robustly and leaves the fast layers as adaptable as possible.

In practical terms, this means that clear height, column grid, floor flatness, floor loading, roof load, fire compartments, cable routes, technical rooms, openings for later services and maintenance access should be treated as strategic design decisions. They are not merely technical specifications; they determine which later logistics processes can be accommodated without demolition or major downtime.

Scenario thinking is essential here. Designers must not predict one future but calculate a limited number of plausible scenarios. One scenario may assume conventional racking storage. A second may involve a highly automated operation. A third may add light production or value-added services. A fourth may assume intensive transport electrification and charging infrastructure. The design question then becomes which choices in structure, height, floor loading, energy, fire safety and layout are robust enough to support several scenarios.

A useful minimum scenario set includes conventional racking, high-density automation, light production or value-added services, intensive charging and second-tenant reuse. The design should then be tested against each scenario. Choices that support several scenarios without excessive material impact deserve priority; choices that serve only one uncertain future should remain modular, demountable or postponed.

This approach refines the concept of flexibility. Flexibility does not mean providing for every conceivable option without limit. An overly generous design wastes material, increases embodied carbon and can undermine financial feasibility. An overly tight design ages quickly and later causes demolition, retrofit or value loss. The skill lies in targeted preparation. Reserving space for transformers, batteries, cable routes, PV, charging infrastructure, data rooms and modular mezzanines can be rational when these elements are highly likely to become relevant. Unlimited overdesign remains technically and climate-wise unsound.

Targeted preparation is especially important for energy and data. A building does not need to install every transformer, charger, battery or automation system on day one. It should, however, reserve routes, spaces and control logic so that such systems can be added without opening finished yards, cutting through structural elements or disturbing an active tenant for long periods.

The materiality of early choices is substantial. The load-bearing structure and building envelope represent a significant share of embodied carbon in many projects. The preparatory documents refer indicatively to a share of 60% to 80% for structure and envelope within a project's embodied carbon. Precisely for this reason, these parts must be designed carefully. Insufficient robustness can lead to major later interventions; excessive robustness can unnecessarily increase the initial material footprint. The right question is not whether one should overdesign, but which form of robustness creates value over the life cycle.

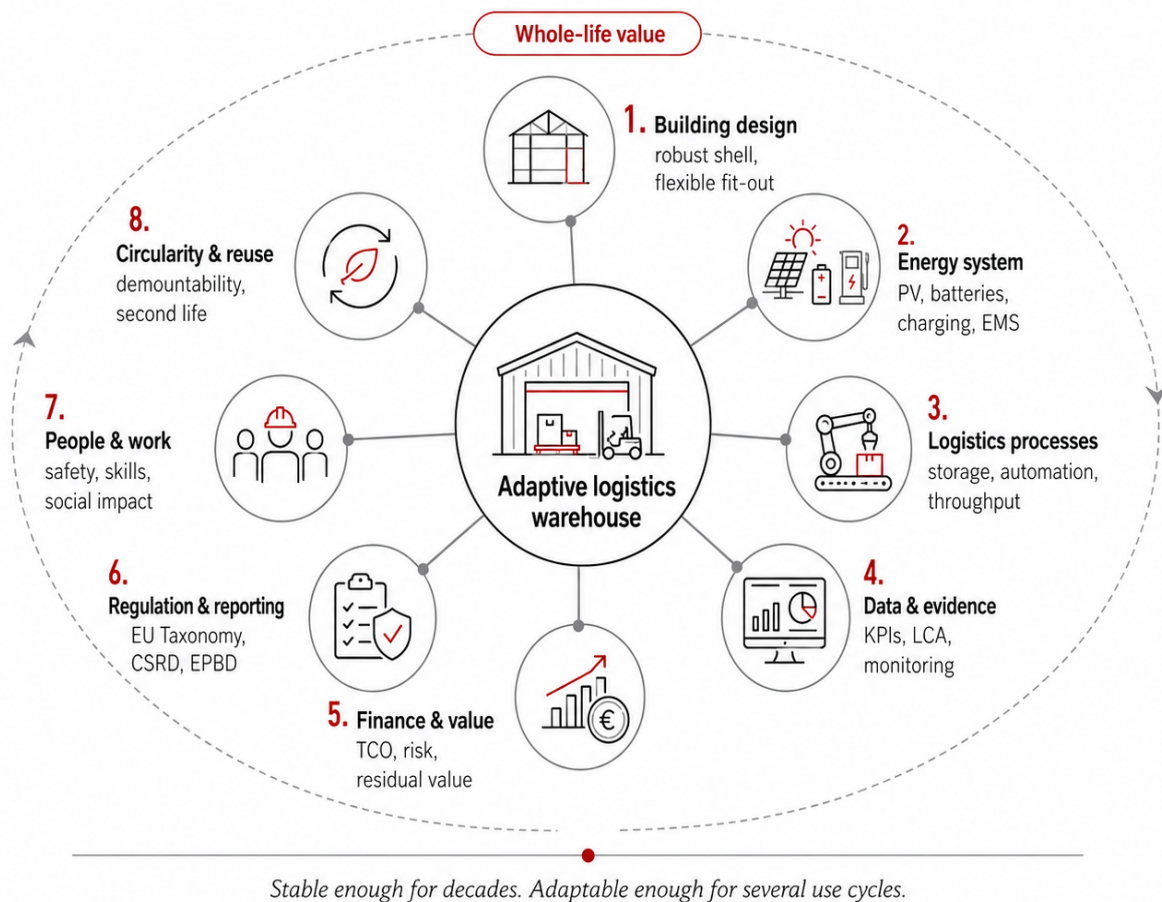
Future-proof construction also requires attention to land use. Logistics buildings take up substantial land. Space scarcity, permitting procedures, societal pressure and climate adaptation make efficient land use more important. Campus logic, brownfield development, shared energy infrastructure, multimodal accessibility and higher spatial density therefore become more relevant. A building that can sustain a second or third life reduces not only material impact, but also the need to build again elsewhere.

The design phase thus becomes the most strategic phase of the real-estate project. Many decisions that later appear as operational or financial problems arise during design. A missing cable route, a roof that can only support the current generation of PV, a cramped technical room, limited clear height or an overly specific building form can become disproportionately expensive later. What can be prepared relatively easily during construction often becomes disruptive, costly and operationally inconvenient after occupation.

Future resilience is therefore not an aesthetic or technical detail, but a value principle. It protects the owner against value loss, the occupier against downtime, the funder against stranded-asset risk and society against avoidable material and energy impact. It does require discipline: making scenarios explicit, documenting assumptions, defining functional units, calculating sensitivities and testing investments against TCO rather than against initial cost alone.

Figure 1. Future-proof logistics as an adaptive system

A logistics building creates value when design, energy, processes, data, finance, regulation and people are aligned across the asset life cycle.



4. Build-to-suit, build-to-last and the logic of reusable value

Build-to-suit and build-to-last are often presented as opposing models. Build-to-suit starts from the specific needs of the first user. The building is aligned with that user's process, installations, flows, layout, energy requirement and timing. Build-to-last starts from the long-term value of the building as an asset. It seeks to avoid the building becoming too specific, too costly or too difficult to adapt after one use cycle. In practice, the most future-proof approach emerges when both logics are carefully combined.

Build-to-suit has clear advantages. It can reduce space loss, optimise processes, focus investments and provide operational advantage for the first user. In logistics real estate, bespoke design may be necessary for cold storage, dangerous goods, pharmaceutical requirements, light production, clean zones, specific loading docks or automation concepts. A generic building that supports such needs insufficiently can build in inefficiency. Bespoke design therefore deserves no principled rejection.

The risk arises when bespoke design becomes fixed in the slow layers of the building. A narrow building form, atypical load-bearing structure, limited clear height, internal partitions that are difficult to remove, overly specific floor build-up or rigid technical infrastructure can deter later users. The building then loses its second and third life. Initial efficiency is later traded for retrofit costs, vacancy or value impairment. In a market where processes and tenants change faster, this risk becomes economically and ecologically relevant.

Build-to-last therefore requires a distinction between generic robustness and specific fit-out. The foundations, structure, envelope, clear height, floor loading, roof loading and energy backbone must support a broad range of future functions. The specific fit-out should, wherever possible, be demountable, replaceable or expandable. A production line, spray line, mezzanine, temporary wall, cold room, battery container or charging configuration can then be adapted without degrading the building as a whole.

The same logic distinguishes real estate from movable technology. The long-lived carrier should remain generic enough to support several tenants and technologies. Robots, sorters, racking, charging points, batteries, software and control systems should be treated as replaceable layers that can evolve without forcing the building envelope into a new structural intervention.

This approach is consistent with the distinction between fit-out and real estate. Real estate forms the long-lived carrier; technology and installations follow shorter replacement cycles. Robots, sorting installations, batteries, chargers, software and racking must be upgradeable without structural damage. This requires space in the design for routes, access, maintenance, replacement and software integration. A building that does not allow such renewal quickly becomes a brake on operational innovation.

The energy backbone illustrates this sharply. A future-proof site need not install every conceivable capacity today, but it must be expandable. Cable routes, technical shafts, transformer space, battery zones, charging yards, control systems and roof loading must be logically prepared. Opening car parks, floors or routes after occupation causes costs, CO₂ impact and disturbance. Limited preparation during construction can greatly simplify later adaptations.

Building form also influences reusable value. Large spans, sufficient clear height, robust floor loads and a well-considered column grid increase the number of possible use scenarios. They make conventional storage, automated systems, light production or value-added logistics easier to accommodate. This robustness must be weighed against material impact. Large spans can require more material; insufficient span can later require more building volume or substantial adaptation. The correct evaluation therefore takes place per functional unit and over the service life.

A practical example is a tenant-specific production or spray line. Such a process may require a separate zone, a specific height or a long and narrow configuration. The build-to-last response is not to freeze the entire building around that first use, but to contain the bespoke element through detachable walls, demountable ceilings, reversible openings and service routes that can be removed or adapted in a later life cycle.

Build-to-last strengthens the business case for build-to-suit. A building that functions specifically for the first user while remaining generically reusable reduces vacancy risk, increases residual value and lowers the probability of becoming a stranded asset.

For funders, this matters because the value of the collateral becomes less dependent on one tenant. For occupiers, it matters because the building can grow with them during the lease period. For developers, it matters because the building can continue to generate returns over several cycles.

This makes build-to-suit and build-to-last complementary rather than contradictory. The first optimises operational fit; the second protects option value. When bespoke requirements are located mainly in the fast layers and the slow layers remain robust, the building can serve the first occupier well while retaining second-life and third-life value.

The key lies in auditable design choices. A developer must be able to explain why a particular robustness has been provided, which scenarios it supports, which additional embodied carbon is associated with it and which operational or financial benefits it is likely to generate. Build-to-last thus becomes not a rhetorical concept, but a testable strategy: keeping a building useful for longer, without unnecessary material input and without blocking later adaptability.

5. The warehouse as an energy hub

The energy context is changing the strategic value of logistics sites. Automation, transport electrification, charging infrastructure, cooling, data processing and energy management increase the complexity of the consumption profile. At the same time, large roof areas create opportunities for PV generation, while batteries and smart control can flatten peaks. The warehouse is therefore evolving from energy consumer to energy hub: a place where energy is consumed, generated, stored, controlled and potentially shared.

In this paper, the energy backbone refers to the high-voltage cabin, transformers, cable routes, roof load, PV interfaces, battery zones, charging infrastructure, EMS, metering architecture and the physical space needed to expand these elements. It is not identical to installed capacity. A backbone can be future-ready without being oversized.

This shift begins with the observation that capacity and consumption are not the same. Users often request a high fixed connection because they want maximum certainty. In practice, the actual profile is sometimes much lower or differently distributed than the requested peak capacity. A future-proof energy approach therefore begins with measurement and modelling. When consumption profiles, charging windows, process peaks and PV generation are analysed together, design can often be smarter than simply pursuing maximum grid capacity.

The design rule should therefore be profile before capacity. Before fixing the requested grid connection, the project team should model operating hours, charging windows, automation peaks, PV production, battery dispatch, simultaneity factors, seasonal variation and potential demand response. In many cases the required fixed connection is lower than the initial request once flexibility is actively managed.

An energy hub combines several building blocks. PV installations provide local renewable generation. Batteries store surpluses, limit peaks and increase self-consumption. An Energy Management System (EMS) controls consumers, storage and generation. Charging infrastructure can operate through demand management. In some cases, a microgrid or shared energy infrastructure emerges within a campus. The objective is not only lower CO₂ emissions, but also predictability, reliability and reduced exposure to grid constraints.

The scenario material reviewed for this paper contains indicative figures that support this logic. An optimised PV installation can reduce dependence on grid electricity by around 65% and reduce operational CO₂ emissions by more than 50%. With battery storage, grid dependence can, according to the same project material, be reduced by up to 89% and peak demand by around 36%. These figures should be read as scenario-based orders of magnitude, not as universal outcomes. The result depends on the load profile, energy prices, grid tariffs, battery degradation, available roof area, CAPEX and the quality of the control strategy.

Grid congestion increases the importance of this approach. When connection capacity is limited, a logistics site cannot simply grow by requesting more capacity. It must reduce, shift or locally compensate its demand. Peak shaving then becomes an operational condition. Charging strategies for trucks and vans must be aligned with departure times, dwell time, battery status and electricity prices. Automation systems can, where possible, be controlled outside peak periods. Energy becomes a process variable.

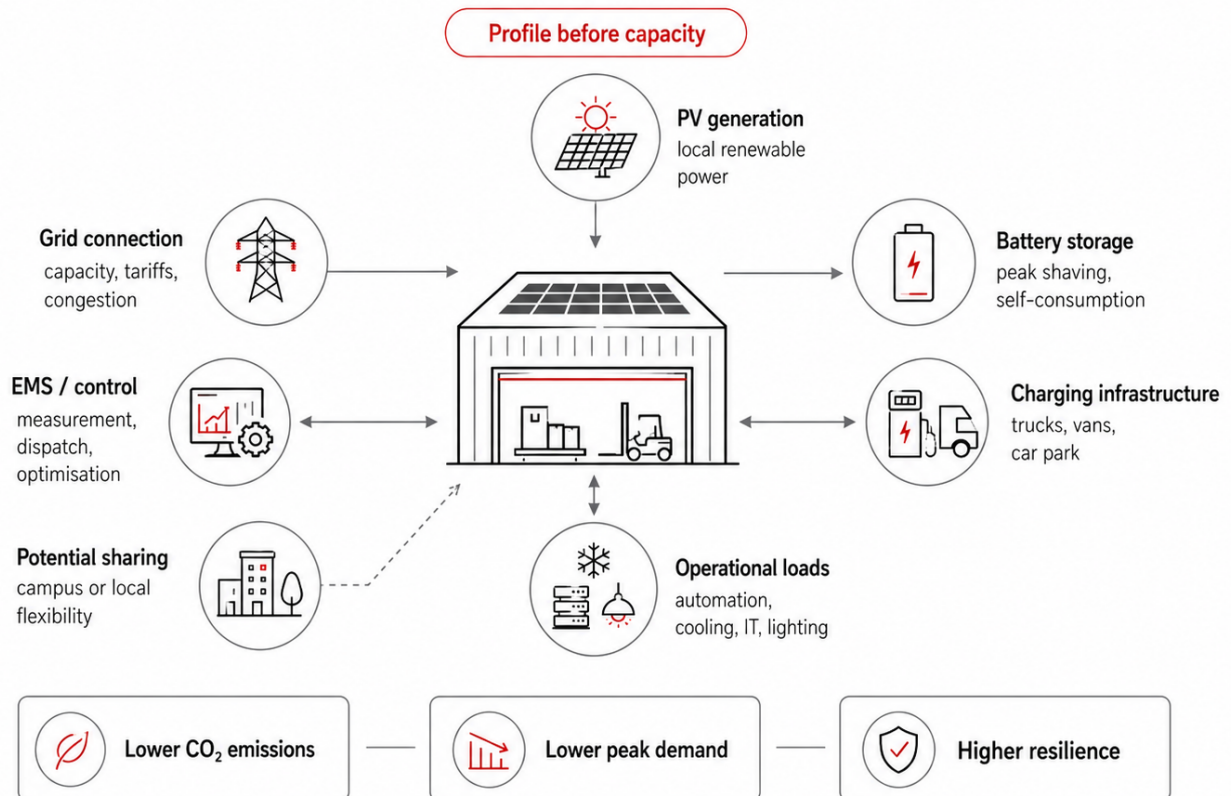
The design implications are considerable. From the first phase, a building must provide space for transformers, batteries, low- and medium-voltage infrastructure, cable routes, fire-safety zones, maintenance access and digital integration. The roof must be able to carry PV, not only under the current panel configuration but also with a view to future generations and possible additional loads. Car parks and charging yards must be prepared for phased roll-out of charging points. A poorly chosen location for battery zones or cable routes can later cause additional earthworks, material use and disruption.

The energy hub must also be assessed from a life-cycle perspective. Batteries, inverters and installations have embodied carbon and shorter replacement cycles than the building itself. Their climate value depends on use, energy mix, peak avoidance, replacement strategy and recycling. Here too, a simple technology claim is insufficient. A battery is valuable when it reduces peaks, increases self-consumption, avoids grid reinforcement, creates flexibility value and lowers operational risks. It is less defensible when it is too large, poorly used or quickly obsolete.

The building as an energy hub connects sustainability with operation. It lowers CO₂, but also reduces uncertainty. It supports occupiers in Scope 2 and Scope 3 reporting, reduces exposure to energy volatility, increases the usability of the site and can improve financeability. The central design rule is this: provide an expandable backbone, avoid blind overdesign and steer on measured profiles.

Figure 2. The warehouse as an energy hub

A future-proof warehouse does not only consume energy.
It can generate, store, control and flexibly use energy across logistics operations.



6. What makes a logistics building green?

The question of what makes a logistics building green appears simple and proves difficult in practice. Many discussions begin with materials: timber, concrete, steel, recycled content, cement substitutes or roof solutions. Material choice matters, but it cannot carry the full sustainability question. A building is credibly green only when its impact over the life cycle is assessed within clear system boundaries and with an appropriate functional unit.

A credible green claim therefore requires discipline. It should state the functional unit, the life-cycle stages included, the assumed service life, the data sources, the emission factors and the operational scenario. Without these elements, green claims risk becoming a comparison of images or materials rather than a comparison of performance.

A material comparison without function is incomplete. Timber can, in certain applications, offer low embodied carbon and carbon storage, but may require other connections, fire concepts, spans or maintenance strategies. Concrete has a high cement-related impact, but can provide robustness, mass, fire resistance, floor quality and long service life. Steel has a significant production impact, but offers strength, span, demountability and high recycling potential. The question is therefore not which material is greenest in the abstract, but which combination of material, function, service life, maintenance, reuse and operational performance delivers the lowest and most defensible life-cycle impact.

No material is green in isolation. A material becomes preferable only when it performs well for the required span, fire concept, durability, maintenance regime, reuse scenario and operational profile. The correct question is consequently not which material appears sustainable, but which assembly delivers the required logistics function with the lowest credible whole-life impact.

The functional unit is decisive. CO₂ per square metre is useful for an initial comparison. In logistics real estate, CO₂ per pallet position, per cubic metre of storage, per year of use or per logistics movement may be more relevant. A building with greater clear height can provide more volume per footprint. A heavier floor can enable automation or higher storage density. A more robust structure can support a second and third use cycle. If one calculates only per square metre, such functional benefits can disappear.

System boundaries also determine the outcome. Is only A1-A3 included, meaning raw materials and production? Or are transport to site, construction, maintenance, replacements, energy use, demolition and recycling also included? Are benefits from reuse in module D made separately visible? Are operational savings over thirty or sixty years included? Is expected grid decarbonisation considered? Every boundary affects the conclusion. Transparency on these choices is necessary to avoid greenwashing, selective evidence or unintended optimisation.

A logistics building can also appear green on paper and perform less favourably over its service life. A green roof can provide ecological value, water buffering and cooling, but requires additional load-bearing capacity and therefore possibly more steel or concrete. Additional insulation can strongly reduce operational emissions but increases initial material impact. A large battery can reduce grid peaks and increase self-consumption but has its own material footprint. A very light structure can lower embodied carbon while being insufficiently future-proof. These examples show that sustainability is rarely contained in a single measure.

The most credible approach is therefore pragmatic and analytical. First, the function is established. Then system boundaries and service life are defined. Next, a material and emissions Pareto is prepared to identify dominant sources. Scenarios are then calculated with one clear variable each time. Finally, assumptions, data quality and sensitivities are documented. This method makes sustainability testable without excessive technical detail.

Green building in a logistics context therefore means that the building delivers several performances at once. It must limit material impact, reduce operational energy, increase reusability, use space efficiently, support energy security, create user value and limit financial risk. A building that performs strongly on only one dimension may be valuable but remains vulnerable. The core of a green logistics building lies in its whole-life value.

7. Embodied carbon, operational carbon and life-cycle thinking

The distinction between embodied carbon and operational carbon is a prerequisite for a mature discussion about sustainable logistics real estate. Embodied carbon comprises the greenhouse gas emissions connected with materials, production, transport, construction, maintenance, replacement, renovation, demolition and waste treatment. Operational carbon refers to the emissions from energy and water consumption during the use phase. Both forms of carbon must be optimised together.

Historically, attention often focused on operational carbon. That was understandable: energy consumption is visible, billable and relatively easy to influence through lighting, insulation, HVAC and renewable energy. As buildings become more energy-efficient and electricity grids decarbonise, the relative importance of embodied carbon increases. The emissions released during construction are also largely immediate. Upfront carbon in A1-A3 and A4-A5 cannot later be reversed. This makes material choice, design optimisation and service-life extension strategic.

An LCA provides the methodological framework for measuring this impact. ISO 14040 and ISO 14044 describe the general methodology for life-cycle assessment. EN 15978 translates this to buildings and structures the life cycle into modules. A1-A3 includes raw-material extraction, transport to production and material production. A4-A5 includes transport to the construction site and the construction phase. B1-B5 includes use, maintenance, repair, replacement and renovation. B6-B7 includes operational energy and water. C1-C4 includes demolition, transport, waste treatment and final disposal. Module D shows benefits and loads beyond the system boundary, such as reuse and recycling.

For practical decision-making, the EN 15978 modules should be made explicit. A1-A3 cover raw material supply, transport to manufacturing and production. A4-A5 cover transport to site and construction or installation. B1-B5 cover use, maintenance, repair, replacement and refurbishment. B6-B7 cover operational energy and water use. C1-C4 cover deconstruction, transport, waste processing and disposal. Module D reports potential benefits and loads beyond the system boundary, such as reuse, recovery and recycling credits.

Environmental Product Declarations (EPDs) play an important role here. They provide standardised environmental data for products and make material comparison possible. Yet the quality of the analysis remains dependent on data quality, the representativeness of EPDs, the chosen service life, replacement scenarios, maintenance strategies and geographical context. An LCA is therefore not a neutral press of a button. It is a decision tool that must be set up and interpreted carefully.

For logistics buildings, Pareto logic is particularly useful. A limited number of components often determines a large share of embodied carbon: foundations, floor slabs, precast concrete elements, columns, steel sheets, roof build-up and façade systems. In an internal Heylen Warehouses LCA case for a large logistics campus of 160,000 m², an embodied carbon baseline of 165 kg CO₂e per m² and 2.84 kg CO₂e per m² per year is reported over a 60-year assessment period. The three largest drivers in A1-A3 are hollow-core concrete slabs (26%), ready-mix concrete columns (23%) and profiled steel sheeting (12%). Such figures show that reduction efforts should start with the dominant sources.

The interaction between embodied and operational carbon requires nuance. Additional insulation increases material impact but can reduce operational emissions. A heavier structure may require more CO₂, but can deliver a longer service life or greater reusability. An energy hub can add embodied carbon through installations, but reduce operational emissions, grid costs and peaks. The correct evaluation weighs these effects over the use period and per functional unit.

This nuance can be expressed through three categories. Some strategies are clearly positive, such as occupancy sensors for lighting when the material input is small and the operational saving is robust. Some strategies are negative when the additional material impact outweighs the operational benefit. Other strategies are conditional, such as additional glazing or daylight concepts that reduce artificial lighting but may increase cooling demand. LCA is valuable precisely because it makes these trade-offs visible.

Robustness deserves a separate place here. Maximum reduction on day one can be attractive but becomes risky when it undermines technical reliability. Foundations are an example. Cement substitutes can reduce CO₂ impact, but the choice must take account of proven performance, ground conditions, service life and risk of later damage. If a foundation proves problematic after twenty years and a building has to be partly demolished, the initial CO₂ saving can be wiped out. Caution here is not conservatism, but life-cycle thinking.

Life-cycle thinking shifts the question from “how low is the initial impact?” to “which choice holds up over the whole service life?” This means that designers, developers and funders must calculate not only emissions, but also uncertainty, replacement risk, downtime, maintenance, expandability and residual value. An LCA is thus linked to TCO and risk management.

8. Regulation, reporting and financial materiality

Regulation is changing the meaning of sustainability in real estate. European frameworks such as the EU Taxonomy, CSRD, EPBD and SFDR make environmental and climate performance visible in investment decisions, reporting processes and credit assessment. These frameworks do not operate only through legal obligations. They also create market pressure. Banks, investors, major occupiers and asset managers increasingly ask for data that goes beyond traditional real-estate information.

The EU Taxonomy functions as a classification system for sustainable economic activities. It helps determine which activities contribute to a net-zero pathway and broader environmental objectives. For real estate, this means that new construction, renovation and operation are increasingly assessed against energy performance, climate adaptation, circularity, waste management and DNSH principles. An investment is assessed not only on return and collateral, but also on whether it fits within sustainable finance frameworks.

The CSRD strengthens the demand for non-financial information. Large companies must report on sustainability, double materiality, climate risks, emissions and value-chain impact. Companies that do not fall directly within the reporting obligation may still experience pressure when their customers, funders or partners do have to report. This indirect effect is often described as a shadow mandate. A logistics occupier may request data on energy, CO₂, renewable generation, certification and material impact because it needs Scope 2 and Scope 3 information itself.

Double materiality is central to that logic. Impact materiality asks how the building affects climate, resources, people and communities. Financial materiality asks how climate policy, energy prices, grid constraints, tenant requirements and technology shifts affect the building's value. Future-proof logistics sits at the intersection of both perspectives.

The 2025 Omnibus proposals have put the scope and application of reporting obligations in motion. The strictest reporting obligations will be limited to the largest undertakings, with voluntary reporting for other large undertakings within the future CSRD scope. This simplification reduces administrative burden, but it does not fully alter the strategic question. Large customers, banks and investors continue to ask for sustainability data when it is relevant to their own reporting or risk assessment.

The EPBD brings building performance itself more sharply into view. The revised directive puts the European building stock on a pathway towards decarbonisation by 2050. For new construction, the standard moves towards zero-emission buildings from 2030, with an earlier date for new public buildings. This has direct implications for logistics real estate: energy performance, renewable generation, life-cycle impact and renovation pathways become strategic design criteria.

Funders look beyond lease contracts in this landscape. Banks report, among other things, through the Green Asset Ratio on the share of green assets. Non-compliant buildings can therefore become less attractive in credit portfolios. Asset managers must make the sustainability of funds transparent. Investors assess stranded-asset risk: the risk that a building loses value more quickly due to regulation, energy prices, technical obsolescence or changing market preferences.

A shadow mandate is also emerging. Even where a party is not yet formally obliged to report in detail, banks, large customers, insurers and investors increasingly request comparable data. The Green Asset Ratio makes this relevant for banks, but the practical effect is broader: weak evidence can become a financing or letting disadvantage before it becomes a direct legal breach.

CO₂ is therefore shifting from a sustainability indicator to a financial parameter. CO₂ influences costs, risk, market access, financeability and residual value. A building with weak energy performance can cause higher OpEx and retrofit costs. A building without usable data can be unattractive to reporting occupiers. A site without energy security can increase operational risk. A building without adaptability can experience vacancy or value decline more quickly.

The market is consequently shifting from a green premium to a brown discount. In an earlier phase, sustainable buildings could generate additional rent or reputational value. As sustainability becomes the norm, the disadvantage shifts to buildings that do not comply. They risk lower valuations, more difficult financing, higher retrofit costs or reduced lettability. The strategic question is then not how much additional value sustainability creates, but how much value is lost when it is absent.

Regulation and reporting therefore make future-proof construction more concrete. They require evidence. Claims must be supported by LCAs, EPDs, energy data, certificates, maintenance data, KPIs and governance. For logistics real estate, this means that sustainability cannot be documented only at the end of the project. It must be built into design, contracts, operation and data flows.

9. The business case: from green premium to brown discount

The economic discussion about sustainable logistics buildings is often narrowed to the question of how much additional CapEx sustainability costs. That question is legitimate, but insufficient. A future-proof warehouse must be assessed on Total Cost of Ownership (TCO), life-cycle costs, energy security, maintenance, downtime, occupancy rate, rental value, residual value, financing conditions and reporting value. CapEx is the beginning of the calculation, not the end.

Sustainable buildings can involve higher initial costs. This applies to better envelopes, higher-quality installations, PV, batteries, charging infrastructure, measurement platforms, certification, LCAs, circular materials or more robust structures. The economic question is which of these investments translate into lower OpEx, less maintenance, higher user value, lower risks or higher residual value. Some investments pay back directly through energy. Others pay back indirectly through lettable, flexibility, reputation or financing.

The literature reviewed for this paper refers to research indicating that green industrial buildings may be up to +- 30% more expensive to construct in a specific context, while saving around 23% in operational costs and 15% in maintenance, with a reported net life-cycle saving of 17% (Weerasinghe et al., 2021). These figures require contextual caution. They should not be read as a universal business case, but as evidence that higher initial costs can be offset when design, operation, maintenance and residual value are assessed over the whole life cycle.

Certification and green building performance can also affect market value. The literature reviewed for this paper mentions rental premiums for LEED-certified commercial buildings between 7.1% and 11.8% and for BREEAM-certified buildings between 8.3% and 9.5%. In the literature reviewed, BREEAM projects show on average 6% to 30% lower energy costs; LEED projects show 18% to 39% energy savings. These figures must be used cautiously because datasets differ strongly and much empirical research focuses on offices. For logistics real estate, the direction is more important than the exact premium: measurable sustainability can contribute to market attractiveness, but its value depends on user context and evidence.

An important economic tension lies in the cost-benefit mismatch. The developer often bears the initial investment, while the occupier benefits from lower energy costs or better working conditions. This split-incentive problem requires contractual innovation. Green leases, performance contracts, shared investments, energy-as-a-service, battery models, sale-and-leaseback structures and transparent data sharing can help distribute costs and benefits more fairly.

Contract design therefore becomes part of the business case. Green leases, shared investment models, performance contracts, energy-as-a-service, battery-as-a-service and transparent data-sharing clauses can align incentives between owner and occupier. Without such mechanisms, the party making the long-term investment may not capture the operational benefit that justifies it.

The business case must also include downtime and retrofit. A cheap building that later must be modified for automation, charging infrastructure or energy reinforcement can prove more expensive than a building that is prepared in a targeted way from the outset. Downtime in logistics is costly. Opening car parks for cables, adapting floors, reinforcing roofs or changing fire concepts creates not only construction costs, but also operational disruption. TCO must include these costs.

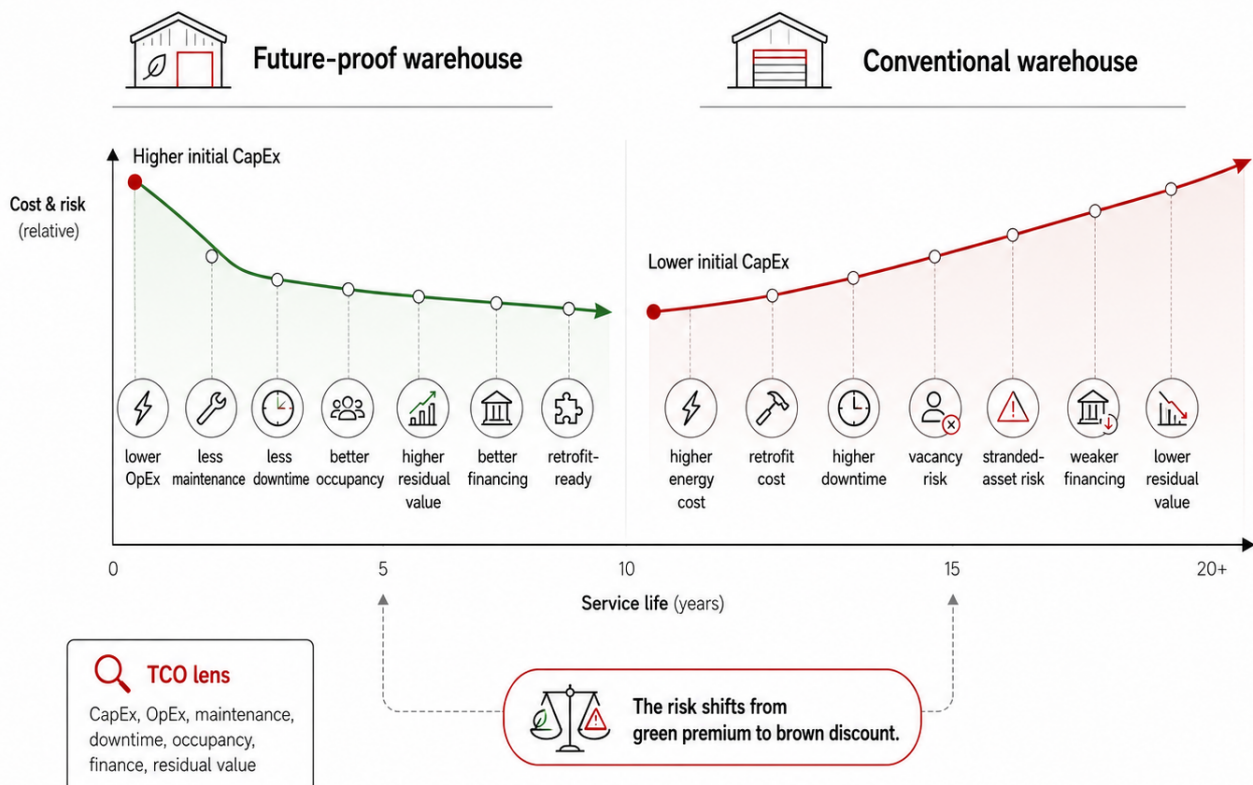
Residual value is also becoming more important. A building with generic robustness, an energy backbone, measurable performance and adaptable layout retains more options. More options mean more potential tenants, lower vacancy risk and better financeability. An overly specific building has a narrower market. In a world of changing processes, that can depress valuation.

The business case for future-proof logistics must therefore be built in scenarios. A base scenario shows initial cost and standard operation. An energy-hub scenario shows investment, grid costs, self-consumption, peak reduction and CO₂ effect. An automation scenario shows floor loading, height, power, data and maintenance. A reuse scenario shows second use, retrofit costs and residual value. The comparison is made per functional unit, per year and over the service life.

This approach makes sustainability financially discussable. It avoids moralising language and shows where sustainability creates value, reduces risk or supports market access. The conclusion is not that every sustainable measure pays for itself. The conclusion is that not investing can increasingly become economically irrational when regulation, energy, reporting and residual value are fully included.

Figure 3. Whole-life value: from green premium to brown discount

The real business case is not initial cost alone, but value and risk over the whole service life.



10. Measurement, certification and relevant KPIs

Measurement forms the bridge between ambition and credibility. Without data, sustainability remains dependent on claims. With data, performance can be managed, compared, financed and reported. For logistics real estate, measurement goes beyond energy consumption. It includes embodied carbon, operational CO₂, energy profiles, peaks, PV generation, self-consumption, water, waste, maintenance, material passports, comfort, safety and functional performance.

Certification systems provide structure. BREEAM, LEED and WELL each have their own focus and methodology. BREEAM works with categories such as management, health and wellbeing, energy, transport, water, materials, waste, land use, ecology, pollution and innovation. LEED uses categories such as integrative process, energy and atmosphere, materials, indoor environmental quality, water, location and innovation. WELL places greater emphasis on health and wellbeing. These systems create a common language and increase market confidence.

Certification also has limitations. No system covers every context perfectly. Certificates can demonstrate strong design intentions, but operational performance depends on use, maintenance and control. A building can obtain a label and later function differently from what was expected. Certification should therefore be treated as a starting point for disciplined management rather than as an endpoint. BREEAM In-Use, periodic reassessment, real-time energy monitoring, energy-management platforms, maintenance data and operational KPI reviews help verify whether performance remains visible after handover and after tenant processes change.

LCA complements certification. Whereas certificates often score broadly against criteria, LCA makes the environmental impact of materials and construction processes quantitatively visible. The combination is strong: certification provides a market and governance framework; LCA delivers depth for material and life-cycle decisions. EPDs, EN 15978 modules and scenario analyses make choices auditable.

KPIs must match the function of the warehouse. CO₂ per m² remains useful for benchmarking and reporting. Yet in logistics this metric can fall short. A building with greater clear height, higher storage density or advanced automation may appear heavier per m² but perform better per pallet position or logistics movement. A KPI set is therefore preferable to a single indicator.

A practical KPI decision rule is to start with the decision that must be supported. Investors may need kg CO₂e per m² and per year for portfolio comparison. Occupiers may need CO₂ per pallet position, per order line or per logistics movement. Energy managers may need kWh per operating hour, peak load per charging window and self-consumption ratio. A single KPI cannot carry all these functions.

A robust KPI set contains at least five layers. The first layer measures building impact: kg CO₂e per m², per year and per life-cycle module. The second measures use impact: kWh per m², CO₂ per pallet position, CO₂ per m³ of storage or CO₂ per order line. The third measures energy-hub performance: PV generation, self-consumption, peak reduction, grid dependence and storage utilisation. The fourth measures flexibility: number of adaptable zones, available reserve in cable routes, expandability of charging infrastructure, clear height, floor loading and multi-tenant potential. The fifth measures value: OpEx, TCO, maintenance costs, downtime, occupancy rate, lease renewal and residual value.

Data quality requires attention. Poor data can create false certainty. Assumptions must be explicit: service life, energy mix, emission factors, occupancy, operating hours, replacements, maintenance and end-of-life scenarios. Sensitivity analyses show which assumptions strongly influence the outcome. This is particularly important for batteries, PV, cement substitutes, timber construction, insulation and future grid decarbonisation.

Measurement also has a behavioural function. What is measured is managed. A building with real-time energy data enables energy management. A building with material data enables circular choices. A building with maintenance data reduces downtime. A building with user data can improve comfort and safety. Measurement therefore supports not only reporting, but also operational excellence.

11. People, technology and social responsibility

Discussions about future-proof warehousing are often dominated by the E of ESG: energy, emissions, materials, LCA and climate. The social dimension deserves equal attention. Logistics real estate is a working environment, a spatial intervention and a link in societal supply. The future of warehouses touches labour, safety, skills, health, land use and local legitimacy.

Labour shortage is a structural factor. The logistics sector in many regions faces ageing workforces, limited inflow and an image challenge. Automation is therefore driven not only by efficiency, but also by continuity. When companies cannot find enough people for repetitive, physically demanding or time-critical tasks, robotics and goods-to-person systems become more attractive. Yet technology does not simply replace people. It changes roles, skills and safety questions.

This makes workforce strategy part of real-estate strategy. A building prepared for automation but not for safe maintenance, training, supervision and human-machine collaboration is incomplete. Future-proofing concerns the quality of work as much as the continuity of throughput.

Human-machine collaboration requires careful building design. Automated systems must be safely accessible for maintenance. Walking routes, emergency routes, loading areas, workstations, acoustics, lighting, temperature, air quality and ergonomics remain relevant. A highly automated warehouse can create new risks when people and machines are not properly separated or when work pressure shifts towards monitoring and intervention.

The social value of buildings also lies in comfort and health. The literature review refers to literature in which green buildings can deliver higher satisfaction, better indoor environmental quality, more daylight and fewer health complaints. For warehouses, the direct empirical basis is more limited than for offices, but modern logistics sites often contain offices, social areas, reception zones and hybrid working environments. Lighting, temperature and air quality also affect warehouse work.

Automation requires skills development. Operators become system managers, maintenance technicians, planners, data analysts or process coordinators. This requires training and career pathways. A future-proof warehouse is therefore not only technologically scalable, but also organisationally capable of learning. The building must provide space for training, maintenance, safe intervention and changing work processes.

Social responsibility also touches land use. Warehouses are visible in the landscape and require significant land, infrastructure and energy. Their legitimacy depends on efficient land use, traffic impact, energy generation, water management, biodiversity, local employment and integration into business parks. A building that maximises only internal efficiency while ignoring external burdens remains socially vulnerable.

The social dimension introduces an important correction to technological visions of the future. Not everything that is technically possible is therefore desirable. A fully automated warehouse may be efficient, but it must be assessed in terms of safety, employment, skills shifts, energy use and resilience. Human presence remains necessary for supervision, maintenance, problem solving, quality control, customer contact and improvement. The question is therefore not whether people will still be present in the warehouse of the future, but which roles they will fulfil and how the building supports those roles.

ESG integration means designing environment, social and governance together. Governance provides measurement, responsibility and decision-making. Social provides workability, safety and legitimacy. Environment provides climate and material performance. A logistics building that seeks to be future-proof must carry all three dimensions at once.

12. Synthesis: principles for future-proof logistics

The preceding chapters show that future-proof logistics does not emerge from one technology, certificate or material choice. It emerges from the connection between building design, energy, processes, data, finance, regulation and people. The warehouse of the future is an adaptive system. It must be stable enough to function for decades and adaptable enough to support several use cycles.

The first synthesis principle is whole-life value. Every design choice must be assessed for its impact over time. This applies to materials, energy, automation, charging infrastructure, maintenance and reuse. The lowest initial CO₂ is not always the best choice. Nor is the lowest initial cost. The question is which choice delivers the best combination of functionality, emissions reduction, risk, TCO and residual value.

The second principle is functional honesty. Comparisons must start from the function delivered by the building. CO₂ per m² remains useful, but logistics buildings often require additional units: pallet position, cubic metre, order line, year of use or throughput. Without a functional unit, tall buildings, automated systems or robust structures can be judged incorrectly.

The third principle is robust adaptability. The slow building layers must be robust; the fast layers must remain adaptable. Foundations, structure, envelope and energy backbone must be able to accommodate future scenarios. Fit-out, technology, installations and software must be replaceable, expandable and demountable.

The fourth principle is energy governance. Energy must be included from the first project phase. Not only connection capacity, but profile, peak, generation, storage, control, charging strategy and grid security determine the value of the site. The warehouse as an energy hub is a logical response to automation, electrification and grid congestion.

The fifth principle is measurable evidence. Sustainability must be auditable. LCAs, EPDs, energy data, KPIs, certification and maintenance data together form an evidence base. This evidence base supports regulation, financing, tenant reporting and operational improvement.

The sixth principle is financial materiality. CO₂, energy and flexibility are not secondary criteria. They influence credit quality, rental value, occupancy rate, retrofit costs, exit value and stranded-asset risk. Future-proof logistics translates sustainability into risk and value terms.

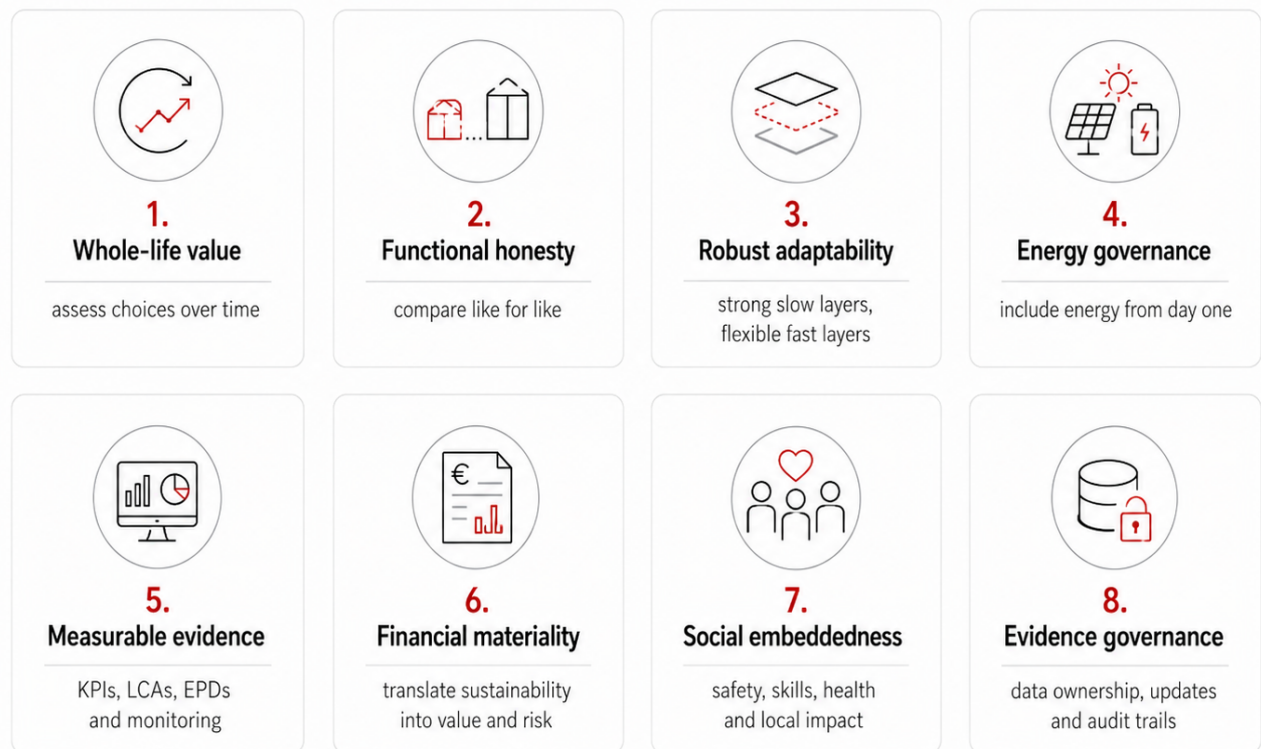
The seventh principle is social embeddedness. Warehouses remain workplaces and social infrastructure. Automation, safety, skills, health, land use and local impact must be part of the design and investment logic.

The eighth principle is evidence governance. Data ownership, update frequency, audit trails, LCA revisions, energy monitoring and KPI responsibility must be defined before operation starts. Without governance, measurement remains incidental and sustainability claims lose credibility over time.

Together, these principles lead to a different development practice. The project does not start with the question of how many square metres can be built, but with the question of which logistics, energy and social function the site must be able to fulfil over several decades. The building follows the system, while the system is not trapped in one present use.

Figure 4. Eight principles for future-proof logistics

A synthesis framework for the design, operation and valuation of logistics real estate.



Future-proof logistics combines design, energy, data, finance and people.

13. Conclusion

The future of logistics real estate is defined by complexity. Warehouses are becoming larger, smarter, more energy-intensive, more regulated and more financially transparent. They support e-commerce, inventory resilience, automation, electrification and data-driven logistics. At the same time, they are under pressure from CO₂ targets, reporting obligations, grid congestion, land use and changing expectations from occupiers and funders.

This paper has argued that future-proof warehousing is credible only when whole-life value is placed at the centre. Embodied carbon and operational carbon must be optimised together. Build-to-suit must be embedded in build-to-last. Energy must be designed as strategic infrastructure. Certification must be linked to actual performance. KPIs must reflect the logistics function. Human and social dimensions must remain alongside technical and financial criteria.

The central shift is conceptual. The warehouse is not a passive box in which logistics takes place. It is a carrier of processes, energy, technology, data and value. A design decision today influences the possibilities for automation, electrification, reporting, reuse and financing in the future. Those who understand that interdependence early build less vulnerable assets. Those who ignore it risk a building that still stands technically, but becomes functionally, energetically or financially obsolete.

Future-proof logistics therefore requires no alarmism, but discipline. The discipline to build scenarios. The discipline to choose functional units. The discipline to consider material impact and use impact together. The discipline to assess investments over the service life. The discipline to collect data and make assumptions explicit. Above all, it requires the discipline to design a warehouse as a long-lived system in a changing economy.

A future-proof warehouse is therefore not the building with the greatest number of measures, but the building whose structure, energy system, data layer and use value remain credible across several technological, regulatory and commercial cycles.

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Disclaimer

This paper was developed through a combination of sources and methodologies. In an initial phase, AI-assisted tools were used to support literature exploration, concept development, structuring of ideas, and the identification of relevant research avenues. The content was subsequently enriched and refined through a series of organised round table sessions involving four expert speakers, including the author. Additional input was drawn from research materials, working documents, and contributions provided by the broader research team.

The final text represents a synthesis of these various sources of knowledge and expertise. While every effort has been made to critically assess, interpret, and integrate the available information, certain formulations, interpretations, and conclusions may have been influenced by the use of AI systems, the nature of the round table sessions, and the scope of the consulted materials.

This paper should therefore be regarded as a discussion document that brings together research findings, professional experience, expert insights, and practical perspectives. Its purpose is to stimulate reflection, support further analysis, and contribute to ongoing debate. It should not be interpreted as a definitive scientific statement, nor as an official position of any participating organisation, researcher, speaker, or institution.

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