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# Decarbonization of the Steel Industry

Medium-Term Goals and Immediate Gains for the Construction Sector: 2026 Updates

constructsteel

Council on Vertical Urbanism

constructsteel

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# 1.0 Introduction

It is the responsibility of humanity to ensure that our collective activities are sustainable, in that today's needs are met without compromising future needs. However, climate change means that our current activities are not sustainable, and that economies must find ways to decarbonize, reduce carbon emissions across energy, industry and infrastructure, and ensure long-term environmental, social and economic sustainability.

It is worth noting that the built environment and construction sector are responsible for about 40% of total global anthropogenic $CO_2$ emissions,[1] while the steel industry is responsible for about 7 to 9%.[2] The global steel industry acknowledges that it is a contributor to climate change, but also recognizes that its steel products are a solution to help mitigate the same.

The steel industry is working to deliver the technologies needed to produce low-carbon steel, but it must also be said that the transition is contingent on the availability of affordable renewable electricity, together with high-quality raw materials. At the same time, while some nations have well-established scrap supply chains and can meet most of their steel demand using scrap, in many countries where steel production and use are still expanding scrap availability remains low, and supply chains still need developing. In such countries, end-of-life scrap availability is expected to grow significantly in the next decades. Although more scrap will become available, the continued growth in global steel demand means that even by 2050, around half of production will still need to come from iron ore.

It is very important to mention that while low-carbon emission steel gradually enters the market, the design and engineering community have at their disposal steel solutions in construction available now, which will lower $CO_2$ emissions via the "four Rs" principle, i.e., "reduce, reuse, recycle and remanufacture."

In 2024, each metric ton (t) of steel produced generated, on average, 1.92 metric tons of $CO_2$. With worldwide production reaching 1.885 million metric tons (1.885 Mt) that year, the industry was responsible for roughly 3.6 billion metric tons of $CO_2$ emissions, about 85% of which came directly from production processes.[2] Steel demand is projected to grow in the coming decades, driven by infrastructure development in emerging economies and the clean energy transition itself.

The traditional blast furnace-basic oxygen furnace (BF–BOF) route, which accounts for about 70% of global steel production, relies on metallurgical coal and produces on average 2.34 $tCO_2$/t steel. This emissions intensity, combined with the sector's scale, makes steel decarbonization essential for achieving global climate targets.

> **"While low-carbon emission steel gradually enters the market, the design and engineering community have at their disposal steel solutions in construction available now, which will lower $CO_2$ emissions via the four 'Rs': reduce, reuse, recycle and remanufacture."**

# 2.0 The Steel Industry – EU and World Key Figures

Steel use by sector is illustrated in **Figure 1,** showing that the construction sector entails more than 50% of the total use.

The production of crude steel in 2025 was about 1,848 Mt, with the following geographical distribution **(see Figure 2).** The production of steel in Asia (China, India, Japan, South Korea, and Taiwan) is about 70% of global production.

Globally, in 2025, the distribution of steel production by process is about 69.4% for BF–BOF and 30.3% for the EAF **(see Figure 3).**

Considering the distribution of steel production by process, in 2023, approximately 55% of steel in the EU27 is produced via the BF–BOF (blast furnace – basic oxygen furnace) route, while in China, this share rises significantly to around 81%.[2]

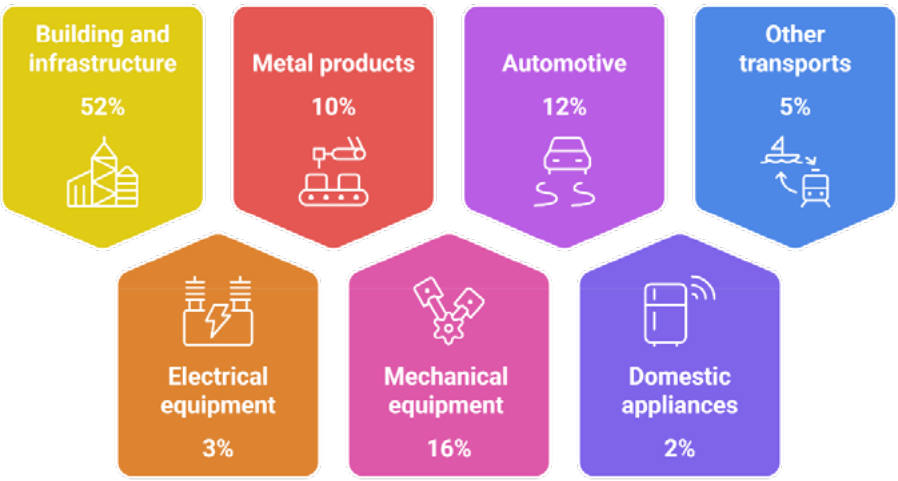


Figure 1. Steel use by sector.[1] © worldsteel, 2026

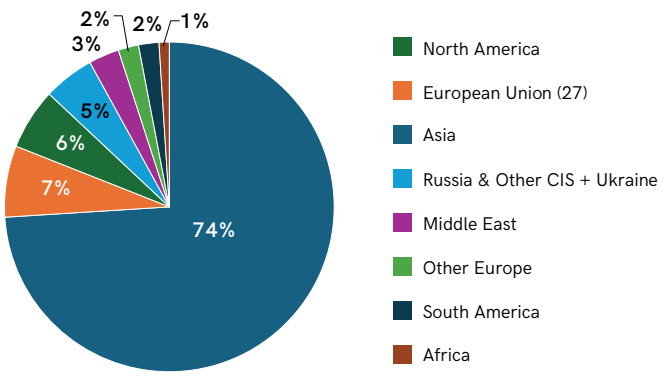


Figure 2. Crude steel production by region.[1] © worldsteel, 2026

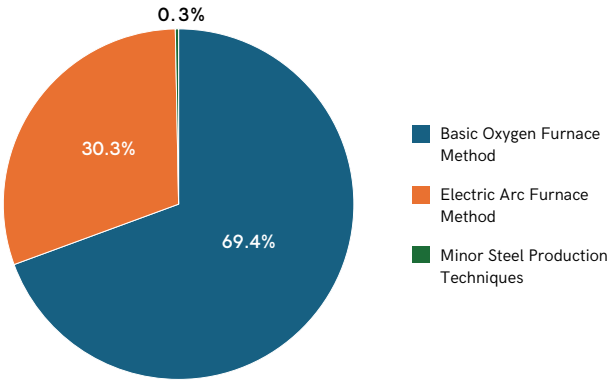


Figure 3. Global crude steel production by process.[1] © worldsteel, 2026

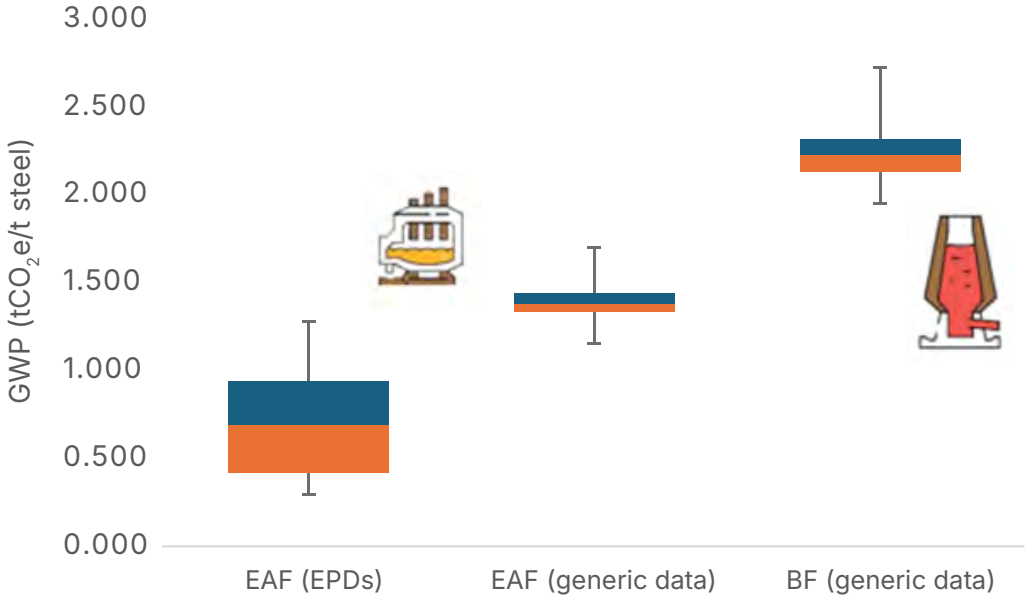


Figure 4. Global warming potential (GWP) for 1 metric ton of steel section via EAF and BF routes.[1, 2] Source: Benchmark of software/tools for LCA (Gervasio et al, 2025)

Steel production via the BF–BOF route is more energy-intensive and carbon-emitting compared to the EAF route. On average, producing 1 metric ton of steel sections via the BF–BOF route results in approximately a mean value of 2.34 $tCO_2$ emissions. In contrast, the EAF route emits less, around 0.68 $tCO_2$/t steel, depending on the amount of scrap used. Direct reduced iron (DRI)-based EAFs emit an average of 1.37 tCO2.[2] **Figure 4** shows the variability in values required to produce 1 metric ton of steel section. The values on the left are based on data from producers' environmental product declarations (EPDs), while the two sets of values on the right are sourced from the Ecoinvent database.[3]

However, it is noted that the data above is generic; it is average data from steel producers at the global scale. Although this data was retrieved from the most recent database, these values do not reflect the recent technological developments in the production of steel. To illustrate this, the first column in the graph of **Figure 4** shows the variability of values from the most recent EPDs relative to the production of steel through the EAF route. In this case, the mean value is 0.67 $tCO_2$/t steel.

# 3.0 Path for the Decarbonization of the Steel Sector

## 3.1 Introduction

Securing the long-term sustainability of the steel industry depends on reducing emissions and achieving decarbonization goals through the scaling of low-carbon technologies and the advancement of breakthrough innovations. Indeed, the technologies required are generally understood and feasible. However, the availability of affordable low-carbon electricity and high-quality raw materials are major constraints. Notwithstanding the above, reducing material demand by applying the four Rs (reduce, reuse, recycle and remanufacture) in the design of buildings may deliver $CO_2$ savings now.

The following sections outline the short- and long-term technological impacts, followed by key strategies for achieving efficiency in steel structure design.

## 3.2 Current Technological Developments (Short-Term Impacts)

### 3.2.1 Enhanced Electric Arc Furnace (EAF) Production

One of the pathways for steel decarbonization involves maximizing the use of electric arc furnaces powered by low carbon electricity. EAF-based steel production primarily uses scrap steel. Currently representing about 28.6% of global steel production, this route offers immediate decarbonization potential as electricity grids become cleaner.[4] Globally, around 80% of EAF production derives directly from scrap, while the remaining is obtained from DRI (see section below). The process allows the recycling of steel, following circular economic principles. One of the main benefits of this technology is the low carbon intensity, particularly scrap-based EAF production with low-carbon electricity.

> **"Securing the long-term sustainability of the steel industry depends on reducing emissions and achieving decarbonization goals through the scaling of low-carbon technologies and the advancement of breakthrough innovations."**

However, it is noted that the production of steel through the EAF will not be sufficient to meet decarbonization targets, as this route is limited by, for example, scrap availability, the high demand for low-carbon energy, and the limitations on steel products and grades that can be produced via EAF. Indeed, worldsteel estimates that despite the increased availability of scrap at the global level, the continued growth of global steel demand means that around half of global steel production will continue to be on the iron-ore route by 2050.

Current developments:

- *Increased scrap processing efficiency*
  EAF-based steel production depends on the availability and quality of steel scrap. Efforts are being made in advanced scrap processing, including cleaning, size control, and tramp element elimination.[5]

- *Advanced sorting and preparation technologies*
  Advances in scrap sorting technologies, including automated sorting with sensor-based systems, improve the quality control of scrap used in EAF. These technologies yield higher-quality input streams and reduce contaminants.

- *Integration with low-carbon energy sources*
  Integration with low-carbon energy supply is a key factor to reduce emissions, since electricity accounts for more than 50% of the carbon footprint of scrap-based EAF production.[6]

- *Improved furnace designs for higher efficiency*
  Improved designs incorporate heat recovery systems and enhanced levels of automation. These improvements reduce energy losses and optimize power consumption.

### 3.2.2 Natural Gas-Based Direct Reduced Iron (DRI)

Natural gas-based DRI production, followed by EAF steelmaking, offers a transitional pathway, reducing emissions by approximately 20–30% compared to BF–BOF. Shaft-furnace DRI plants can be adapted for hydrogen, though full conversion requires significant modification and depends on the design/licensor. DRI adoption depends on the availability and cost of natural gas.

DRI is obtained by reducing iron ore in the solid state at a temperature lower than the melting point of iron with natural gas or coal, though the former is predominant (around 85%). The resulting material (DRI) is then melted in an EAF to produce steel. Gas-based DRI/EAF steel production is less $CO_2$-intensive than BF/BOF typically emitting around 1.37 $tCO_2/t$ in 2024.[2]

Current status:

- *Fully commercial*
  Natural gas-based DRI technology has been used on an industrial scale and commercialized for decades. The global capacity is around 100 millon metric tons per year, showing commercial viability.

- *Significant capacity expansion planned globally*
  Several projects are being developed in the United States, Middle East, and Europe. The European Union has announced around 36 millon metric tons of new DRI capacity.[7]

- *Can be retrofitted for hydrogen use and CCS later*
  Gas-based DRI plants can be adapted to use hydrogen as the reducing agent. As aforementioned, this is already being planned. Additionally, coupling with carbon capture and storage (CCS) is already being adopted. This is particularly viable in regions with abundant natural gas due to the subsequent availability of storage. It is currently in limited use in the steel industry.

- Natural gas-based DRI depends on securing low-cost natural gas supply. This explains the predominance in the Middle East and United States, whereas in Europe adoption has been more limited.

## 3.3 Breakthrough Developments (Medium-to-Long Term Impacts)

### 3.3.1 Hydrogen-Based Direct Reduced Iron ($H_2$-DRI)

Green hydrogen-based DRI represents a promising breakthrough for primary steel production. When powered by low-carbon electricity, this process can reduce emissions by over 80% compared to

current production processes. To convert iron ore into direct reduced iron, which is then melted in an EAF powered by low-carbon electricity, this technology uses hydrogen as the reducing agent instead of gas. Green hydrogen is produced by splitting water molecules through electrolysis, using low-carbon energy.

Development status:

- *Demonstration scale*
  Several pilot projects are planned, but large-scale commercialization is still in the demonstration phase.

- *Expected commercial deployment: 2030–2035*
  $H_2$-DRI steel production (DRI-EAF) is projected to be commercialized and competitive with conventional steel production by the mid-2030s.

- Some projects are underway in Europe and elsewhere – such as Hydrogen Breakthrough Ironmaking Technology (HYBRIT) and Stegra – that will come on-line within the next couple of years.

- *Challenges*
  Low-carbon hydrogen availability, cost, and high-quality ores.

Green hydrogen production is currently about 5% of total hydrogen production[7] and large-scale availability is still limited. Moreover, $H_2$-DRI requires high-grade iron ore, with only one-third of global reserves being suitable for direct reduction.

> **"Decarbonization of steel will not follow a single path: it depends on access to low-carbon energy, supporting infrastructure, and strong market demand backed by policy and regulation."**

If hydrogen-based production is to expand to a significant proportion of global iron production, a solution needs to be found to enable the use of BF-quality ores, for example through enhanced beneficiation or the electrical smelting furnace.

Key breakthrough potential:

- *Near-zero emissions primary steel production*
  Carbon intensities as low as 0.1–0.4 $tCO_2/t$ can be found.[8]

- *Utilization of existing EAF infrastructure*
  Existing EAF infrastructures can be used to melt the product given the output is DRI. In this case, retrofitting and adapting the infrastructures is more feasible than completely new process routes.

- *Scalable technology suitable for large-scale deployment*
  Green $H_2$-DRI can be deployed at industrial scale once green hydrogen production and supply chains mature and expand.

### 3.3.2 Carbon Capture, Utilization, and Storage (CCUS)

CCUS refers to technologies that capture $CO_2$ from large point sources (e.g., power plants or industrial facilities). The $CO_2$ can then be compressed and transported for storage in geological formations (CCS) or used in the production of commercial products (CCU).[6]

CCUS technologies can be implemented to reduce emissions from existing BF–BOF or DRI production. While they do not eliminate emissions entirely, CCUS can capture 80 to 95% of $CO_2$ emissions from steel production.

*The International Energy Agency Net Zero Emissions Roadmap* projects the capture of 0.7 $GtCO_2$/year from steel production by 2050, with about 50% of global primary steel production equipped with CCUS.[7] Overall, it is expected to reduce around 25% emissions by 2050.[6]

Most projects have focused on blast furnaces, given they are the largest source of emissions.[7]

The main challenges are related to engineering and cost.[8]

Current implementations:

- In pre-combustion systems, a primary fuel (coal, natural gas, or biomass) is first gasified or reformed to produce a synthetic gas ($CO + H_2$). The CO is shifted to $CO_2$, which is captured, leaving $H_2$ as a clean fuel. Post-combustion systems capture $CO_2$ from flue gases.

- Integration with existing blast-furnace and DRI operations: a key advantage is the possibility of integration of CCUS with existing BF–BOF plants, increasing the lifetime of assets while reducing carbon emissions.

- *$CO_2$ utilization for chemical production* The captured carbon can be converted into commercial products such as fuels (e.g., methanol) and chemicals (e.g., ethylene), adding economic value and simultaneously reducing fossil resources use.

- *$CO_2$ utilization for enhanced oil recovery (EOR)* $CO_2$ is compressed and injected into mature oil fields to increase oil recovery, with part of the $CO_2$ remaining permanently stored underground.

- *Storage in geological formations:* CCUS allows compression and injection of $CO_2$ into geological formations for permanent storage.

### 3.3.3 Biomass and Waste-Based Technologies

The use of biomass and waste as an alternative to fossil coal in steel production is emerging as a potential decarbonization pathway. Biomass and biowaste materials (e.g., sustainable forestry and agriculture residues) can be used to produce bioenergy for steel production or as an alternative reductant. Waste, such as plastic waste, can also be employed as an energy source. These approaches may provide carbon-neutral or circular carbon sources. Although still in varying stages of technological readiness, pilot projects demonstrate their potential contribution to more sustainable steel production.[8]

Biomass Integration:

- Using biochar and biogas in existing furnaces: biomass sources such waste wood, forestry residues or grown plant material can be converted into biochar and biogas to replace coal in BF and EAF.

- Technical maturity depends on specific applications.

- Biomass integration can provide carbon-neutral reducing agents.

- It is limited by sustainable biomass availability.

Waste Utilization:

- Converting plastic waste and non-recyclable materials: Non-recyclable plastics, rubber tires, and wastes derived from wood (paper, post-consumer timber) may be used as alternatives to reduce coal dependency and divert waste from landfills.

- Circular economy benefits.

- Early-stage development with promising pilot projects.

## 3.4 Design Efficiency of Steel Structures

Enhanced design efficiency is a critical component of the roadmap toward carbon neutrality and broader sustainability, valued both for its impact and its near-term applicability. Techniques such as topology optimization, high-strength material utilization, lightweight structural systems, and modular or prefabricated design can reduce material demand without compromising performance. In parallel, design approaches that facilitate disassembly, reuse of structural components, and closed-loop recyclability further extend the potential for substantial embodied carbon reductions.

> **"For the construction industry, creating demand for low-carbon steel through standards, procurement models, and product certifications is a critical enabler of the transition."**

A hierarchy of design options is illustrated in **Figure 5,** in decreasing order of would change importance to impact. **Build less** emphasizes repurposing, refurbishing, and reusing existing building stock instead of demolishing and starting anew. While repurposing or refurbishment may require some new materials, the primary goal is to preserve as much of the current structure as possible. Reuse, on the other hand, refers to creating new buildings that incorporate, wherever feasible, materials salvaged from deconstructed or obsolete structures.

**Build clever** refers to the selection of appropriate structural configurations and design criteria, avoiding overdesign. For example, steel solutions offer the opportunity of longer spans, thus maximizing the space utilization and allowing for a higher adaptability of the building to cope with new functional requirements over its life span.

**Build efficiently** relates, for example, to design optimization, tailoring components to their required functionality, or the use of high-strength steel to allow the use of lighter structural components.

Finally, minimizing waste generation involves adopting circular economy practices to enhance recycling and reuse, as well as utilizing off-site construction and prefabrication techniques to reduce construction waste. Key design strategies to lessen the waste burden include: (i) designing components for reuse and recovery; (ii) designing for prefabrication; (iii) optimizing material use in design; and (iv) incorporating adaptability and flexibility to extend building lifespans.[10]

The above strategies for a more efficient design of steel structures are illustrated in the following examples of real-life case study buildings.

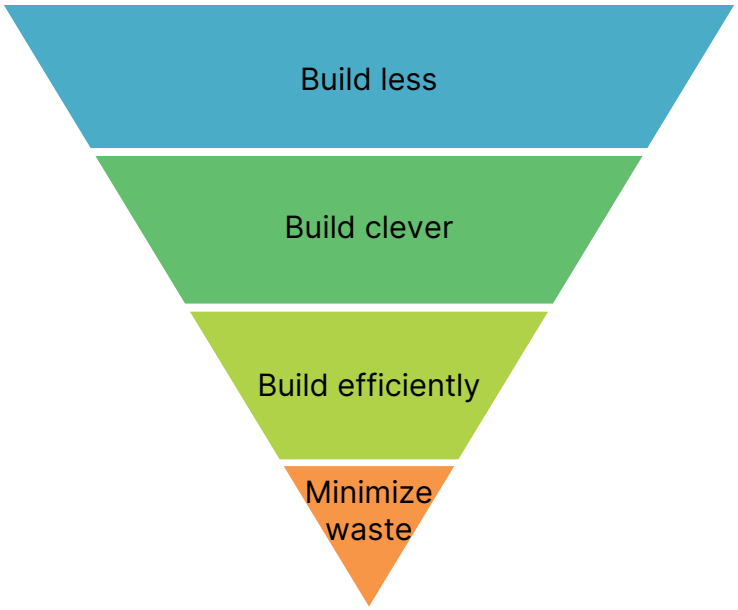


Figure 5. Hierarchy of design decisions.[8] Source: Adapted from Balan et al. 2024

# 4.0 Decarbonization Practices in the Built Environment

The steel industry's decarbonization efforts are already making a tangible impact on the built environment. As low-carbon steel production methods continue to evolve and scale, their influence can be seen in both new construction and the renovation of existing buildings.

Beyond reduced emissions, steel offers a range of benefits compared to alternative structural materials. Its inherent properties – such as high strength-to-weight ratio, precision fabrication, and modularity – facilitate the reuse, adaptation, and refurbishment of structural elements. These characteristics not only extend the lifespan of buildings but also reduce the demand for new raw materials, further supporting circular-economy principles.

The following real-world examples showcase innovative projects where steel structures play a key role in advancing global decarbonization goals. These case studies highlight how thoughtful design and material choice can align architectural excellence with sustainability imperatives.

## 4.1 Adoption of Low-Carbon Steel Solutions

Below are case studies showing the use of low carbon steel together with the application of the 4Rs i.e., reduce, reuse, recycle and remanufacture.

> **"Low-carbon steel solutions are being delivered now – through low-carbon-powered, scrap-based procurement and project-led optimization – achieving reductions of about 30% in embodied-carbon metrics in real projects."**

## The Korakuen PREX Building, Tokyo

### *Project Summary:*

| | |
|---|---|
| Type of project | Office |
| Location | 23-2, 1-chome, Hongo, Bunkyo-ku, Tokyo |
| Client | Sumitomo Corporation |
| Architectural team | Nikken Sekkei Construction Management |
| Contractor | Kumagai Gumi |
| Steel producer | JFE Steel and others |
| Total weight of steel | 400 metric tons |
| No. of floors | 10 |
| Total area | 2,475 m² |

***Key Facts:***

The Korakuen PREX building **(see Figure 6)** was mainly built with low-embodied carbon steel, **reducing about 30% of embodied carbon.**

Figure 6. Korakuen PREX Rendering. © Sumitomo Corporation

## 2 Aldermanbury Square, London

Embodied carbon reduction has been a central focus at 2 Aldermanbury Square **(see figures 7 and 8).** Since 2021, a roadmap of opportunities was developed to meet Great Portland Estates' 2030 target of 572 $kgCO_2e/m^2$ of gross internal area (GIA) (A1–A5). At Stage 4, the project measured 207 $kgCO_2e/m^2$ GIA (A1–A4), with a target of 179. Final results show 124 $kgCO_2e/m^2$ GIA (A1–A4), i.e., a 31% reduction from Stage 4.[11]

***Project Summary:***

| | |
|---|---|
| Type of project | Office |
| Location | 2 Aldermanbury Square, London |
| Client | Great Portland Estates Plc |
| Architectural team | Allies and Morrison |
| Structural engineering | Arup |
| Main contractor | Bovis |
| Steel fabricator | William Hare |
| Cost | Gardier & Theobald |
| Services | Sweco |
| Total weight of steel | 3,700 metric tons |
| No. of floors | 13 |
| Total area | 43,714 $m^2$ |

***Key Facts:***

- Procurement of **low-carbon steel produced with 100% low-carbon energy and scrap (333 $kgCO_2e/t$).**
- Structural steel sizes optimized for efficiency.
- **Upgrading to S460** and innovative low-alloy steel grades with enhanced strength and weldability.
- **Reuse of 38 metric tons of steel** from the existing building.
- Metal decking thickness reduced from 1.0 mm to 0.9 mm.
- Third-party verified steel decking procured to support Scope 3 reductions.

Figure 7. 2 Aldermanbury Square, London. © Allies & Morrison

Figure 8. 2 Aldermanbury Square,London – under construction. © Bovis

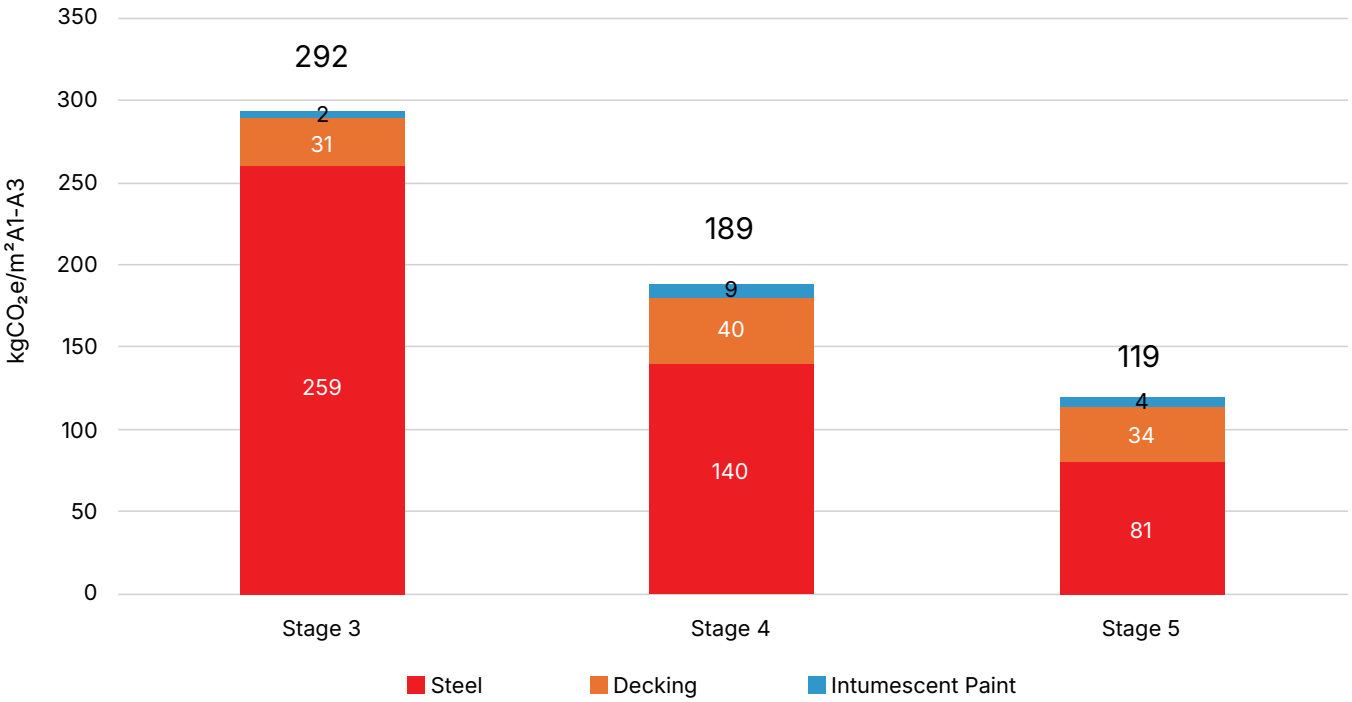


Figure 9. Emissions in A1–A3.[10] © Laura Mahoney, BOVIS

## Airport Terminal Lobby and International Arrivals Facility, Nashville

### *Project Summary:*

| | |
|---|---|
| Type of project | Aviation |
| Location | Nashville |
| Date of Completion | 2023 |
| Client | Metropolitan Nashville Airport Authority |
| Architectural team | Fentress Studios, a Populous Company, and Corgan |
| Engineering team | Magnusson Klemencic Associates |
| Contractor | Hensel Phelps |
| Steel fabricator | ArcelorMittal, Banker Steel Company |
| Total weight of steel | 5,700 metric tons |
| No. floors | 5 |
| Total area | 19,500 m² expansion and 32,500 m² retrofit |
| No. Floors | 13 |
| Total Area | 43,714 m² |

***Key Facts:***

- The total length of the new long-span truss roof system is 200 meters **(see Figure 10).**
- The design features a maximum clear span of 55 meters, which keeps the terminal open and reduces the need for columns **(see figures 11 and 12).**
- By preserving existing concrete and steel, the project reduced its embodied carbon footprint by 50% compared to a total rebuild.
- The renovations allowed 100% of the original foundations and floor slabs to remain in place.
- Construction was managed so that the facility remained safe and fully operational for passengers.
- The long-span approach bypassed the need for extensive retrofitting in crowded spaces.

Figure 10. Cantilevered truss during construction. © Matt Good

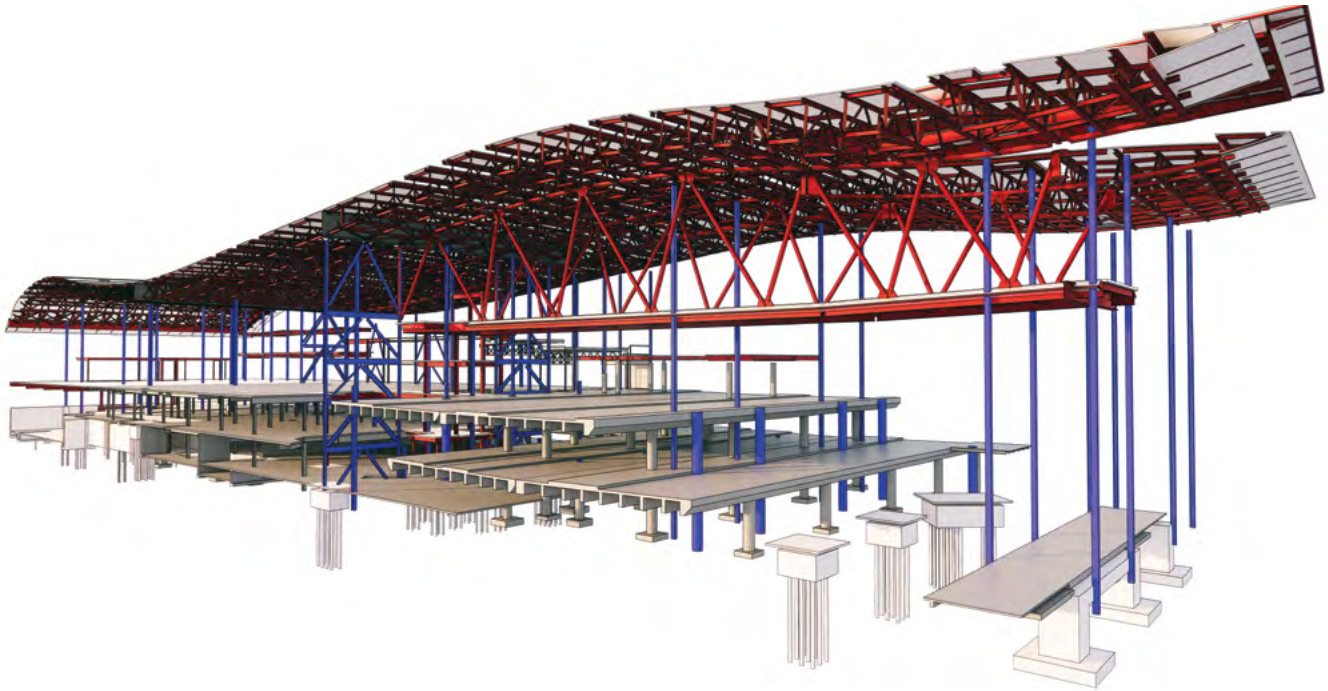

Figure 11. Initial Design. Proposed additional columns and retrofitted elements (in blue). © Magnusson Klemencic Associates.

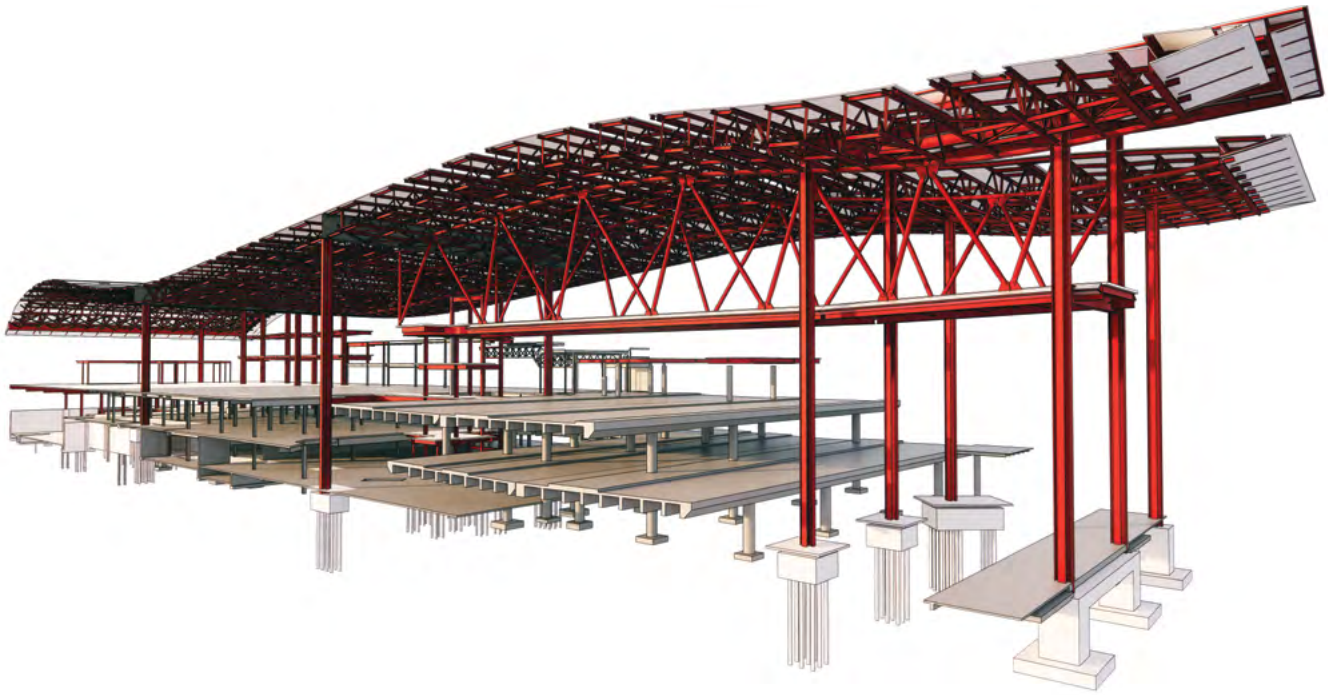

Figure 12. Truss system with minimal intervention, preserving the existing substructure. © Magnusson Klemencic Associates.

## Salesforce Tower, Chicago

### *Project Summary:*

| | |
|---|---|
| Type of project | Office |
| Location | Chicago |
| Date of completion | 2023 |
| Client | Hines |
| Architectural team | Pelli Clarke & Partners and HKS Architects |
| Engineering team | Magnusson Klemencic Associates |
| Contractor | The Walsh Group |
| Steel fabricator | Cives Steel Company |
| Total weight of steel | 8,800 metric tons |
| No. of floors | 60 |
| Total area | 134,709 m² |

***Key Facts:***

- This was the first building in Chicago to mandate Environmental Product Declarations (EPDs) during the bidding process to evaluate carbon emissions against industry averages **(see Figure 13).**
- The structural team utilized a mix of steel grades, specifically 50, 65, 70, and 80 ksi (345, 448, 483, and 552 Mpa), to optimize the strength-to-weight ratio of the columns.
- A 9% reduction in overall steel tonnage was realized, stripping 800 metric tons of material from the structure.
- The project achieved an embodied carbon intensity of 550 $kgCO_2e/m^2$.
- Beyond material savings, the lower tonnage reduced hoisting requirements and welding fabrication energy during construction.
- It served as the inaugural project for the ***Hines Embodied Carbon Reduction Guide,*** developed by MKA and Hines.

Figure 13. Salesforce Tower and Wolf Point East view. © Angie McMonigal.

## 4.2 Reuse of Steel Structures

The reuse of steel structures or steel components avoids the production of new steel and minimizes waste flows.

### 34–35 Farringdon Street, London

This is a 13-story modern, sustainable office building, whose design prioritizes adaptability, sustainability, and health, incorporating biodiverse green terraces, communal social areas, and a dedicated Wellness Wing with fitness facilities **(see figures 14 and 15).**

The project targets BREEAM Outstanding and WELL Shell and Core Platinum certifications, with BHC Ltd responsible for steel procurement, fabrication, and steel erection.

***Project Summary:***

| | |
|---|---|
| Type of project | Office |
| Location | 34–35 Farringdon Street, London |
| Client | Royal London Asset Management (RLAM) |
| Architectural team | PLP Architecture |
| Engineering team | Heyne Tillet Steel (HTS) |
| Contractor | Multiplex |
| Steel fabricator | BHC |
| Total weight of steel | 2,980 metric tons |
| No. of floors | 13 |
| Total area | 35,948 m² |

***Key Facts:***

- **87 metric tons of reused steel columns** were used on the project, with an embodied carbon of 46 $kgCO_2e/t$.
- **60% of the total material procured on this project was** low-embodied-carbon steel, produced using 100% renewable energy and 100% scrap, leading to 333 $kgCO_2e/t$ (production stage).
- Fabrication with 100% low-carbon energy, reducing carbon emissions associated with fabrication by 44% from 138 $kgCO_2e/t$ to 77 $kgCO_2e/t$.
- Steel fibers were used instead of reinforcement, which helped to reduce the carbon associated with the upper floor topping.
- Embodied carbon of the steel structure: 67 $kgCO_2e/m^2$.

Figure 14. Office building at 34–35 Farringdon Street, London. View from Holborn Viaduct. © PLP Architecture

Figure 15. View of the 34-35 Farringdon Street building from Holborn Viaduct. © Wire Collective, image courtesy of PLP Architecture.

## The CAB at Civic Center, Auckland

The CAB at Civic Center, a residential apartment tower, Auckland, is the former Civic Administration Building **(see Figure 16).**

***Project Summary:***

| | |
|---|---|
| Type of project | Residential (adaptive reuse of former office building). |
| Location | Aotea Square, Auckland (Civic Quarter) |
| Date of completion | 1966 |
| Retrofit completion | 2022 |
| Developer | Love & Co. |
| Architectural team | Jasmax Salmond Reed Architects (Heritage Architect) |
| Engineering team | Beca |
| Contractor | Naylor Love |
| Total weight of steel | 675 metric tons |
| No. offloors | 20 |
| Total area | 9,000 m² |

***Key Facts:***

- The project involves the restoration and refurbishment of the former Civic Administration Building (CAB) into high-end central city apartments **(see Figure 16).**
- The transition from office to residential use prioritizes "adaptive reuse" to significantly lower the building's total environmental impact.
- A conservative embodied carbon avoidance factor of 95% has been adopted for the proposal to account for refurbishment, recoating, and practical constraints.

Figure 16. The CAB at Civic Center, Auckland. © Kaveh Andisheh, HERA.

> **"Steel reuse turns 'end of life' into a new starting point: reusing structural frames and components avoids new steel production and keeps high-value material in circulation – cutting emissions and waste at the same time."**

## St. Marys Integrated Project Office (IPO), Sydney

### *Project Summary:*

| | |
|---|---|
| Type of project | Office |
| Location | Sydney |
| Client | Sydney Metro |
| Architectural team | Place Studio |
| Engineering team | Robert Bird Group |
| Contractor | Built |
| Steel fabricator | Proline Steel |
| Total weight of steel | 95 metric tons |
| No. floors | 4 |
| Total area | 3,000 m² |

### *Key Facts:*

- The temporary four-story facility provides 200 workstations to support the Western Sydney Aerotropolis line **(see figures 17 and 18).**
- The structure features a 50-year design life, with a plan to be demounted and relocated every 10 years.
- Compared to building five separate standalone structures, this relocatable model is estimated to save 2,252 $tCO_2e$ over its full life span.
- For a single life cycle (cradle-to-gate), the building's carbon footprint was measured at 563 $tCO_2e$.
- Targeted material optimization in the design reduced steel-related emissions by 33.5 $tCO_2e$.
- The design prioritizes reusable construction methods to minimize waste and meet an accelerated delivery schedule.

Figure 17. St. Marys Integrated Project Office (IPO), Sydney. during construction. © Joseph Bonica, RBG

Figure 18. St. Marys Integrated Project Office (IPO), Sydney.
© Joseph Bonica, RBG

## 4.3 Extension of the Service Life (Building Rehabilitation/Refurbishment)

### Urban Bloom – Galleria Timeworld, Daejeon

***Project Summary:***

| | |
|---|---|
| Type of project | Retail |
| Location | Daejeon |
| Client | Hanwha Galleria |
| Architectural team | CA Plan |
| Engineering team | POSCO |
| Contractor | Exhibit Korea |
| Steel fabricator | INFESO |
| Total weight of steel | 500 metric tons |
| No. floors | 5 |
| Total area | 17,178 m² |

***Key Facts:***

- Refurbishment of the entire façade of a massive department store built 25 years ago **(see figures 19 and 20).**
- The engineering team carried out alternative design and engineering by changing the originally planned 3-mm-thick aluminum exterior cladding to 1.2-mm-thick steel **(see Figure 21).**
- Carbon emissions were reduced by approximately 86% compared to the solution with aluminum.

Figure 19. Urban Bloom – Galleria Timeworld. © CA Plan, courtesy of POSCO

Figure 20. Urban Bloom – Galleria Timeworld. © CA Plan, courtesy of POSCO

> **"Refurbishment and life-extension strategies can deliver immediate embodied-carbon gains – case studies report ~80% to ~86% reductions in façade-related carbon impacts through informed material and design choices."**

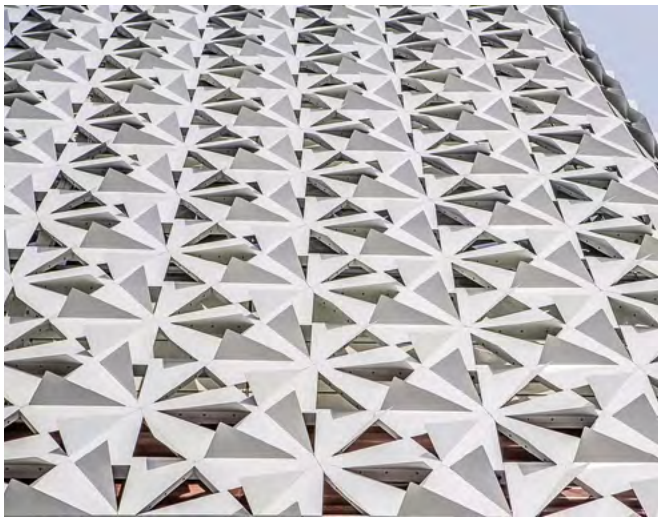

Figure 21. Urban Bloom – Galleria Timeworld. © CA Plan, courtesy of POSCO

## The Sharp Yeomju Central Park, Gwangju

### *Project Summary:*

| | |
|---|---|
| Type of project | Residential - steel façade of apartment |
| Location | Gwangju |
| Date of completion | October 2022 |
| Client | POSCO E&C |
| Architectural team | POSCO A&C |
| Engineering team | POSCO |
| Contractor | POSCO E&C |
| Steel fabricator | JEIL LOUVER |
| Total weight of steel | 193 metric tons |
| No. of floors | 33 (x 18 buildings) |
| Total area | 4,260 m² |

Figure 22. The Sharp Yeomju Central Park, Gwangju.
© POSCO E&C

***Key Facts:***

- The project transformed a 1985 apartment complex into a modern residential hub, featuring 18 buildings and 1,976 housing units **(see Figure 22).**
- A major design shift replaced the originally specified 3-mm aluminum façade system with a 1.6-mm PosMAC® (coated steel) system **(see Figure 23).**
- The transition to a steel façade solution resulted in a total reduction of approximately 824 $tCO_2e$ in emissions (from 1,030 $tCO_2e$ to 206 $tCO_2e$.)
- This material substitution achieved an 80% reduction in carbon emissions compared to the aluminum-based design.
- The engineering strategy utilized thinner-gauge steel to maintain architectural identity and visual harmony, while significantly lowering the project's life-cycle carbon perspective.

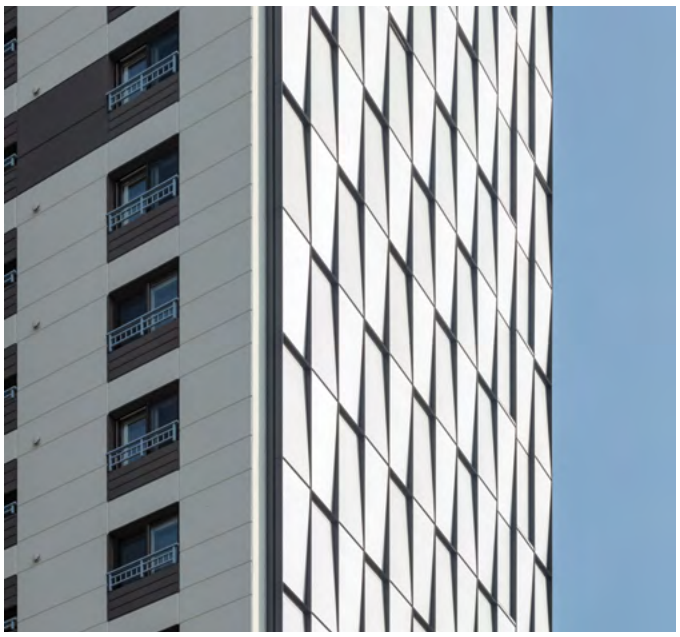

Figure 23. The Sharp Yeomju Central Park, Gwangju – façade detail.
© POSCO E&C

## Gaepo Xi Presidence, Seoul

### *Project Summary:*

| | |
|---|---|
| Type of project | Residential – steel façade of apartment |
| Location | Seoul |
| Date of completion | February 2023 |
| Client | GS E&C |
| Architectural team | SKM |
| Engineering team | POSCO |
| Contractor | GS E&C |
| Steel fabricator | JEIL LOUVER |
| Total weight of steel | 730 metric tons |
| No. floors | 39 (x 35 buildings) |
| Total area | 15,931 m² |

***Key Facts:***

- The project transformed a 1982 apartment complex into a massive high-density residential site with 35 buildings and 3,375 housing units **(see Figure 24).**
- A strategic engineering shift replaced the originally specified 3-mm aluminum façade with a 1.6-mm PosMAC® (coated steel) system.
- This material substitution achieved an 80% reduction in carbon emissions compared to the initial aluminum design.
- The adoption of the steel façade system resulted in approximately 2,440 $tCO_2e$ of avoided carbon emissions (from 3,050 $tCO_2e$ to 610 $tCO_2e$.)
- The design utilized metal façade systems on the side elevations to provide architectural differentiation within a dense urban context.

Figure 24. Gaepo Xi Presidence, Seoul, South Korea. © POSCO E&C

## 4.4 Building Efficiency and Livability

### The Zero Energy Building, Bhubaneswar

***Project Summary:***

| | |
|---|---|
| Type of project | Residential |
| Location | Bhubaneswar, India |
| Client | CRE, Tata Steel |
| Architectural team | Nest-In, Tata Steel, Ecofirst |
| Engineering team | Nest-In, Tata Steel |
| Contractor | Pasa Resources Pvt. Limited |
| Steel fabricator | Wootz Buildsys LLP |
| Total weight of steel | 9 metric tons |
| No. floors | 1 |
| Total area | 170 m² |

Figure 25. The Zero Energy Building, Bhubaneswar, India. © TataSteel & constructsteel

Figure 26. The Zero Energy Building, Bhubaneswar, India – front view. © TataSteel & constructsteel

***Key Facts:***

- The structural steel global warming potential (GWP) for the A1–A5 stages was measured at 126 $kgCO_2e/m^2$.
- This represents a 67% reduction in carbon emissions compared to a standard reinforced concrete (RC) frame structure, which measures 384 $kgCO_2e/m^2$.
- The A1–A5 carbon assessment includes raw material extraction, transportation, manufacturing, and erection.
- The building can switch to solar power during peak hours (5:00 p.m. to 10:00 p.m.), ensuring zero grid dependency during those times.
- The design allows for vertical scalability, with an option to add an additional floor without major structural changes.
- Adaptive reuse of internal spaces is enabled through Trimawall panels, allowing rooms to be reconfigured (e.g., from an office to a bedroom) to lower life-cycle carbon.
- Residents can manage energy use in real-time through AI-enabled equipment and smart monitoring solutions.
- The project targets the middle-income group to make energy-efficient living financially accessible.

Greenhouse gas (GHG) emissions are projected to decrease by 325.5 $tCO_2e$, representing a 46% reduction, owing to the Zero Energy Building (ZEB) efficiency realized within the project **(see figures 25, 26, and 27),** when compared to equivalent conventional buildings. A scope-wise breakdown of these savings is presented below **(see Table 1).**

Figure 27. Zero Energy Building render showing light-gauge steel frame (LGSF) used. © TataSteel & constructsteel

| Relevant purchased/ imported materials & energy | UoM | Added Quantity (UoM) | | | GHG Emission ($tCO_2e$) | | | % |
|---|---|---|---|---|---|---|---|---|
| | | Conventional Building | Proposed Nest in Building | Increase | Conventional Building | Proposed Nest in Building | Increase | Increase |
| Electricity (grid) | MWh | 707 | 358 | -349 | 596 | 302 | -295 | -49% |
| Electricity (solar) | MWh | - | 164 | 164 | - | - | 0 | 0% |
| Construction materials | t | 70 | 19 | -51 | 43 | 14 | -29 | -68% |
| Equipment, services & miscellaneous | Rs. Cr. | 0.36 | 0.47 | 0.1 | 37 | 48 | 11 | 29% |
| Refrigerant leakage | t | 0.05 | 0.03 | -0.02 | 35 | 23 | -12 | -33% |
| End of life treatment | t | 70 | 19 | -51 | 1 | 0.4 | -0.3 | -43% |
| Material recovery credit | t | 6 | 2 | -4.1 | -8.26 | -2.81 | 5 | -66% |
| Transportation: roadways | t.km | 4.E+04 | 1.E+04 | -3.E+04 | 8 | 2 | -6 | -72% |
| Total | | | | | 712 | 387 | -325 | -46% |

Table 1. GHG emissions reduction achieved through use of light-gauge steel and other strategies at Zero Energy Building, Bhubaneswar, India.

**"Efficiency and livability reinforce each other: the Zero Energy Building developed in India reports a projected reduction of 325.5 $tCO_2e$ – a 46% decrease – compared with conventional buildings, while maintaining occupant-focused performance."**

## Torre Reforma, Mexico City

### *Project Summary:*

| | |
|---|---|
| Type of project | Office |
| Location | Mexico City |
| Date of completion | 2016 |
| Client | Fondo Hexa, S.A. de C.V. |
| Architectural team | LBR&A Arquitectos |
| Engineering team | Arup, Rodolfo Valles Mattox & DITEC |
| Contractor | Capital Vertical Grupo Inmobiliario |
| Steel fabricator | Recal Aceros |
| Total weight of steel | 9,830 metric tons |
| No. of floors | 56 |
| Total area | 89,657 m² |

Figure 28. Torre Reforma, Mexico City. © Dan (cc by-sa)

***Key Facts:***

- The project achieved an embodied carbon intensity of 670 kg $CO_2e/m^2$ **(see Figure 28).**
- A total of 100% of wastewater undergoes tertiary-level treatment and is fully reused within the building.
- Occupant well-being is prioritized, with 94% of regularly occupied areas featuring an outside view.
- Natural daylighting is accessible to 79% of regularly occupied areas.
- Waste management efforts resulted in 51% of construction waste being separated for reuse or recycling.
- Regional sourcing was a priority, with 42% of construction materials manufactured within 800 kilometers of the site.
- The design achieved a 32% reduction in the use of potable water.
- Indoor air quality is enhanced by providing 30% more outside air than the minimum rates required by ASHRAE standards.
- The building's operational efficiency led to a 20% savings in total energy consumption costs.

# 5.0 Conclusions

The global steel industry is committed to its long-term sustainability by reducing greenhouse gas emissions and meeting decarbonization targets via three main levers: (1) Energy efficiency, (2) maximizing scrap availability and use and (3) breakthrough technologies. It is important to mention that the decarbonization of steel will not follow the same path everywhere. Indeed, low-carbon energy and appropriate cost, relevant infrastructure for storage, transportation and conversions are all key necessities in the decarbonization journey, together with a strong and reliable market demand, including government and policy support.

The steel industry is attempting to work closely with governments, industry, stakeholders and customers to collectively act on various issues to promote and speed up the transition towards a decarbonized steel industry.

For the construction industry, it is critical to create demand for low-carbon steel, develop standards, procurement models and product certifications. The steel industry must engage proactively with construction stakeholders to ensure clear communication of progress, challenges and trade-offs during the transition, and ensure interoperability of national policies with international frameworks.

At the same time, the design and engineering community have at their disposal levers that may reduce carbon emissions in buildings now and via the application of the 4Rs: reduce, reuse, recycle, and remanufacture. For example, usage of high-strength steel, may lead to a 20~40% reduction of $CO_2$ emissions. Implementation of low-carbon engineering and application solutions can help lead to huge reductions in $CO_2$ now.

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