The intelligent construction choice

Steligence®

22-Storey Residential Building Case Study:

Comparing Carbon Footprint, Build Speed and Cost by Structural System

ArcelorMittal

About Steligence®

Steligence® is a global initiative by ArcelorMittal using scientific evidence to show the benefits of steel design in building construction. Using a holistic analysis concept, competitive steel building solutions are identified.

It allows building owners, architects, and engineers a fact based approach to view building construction, for collaboration to build sustainable, more cost-effective buildings.

Smarter steels for people and planet

ArcelorMittal is one of the world's largest steel and mining companies. Guided by a philosophy to produce safe, sustainable steel, it is a leading supplier of quality steel products in all major markets including automotive, construction, energy, household appliances and packaging. ArcelorMittal is present in more than 60 countries and has an industrial footprint in more than 20 countries.

With a strong presence in North America, Europe, South America and South Africa, and an emerging presence in China, ArcelorMittal delivers a large scale of products, solutions and services to customers with the same quality focus in all regions. ArcelorMittal is a leader in steel technology, both in the breadth and depth of our product portfolio, and in our ability to supply a range of grades throughout the world. ArcelorMittal is a supplier of choice for all markets, a testament of our commitment to working collaboratively with our customers to engineer advanced steel grades to meet their needs.

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Introduction

Major cities and the surrounding regions continue to be drivers of both local and national economies today. As economies steadily expand and job demand grows, there is a pressing need to increase the affordable housing supply for the population, through densification in high-rise buildings while limiting urban sprawl.

Project Partners

ArcelorMittal Dofasco partnered with several firms to develop the 22-storey case study.

Architectural Design

mcCallumSather

Structural Engineering

wsp

Cost and Construction Schedule Estimation

Hanscomb
QUANTITY SURVEYORS

Third Party LCA Reviewer

ha/f

Building Overview & Functionality

The case study was designed as a 22-storey residential building for a corner site overlooking two streets located within the Greater Toronto and Hamilton area.

Size: 41,081 m² Gross Floor Area (442,192 ft²)

Stacking: 22-storey

Basement – 2 levels underground parking

Ground floor – main entrance, amenities, services/utilities, access to parking

Unit Types: 1BR, 2BR, 3BR

Levels 2-12 – residential, 18 units per floor

Levels 13-22 – residential, 9 units per floor

Rooftop mechanical penthouse

Design Scenarios

Two unique building scenarios were analyzed comparing a steel-based design with concrete. For the purposes of the study, only the structural elements were significantly altered in each scenario.

	Steel	Concrete
Foundation, Underground Parking	Cast in place concrete (CIP) slabs & columns; strip/spread footings	
Floors	Deep composite deck	Two-way CIP concrete slabs
Columns	Wide-flange sections	CIP concrete
Beams	Wide-flange sections	CIP concrete
Core, Shear walls	Chevron braced frame	CIP concrete
Envelope	Steel stud with exterior insulation & metal panel, window wall glazing	
Roof	Deep composite deck	CIP concrete slabs
Interior Framing	Light steel framing (LSF)	
MEP Systems	Standard mechanical, plumbing, electrical systems per Ontario Building Code	
Interior Finishes	Modern residential floor, wall, ceiling finishes and fixtures	

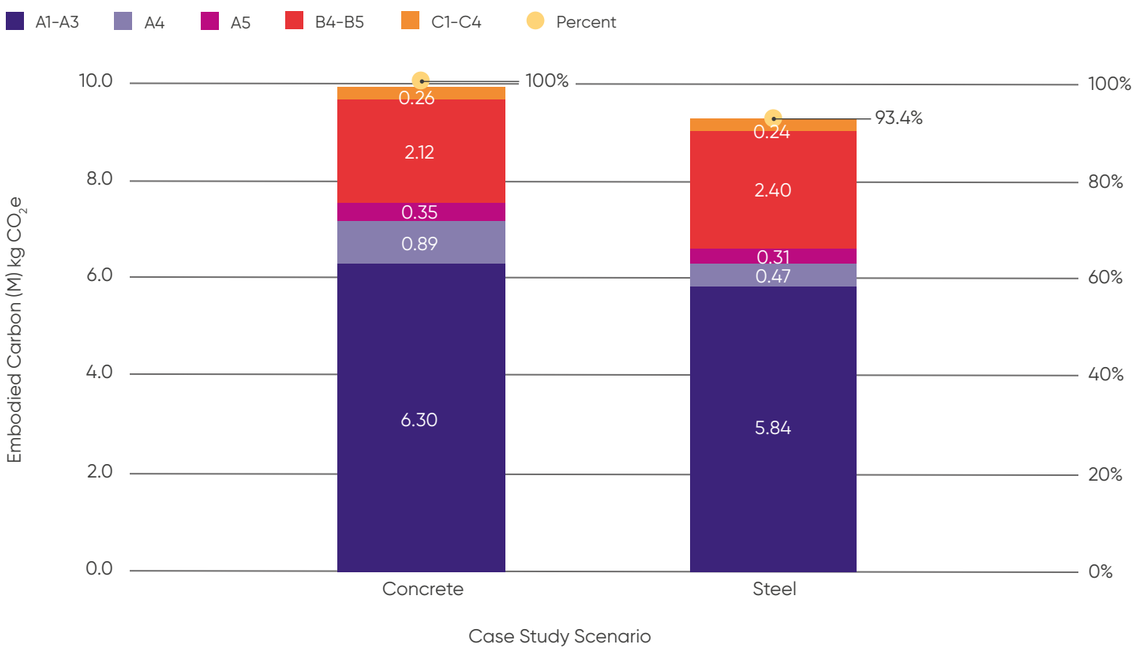
Global Warming Potential Results

A whole building life-cycle assessment was conducted using OneClick LCA to assess the global warming potential of both design scenarios from cradle to grave. OneClick LCA is one of the most frequently used and cited tools for building life cycle analysis. The National Whole Building Life Cycle Assessment Practitioners Guide, published by the National Research Council (October 2024), was used as the basis for embodied carbon reporting. The scope of the LCA extended beyond the mandatory fields, and included optional scope items as well, such as interior finishes and doors.

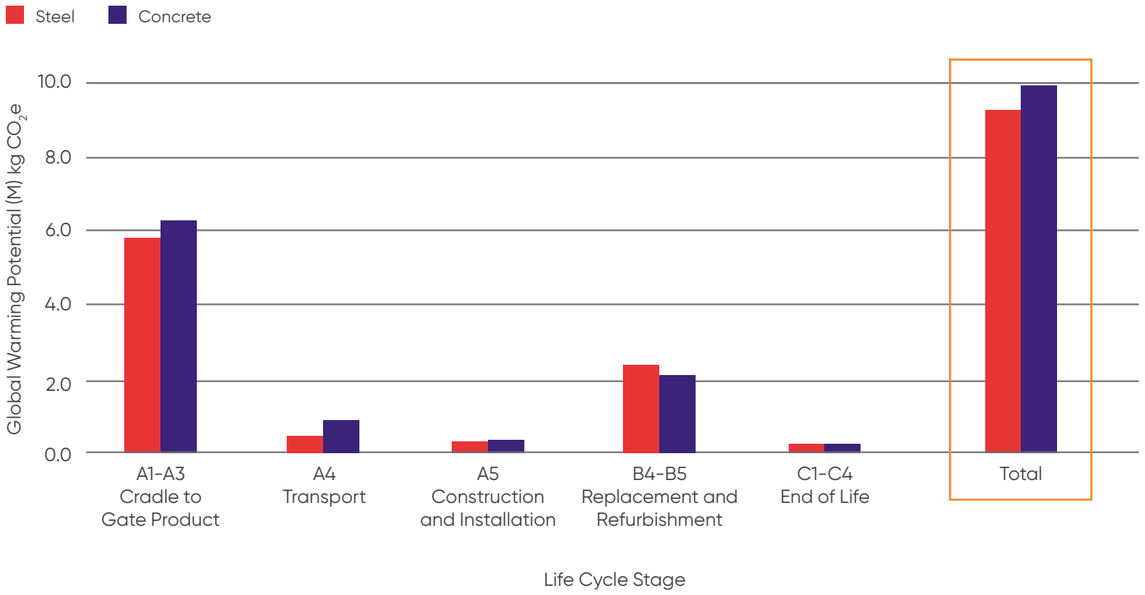
A bill of materials was generated using Revit Schedules from the architectural and structural models, from both design scenarios. Environmental product declarations (EPDs) were selected following a local procurement strategy, initially considering products in the Greater Toronto Area (GTA), then expanding to Ontario, Canada, and globally. Product specific EPDs were selected whenever possible, in lieu of industry average. This analysis compares lower-carbon material options in both scenarios, as outlined in the table below. The lower carbon alternatives were held constant across both scenarios. For example, XCarb® steel studs were considered in both steel and concrete based designs.

Building Element	Lower Embodied Carbon Scenario
Footings	50% Slag + GUL cement
Concrete Walls	35% Slag + GUL cement
Concrete Columns	35% Slag + GUL cement
Concrete Slab-on-Grade	50% Slag + GUL cement
Concrete Beams/Slabs	35% Slag + GUL cement
Interior & Exterior Steel Studs	ArcelorMittal Dofasco XCarb® – Cold-formed sections
Steel Cladding	ArcelorMittal Dofasco XCarb® – Steel cladding & roofing
Furring & Resilient Channels	ArcelorMittal Dofasco XCarb® – Cold-formed sections
Steel Wide-flange Sections	ArcelorMittal XCarb® - Structural Shapes

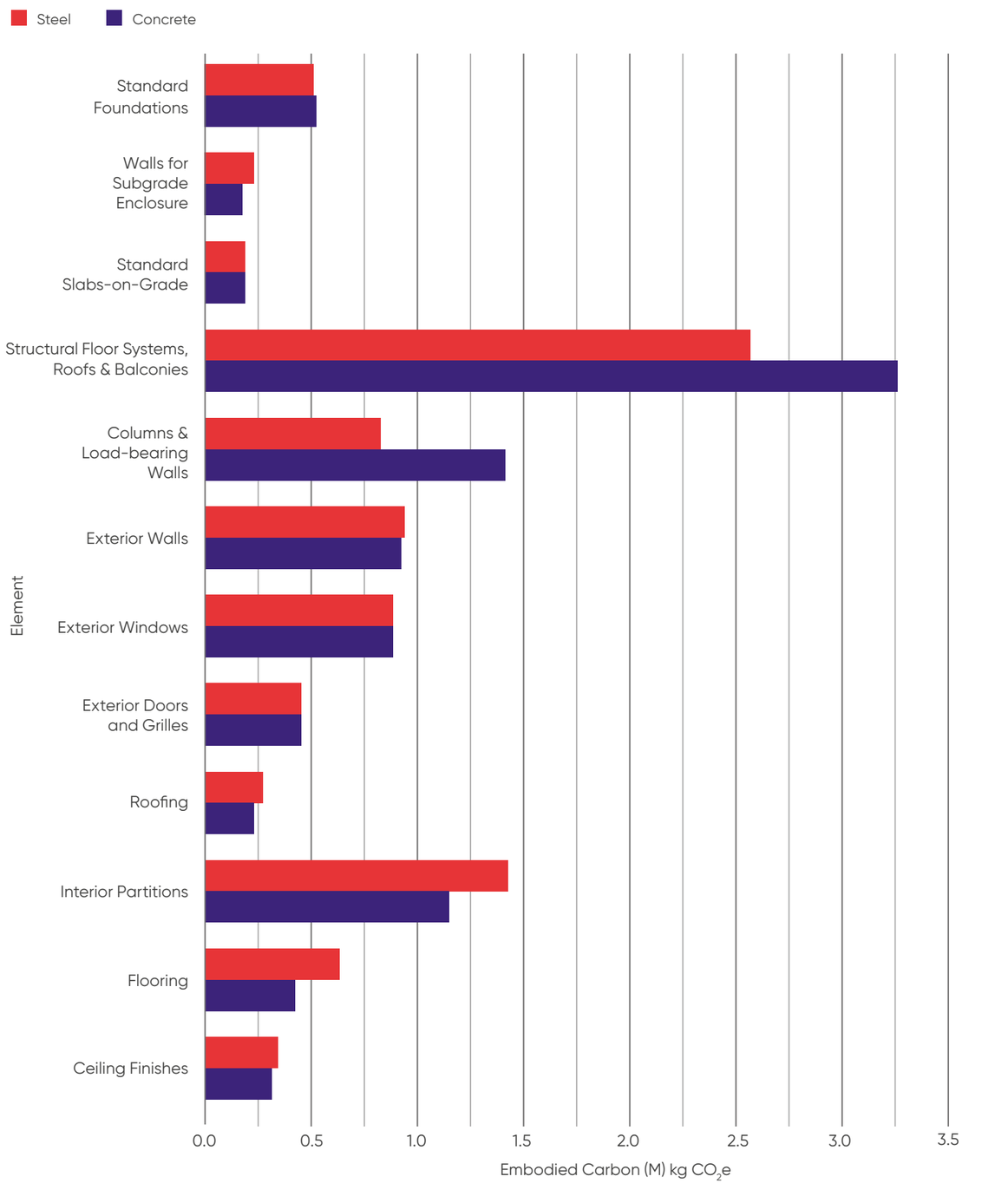
Whole Life Carbon Life Cycle Assessment (M) kg CO_2e



Life Cycle Stage



Life Cycle Carbon - Global Warming Potential (M) kg CO_2e Element Comparison



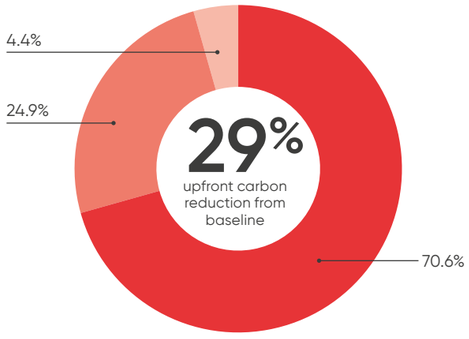
The steel-based design exhibited an approximately 7% lower overall Global Warming Potential (GWP) compared to the concrete-based design. In both design options, more than 70% of total carbon emissions were concentrated in the A1–A3 life cycle modules, indicating that material production and manufacturing dominated the embodied carbon impacts. At the structural system level, the steel-based design demonstrated a 21% lower GWP for the structural floor systems. This reduction is primarily attributed to the use of deep composite steel deck, minimizing the required concrete and rebar while efficiently leveraging the structural capacity of the steel framing, coupled with the benefits of utilizing XCarb® RRP structural steel sections and decking. The steel building also appears to have a 42% embodied carbon savings in columns and load bearing walls. However, as the concrete building mobilizes interior partition walls as part of the gravity system, this number is slightly misleading, as certain walls that would otherwise be captured under interior partitions, have been shifted over to the columns and load bearing walls category.

Analyzing the cumulative effects of the columns & load bearing walls category and interior partitions, the steel building yields a more modest 13% embodied carbon savings.

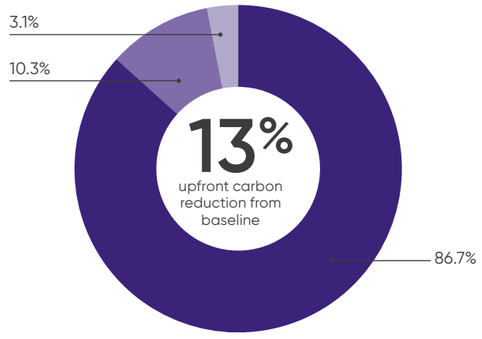
OneClick LCA was used to quantify the potential reduction in global warming potential (GWP) associated with the use of lower carbon materials. The analysis was re-run by substituting the low carbon concrete and steel options with their respective baselines: the Concrete Ontario benchmark for concrete and the Canadian Sheet Steel Building Institute industry average environmental product declaration for steel.

For the steel-based design, the use of low carbon materials resulted in a 29.4% reduction in A1–A5 GWP, approximately 85% of which was attributable to the use of XCarb® steel. In the concrete-based design, GWP was reduced by 13.3%, driven primarily by the use of low carbon concrete, as the scenario included minimal quantities of hot rolled steel sections or steel deck.

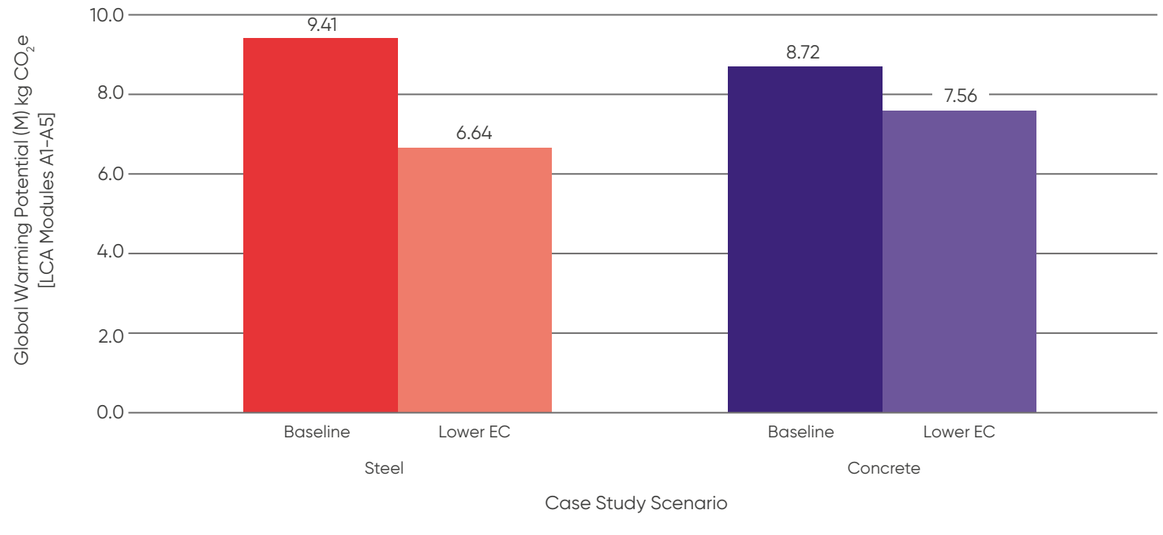
Steel



Concrete

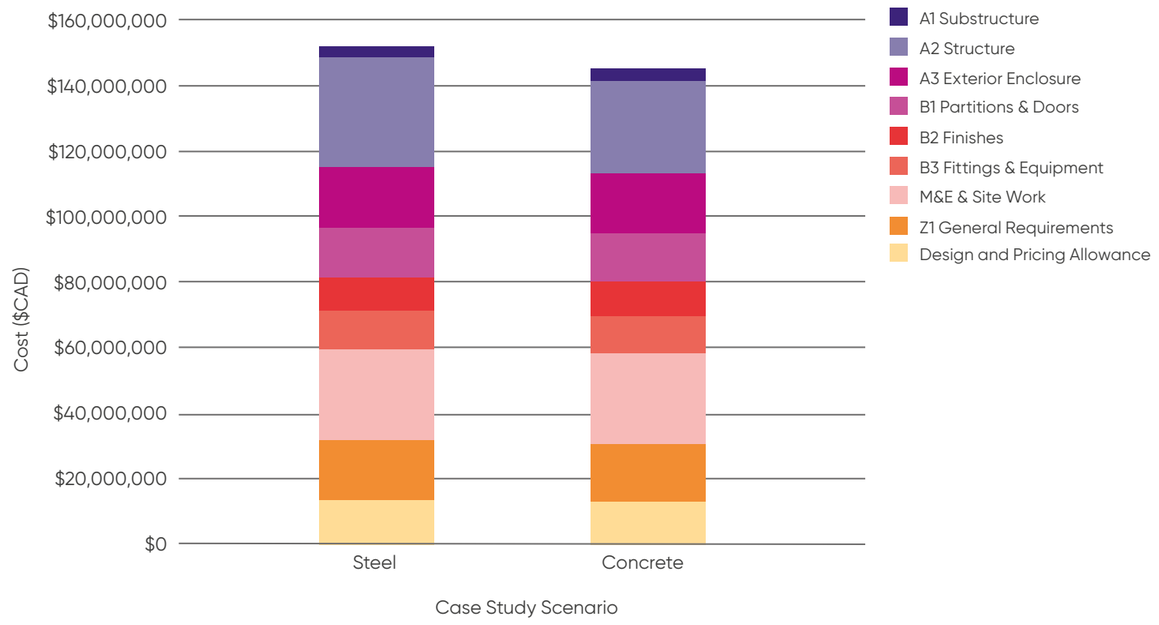


Upfront Carbon (A1-A5) Reduction From Baseline



Financial Results

Hanscomb provided a detailed class D cost estimate for both scenarios studied. Overall, both scenarios were comparable in total cost with the concrete scenario having a slight advantage, just under 5%.



Major categorical cost differences between the two scenarios are outlined below.

	Concrete	Steel
A1 Substructure	$3,531,500	$3,370,800
A2 Structure	$28,483,800	$33,106,600
A3 Exterior Enclosure	$18,174,800	$18,764,800
B1 Partitions & Doors	$14,749,700	$14,946,100
B2 Finishes	$10,341,000	$10,443,000
B3 Fittings & Equipment	$11,397,600	$11,397,600
M&E & Site Work	$27,614,700	$27,614,700
Z1 General Requirements	$17,555,400	$18,377,200
Design & Pricing Allowance	$13,184,900	$13,802,100
Total	**$145,033,400**	**$151,822,900**

Construction Schedule

Hanscomb developed the construction schedule and determined that the steel-based design achieves an approximately 3.5-month reduction in overall construction duration, primarily attributable to increased efficiency in structural build-out.

Conclusion

This Steligence® case study found the steel-based design to have a lower overall GWP by approximately 7%, and was faster to construct by 3.5 months when compared to the concrete-based design. The concrete-based design was found to be about just under 5% more cost effective.

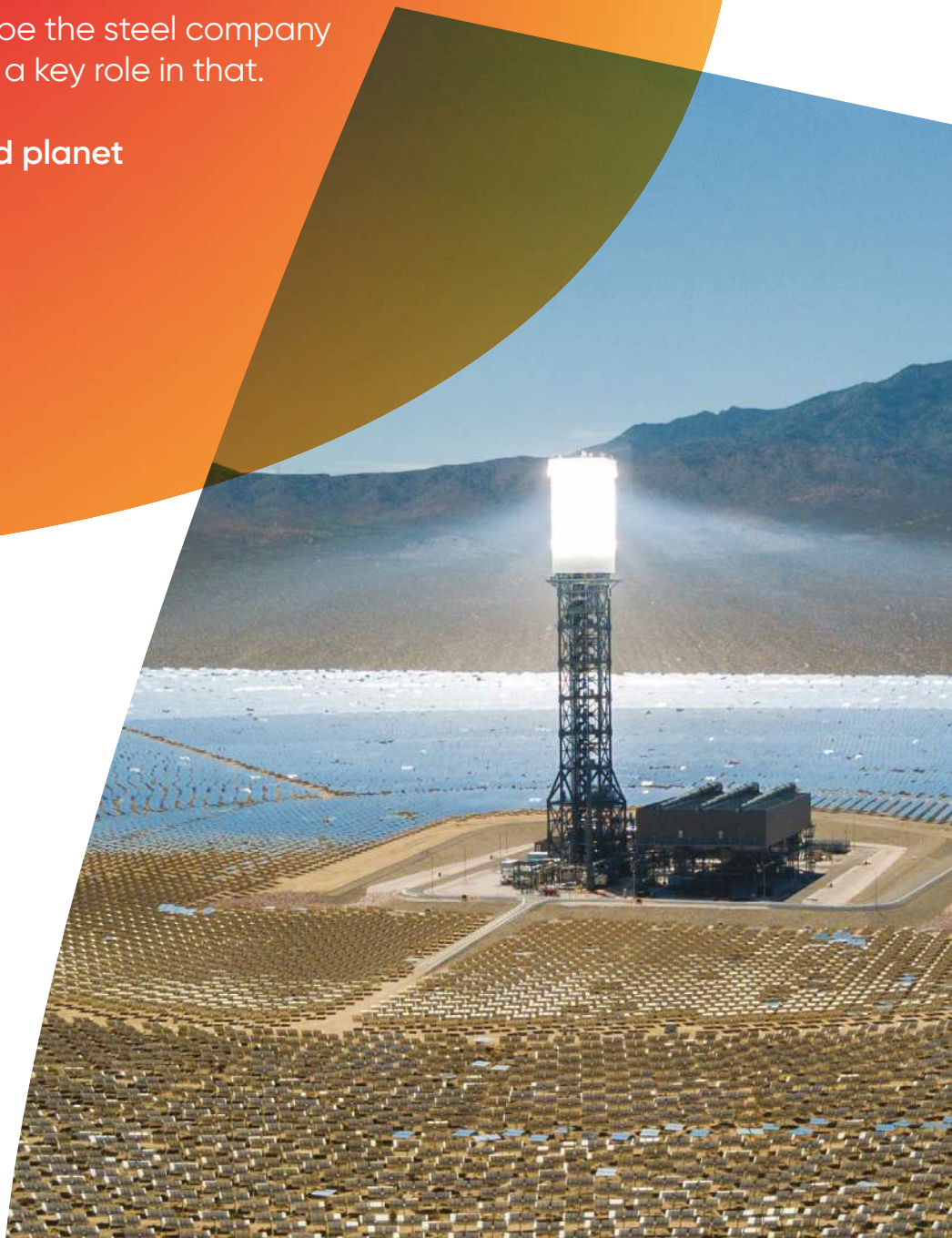
XCarb®

Towards net zero steel

XCarb® is ArcelorMittal's 'towards net zero steel' transformation programme. It brings together all of the company's reduced, low and zero-carbon steel products, processes and technologies, innovation projects, initiatives and alliances in one single-minded effort to make the changes needed to get our organisation and our industry to carbon neutrality by 2050.

ArcelorMittal's objective is to be the steel company of the future. XCarb® will play a key role in that.

Smarter steels for people and planet



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