September 30, 2025

International Institute of Building Enclosure Consultants (IIBEC)
24 Fayetteville St. Suite 2400
Raleigh, North Carolina
27601, US

Hello:

Subject: **IIBEC – 2026 EBEC Awards - Roofing Supporting Documents**

Please refer to attached supporting documentation for WSP’s 2026 EBEC submission under the roofing category. A list of supporting documents can be found below:

- Client Testimonial from Oxford Properties Group
- IIBEC Interface and BSAO PTE article submitted for the 2025 December – Sustainability Issue, issued to share our results with other IIBEC members.
- Published Article on WSP’s Insights page
- Sample images of Roof System Embodied Carbon Calculator created by WSP
- Photo Appendix of Roofing recovery project in progress
- Embodied Carbon Study Report for 255 Chrysler by WSP
- Industry Accolades for WSP Roof Recovery Projects

Yours sincerely,

Milirsan Pugalendiran, P.Eng., RRO
Project Manager/Building Envelope Engineer

APPENDIX

CLIENT TESTIMONIAL

CLIENT TESTIMONIAL

"Opting for roof recovery allowed us to achieve significant cost savings and minimize tenant disruption, while reducing construction waste. It's a practical, future-ready approach to asset management."

Donny Baldassarra
Senior Property Manager - Industrial, of Oxford Properties Group

APPENDIX

IIBEC INTERFACE & BSAO PTE TECHNICAL ARTICLE SUBMISSION

July 12, 2025

International Institute of Building Enclosure Consultants (IIBEC)
24 Fayetteville St. Suite 2400
Raleigh, North Carolina
27601, US

Hello:

Subject: **IIBEC Interface**
December 2025 – Sustainability, Peer Review Submission

We are pleased to submit this article for Peer Review. We believe it will a great addition to the **December 2025 - Sustainability** Interface issue.

The article '*Advancing Sustainable Roof Restoration: Enhancing Roof Recovery with Embodied Carbon Analysis and Innovative Material Choices*' advocates for roof recovery over full replacement as a sustainable and economically beneficial strategy for existing industrial and warehousing buildings.

WSP's approach integrates detailed embodied carbon calculations and optimized material selection. A case study on a large industrial warehouse roof demonstrated significant environmental and financial benefits: up to 61% reduction in full lifecycle embodied carbon emissions and 4,200 tonnes of waste diverted, compared to traditional replacement. Unexpected cost savings of 25-26% were also realized due to economies of scale and labor efficiencies from using larger dimension, lower embodied carbon materials like gypsum board and base sheet membrane panels. The article emphasizes that sustainable design can deliver environmental benefits without increasing project costs, and highlights industry recognition for this innovative approach.

If you have any questions or concerns, please feel free to contact us and we will be happy to provide additional clarification.

Yours sincerely,

Milirsan Pugalendiran, P.Eng.
Project Manager/Building Envelope Engineer

Michelle Christopherson, Dip.T., ENV SP
Practice Lead - Embodied Carbon

Advancing Sustainable Roof Restoration: Enhancing Roof Recovery with Embodied Carbon Analysis and Innovative Material Choices

While the building industry's carbon discourse has increasingly focused on new construction, a significant opportunity lies quietly in the vast inventory of existing buildings. Roof recovery—which focuses on membrane replacement rather than full-system tear-off and replacement —is a well-established strategy for extending roof life and reducing waste. WSP aimed to take this approach further by integrating detailed embodied carbon calculations and optimizing material selection to maximize environmental and economic benefits.

Large-scale industrial/warehousing buildings were prime candidates to explore optimized roof recovery strategies. These roof-centric assets have long lifespans but relatively short roof cycles, with renewals required roughly every 20 years (dependent on the membrane system). Traditional practices often default to full roof replacement, resulting in disposal of large volumes of otherwise serviceable insulation and coverboard materials, and the associated emissions and landfill impact. WSP's enhanced recovery methodology challenges this assumption by focusing on membrane renewal and selective replacement, supported by condition assessments and life cycle embodied carbon analysis.

What makes this approach both technically robust and replicable is its reliance on conventional materials and assemblies, ensuring contractor familiarity, competitive bidding, and long-term membrane performance. Beyond sustainability, this approach also aligns with owners' financial and operational goals. Restoration projects yield construction cost savings of 20–25% and schedule reductions of up to 50 weeks, often with minimal disruption to continuous building operations—a crucial consideration in 24/7 industrial environments.

Existing Industrial Building BUR Roof System

The process begins with a comprehensive feasibility study, including drone infrared thermography scan, targeted test cuts, and on-site moisture meter readings. These diagnostics determine the salvageability of concealed components, allowing WSP to identify saturated or deteriorated areas for localized replacement. Where insulation and substrate remain largely intact, existing components are retained, and a new membrane (i.e. 2-ply modified bitumen membrane) is installed.

Key engineering concerns are carefully managed. Air and vapour barrier discontinuities are addressed through localized detailing at penetrations, perimeters, and expansion joints. Furthermore, engineering judgment is crucial in determining appropriate fastener and adhesive spacing for wind uplift as these systems will incorporate both old & new roof component with an assembly composition that may not match tested systems. Fastener length and underdeck conduit mapping is specified to avoid contact with conduits beneath steel decks—a critical consideration in active industrial environments. Where moisture-damaged insulation is found, underlying steel decks are inspected and treated or repaired as necessary.

Existing BUR membrane removed and localized 'wet' insulation being replaced

The environmental benefits are quantifiable. At one of WSP's roof recovery projects, a building with 800,000 sq.ft of roof area achieved an estimated 310 tons of CO_2-equivalent savings and diverted approximately 400 tons of material from landfill, over a 60-year study period. WSP has completed a total of approximately 2.1 million sq.ft of roof recovery projects to date, with each project executed under this enhanced recovery model demonstrating embodied carbon reductions of 28% or more compared to full replacements. Based on extrapolation, we estimate our roof recovery projects have saved over 1,800 tons of carbon emissions and diverted nearly 2,000 tons of waste.

New Roof Recovery system installed

Case Study: Quantifying Impact on a Large Industrial Warehouse

To further validate and refine these principles, WSP undertook a comprehensive embodied carbon study for a significant project: a large, one-storey industrial warehouse facility with approximately 1,076,000 sq. ft. roof area. The existing conventional Built-Up Roof (BUR) system was at its end-of-service life. The cradle-to-grave embodied carbon assessment aligned with the NRC's National Whole-Building Life Cycle Assessment Practitioner's Guide and primarily leveraged product-specific Environmental Product Declarations (EPDs). The study evaluated three distinct roofing restoration scenarios over a 60-year study period:

- **Scenario 1: Roof Replacement (Baseline):** This represented a typical full roof system replacement with a new 2-ply modified bitumen system, including new insulation and air/vapor barrier. This scenario assumed two additional full replacements over the 60-year study period.
- **Scenario 2: Roof Recovery/Renewal:** This involved removing only the existing multi-ply membrane while retaining the existing overlay fibreboard, insulation, and vapor retarder. The existing membrane is to be removed and replaced with a 2-ply modified bitumen membrane and two (2) new 0.25" asphaltic overlay boards – the first layer mechanical fastened to separate the new & old system and the second adhered to reduce risks with fastener backout below the membrane. Crucially, this scenario incorporated a "resurfacing" strategy for subsequent roof renewal cycles, where only a 1-ply cap sheet membrane would be installed, with no further material removal, significantly reducing future impacts. One initial recovery and two resurfacings were assumer over 60 years.
- **Scenario 3: Roof Recovery/Renewal 'V.2' (Embodied Carbon Optimized):** Similar to Scenario 2 in its recovery approach, this scenario specifically selected lower embodied carbon materials. Instead of two layers of asphaltic board, it specified a base sheet membrane panel (a membrane laminated onto an asphaltic board) and a 0.25" gypsum overlay board. This scenario also assumed one initial recovery with optimized materials and two subsequent resurfacings over 60 years.

The results from this large industrial warehouse study provided powerful validation:

Embodied Carbon and Waste Reduction: Compared to the baseline full roof replacement (Scenario 1), the roof recovery options demonstrated significant embodied carbon savings (also see table 1):

- **Upfront (Initial Restoration) Carbon Savings:**
  - Scenario 2 (Roof Recovery/Renewal): Approximately **7%** reduction in embodied carbon (from ~2,020,000 kg CO_2 eq to ~1,880,000 kg CO_2 eq). Notably, the study revealed that these initial savings were not as high as initially expected, primarily due to the relatively high embodied carbon content of the multiple asphaltic overlay boards.
  - Scenario 3 (Optimized Roof Recovery/Renewal V.2): A substantial **24%** reduction in upfront embodied carbon (to ~1,520,000 kg CO_2 eq). Most of the upfront embodied carbon savings (~90%) was from the base sheet panel.
- **Full Life Cycle (60-year study period) Carbon Savings:**
  - Scenario 2 achieved a remarkable **55%** reduction in embodied carbon (from ~6,060,000 kg CO_2 eq to ~2,720,000 kg CO_2 eq).
  - Scenario 3, with its optimized material choices, delivered an even greater **61%** reduction (to ~2,360,000 kg CO_2 eq). This was largely driven by the "resurfacing" strategy for future cycles, which resulted in a **75%** embodied carbon intensity reduction compared to repeated full replacements.
- **Avoided Waste:** Both recovery scenarios (2 and 3) diverted approximately **480 tonnes** of upfront construction waste from landfills. Over the full 60-year lifecycle, this figure soared to an estimated **4,200 tonnes** of waste diverted.

Table 1: Embodied Carbon Emissions Results			
	ROOF REPLACEMENT (Baseline)	ROOF RECOVERY/RENEWAL	ROOF RECOVERY/RENEWAL V.2
Upfront Embodied Carbon Emissions (LCA Stages A1-A5)			
Embodied Carbon Intensity (~kg CO_2 eq/m²)	**20.5**	**19**	**15.5**
Embodied Carbon (~kg CO_2 eq)	**~2,020,000**	**~1,880,000**	**~1,520,000**
Embodied Carbon Savings compared to Roof Replacement (~%)	**N/A**	**7%**	**24%**
Full Life Cycle Embodied Carbon Emissions (Life Cycle Stages A-C)			
Embodied Carbon Intensity (~kg CO_2 eq/m²)	**61**	**27.5**	**24**
Embodied Carbon (~kg CO_2 eq)	**~6,060,000**	**~2,720,000**	**~2,360,000**
Embodied Carbon Savings compared to Roof Replacement (~%)	**N/A**	**55%**	**61%**

Embodied Carbon calculation Summary

Unexpected Cost Savings: Taking these principles further, WSP applied embodied carbon optimization on a large industrial warehouse roof by developing an alternate design that prioritized lower embodied carbon materials with Environmental Product Declarations (EPDs). Instead of the typical two layers of asphaltic board, the design specified a base sheet panel—a membrane laminated onto an asphaltic board—for the first layer, and roof grade gypsum board replacing the second asphaltic board layer. The base sheet panel and gypsum board both have a higher material cost compared to their base sheet membrane and asphaltic board counterparts.

The low embodied carbon design was tendered to six (6) contractors across three (3) warehouse buildings, including the building reviewed for the aforementioned embodied carbon calculations. Contrary to the initial expectation that these lower embodied carbon materials might increase direct material costs, contractor bids collectively reflected significant project cost savings compared to the base design. Tender results of the project are summarized below:

- **Scenario 2 (Roof Recovery/Renewal):** Achieved approximately **22-24%** project cost savings compared to full replacement.
- **Scenario 3 (Optimized Roof Recovery/Renewal V.2):** Delivered even greater savings, ranging from **25-26%**,

Table 2: Tender Results Summary

	Building No. 1	*Building No. 2*	*Building No. 3*
Roof Area (sq.ft)	420,000	546,000	1,076,000
Roof Recovery Project Cost Savings compared to Roof Replacement (~%)	22%	22.7%	22%
Roof Recovery V.2 Project Cost Savings compared to Roof Replacement (~%)	24%	23.2	25%

Discussions with contractors provided key insights into these unexpected overall savings passed to the client:

- **Economies of Scale:** The vast roof area enabled contractors to secure more competitive pricing from manufacturers and suppliers due to large material quantities.
- **Material Dimensions and Labour Efficiency:** The larger dimensions of the base sheet membrane panels (3'x8') and gypsum boards (4'x8') compared to standard 4'x5' asphaltic overlay boards significantly reduced labor time, especially on a largely unobstructed roof with a low number of penetrations. This enhanced labour efficiency proved to be the primary factor contributing to the reduced total project cost, effectively offsetting any higher per-unit material costs.

The Tender results highlight the importance of considering both material AND labour cost when making material substitution related to embodied carbon and/or other reasons. Substitutions, for lower embodied carbon results, may result in a material cost increase however there may be labour cost savings that are not being recognized.

Industry Recognition

The leadership demonstrated by this enhanced recovery approach have garnered significant industry recognition. WSP's work on roof recovery/renewal projects has received accolades, including:

- **Carbon Leadership Forum (Toronto Chapter):** Honorable Mentions (2nd Place) at the 2024 Embodied Carbon Awards
- **Professional Engineers Ontario (York Chapter):** Finalist (Top 3) for the 2025 Engineering Project of the Year

Honorable Mentions at the 2024 Embodied Carbon Awards (Toronto Chapter)

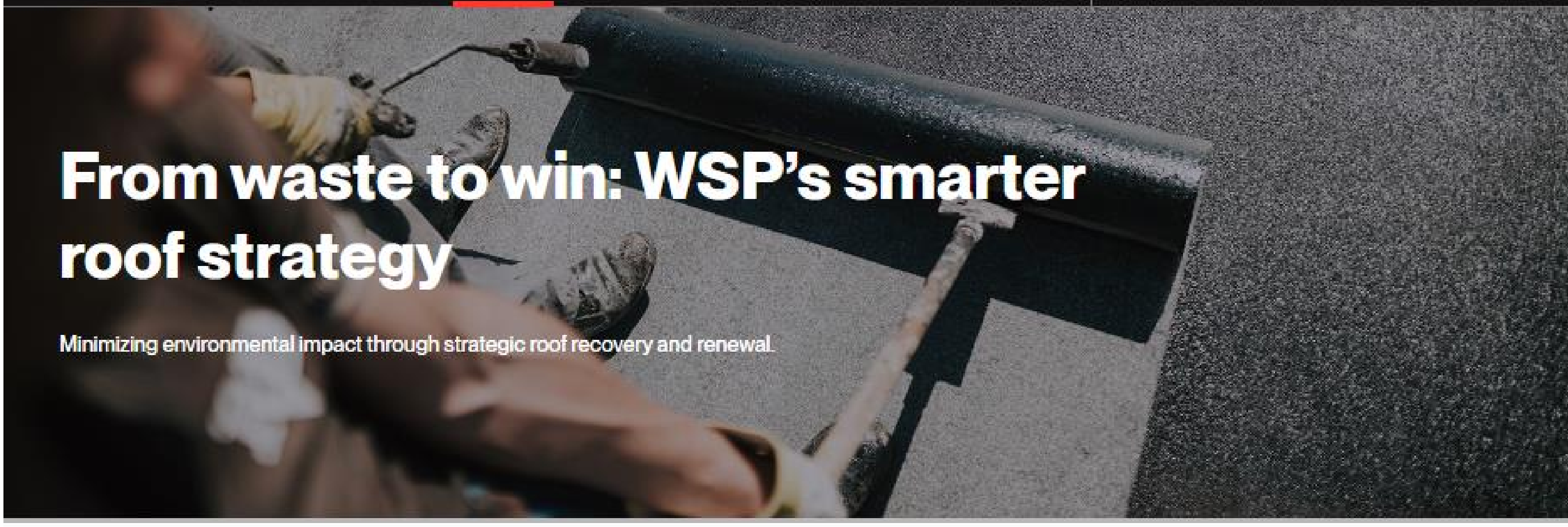
This experience underscores that embedding sustainability objectives into design and procurement can deliver environmental benefits without increasing total project costs. It challenges the perception that lower embodied carbon materials necessarily entail premium pricing, reaffirming roof recovery as a practical and impactful strategy for embodied carbon reduction.

The case for roof renewal is well-established and growing. WSP's enhancements show that embodied carbon savings in retrofit can rival those promoted in new construction. As policy focus eventually shifts towards existing buildings, strategies like these will be central to meeting carbon targets. The industry would do well to recognize that improving and restoring existing roofs offers one of the most meaningful opportunities for sustainable progress.

APPENDIX

PUBLISHED ARTICLE ON WSP INSIGHT PAGE

Hyperlink: https://www.wsp.com/en-ca/insights/ca-from-waste-to-win



From waste to win: WSP's smarter roof strategy

Minimizing environmental impact through strategic roof recovery and renewal.

Canada | July 3, 2025

Roofs are often overlooked - until they fail. Roof performance is crucial to building longevity in the face of climate change, aging infrastructure, and rising operational costs. Frequently replaced in full at the end of their service life, roof replacement represents a significant source of embodied carbon, and is also costly and disruptive. That's where WSP's approach to roof recovery and renewal provides an intelligent solution.

Sustainability meets strategy

WSP's roof recovery and renewal services are a crucial step toward achieving net-zero targets, reducing environmental footprints, and future-proofing property portfolios, paving the way for a more sustainable and cost-effective future. Our strategy combines technical assessments with sustainability-focused design to transform routine maintenance into a strategic opportunity to save money and promote climate action.

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Big roofs. Big opportunity for change

Oxford Properties Group, a leading global real estate investor, developer and manager, and one of Canada's largest commercial real estate owners, was confronted with a common yet complex challenge: large industrial properties with aging roofs. The roof systems of these buildings were nearing the end of their expected service lives. For owners and property managers, roof systems must be more than just watertight; they must also deliver long-term value, reduce maintenance burdens, and help achieve sustainability goals.

Five of Oxford's industrial buildings (~2.1 million square feet) located at Royal Group Crescent in Vaughan, Ontario have already undergone roof recovery; one is currently in progress (~1.2 million square feet), and two additional building roofs (~1 million square feet) will be completed over the next few years. Replacing these roofs entirely would incur significant financial and environmental costs and increase the risk of tenant disruption. Replacing the existing roofs also generates substantial embodied carbon due to demolition, waste transport, disposal, and manufacturing new materials.

Oxford sought a solution to preserve asset value, meet performance requirements, minimize tenant disruption, and align with its climate goals. They turned to WSP to explore a path forward.

"Opting for roof recovery allowed us to achieve significant cost savings and minimize tenant disruption, while reducing construction waste. It's a practical, future-ready approach to asset management."

Donny Baldassarra
Senior Property Manager - Industrial, of Oxford Properties Group

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Recover, renew, reduce

WSP applied a sustainability-first lens to Oxford's roof recovery and renewal strategy, positioning roof systems as an opportunity to reduce carbon, conserve resources, and support long-term resilience.

"Roof systems are often overlooked in sustainability discussions, but this project demonstrates how our roof recovery process supports decarbonization. At WSP, we're helping clients make smart, sustainable decisions, one building at a time."

Milirsan Pugalendiran
Project Manager, WSP in Canada

Low-carbon recovery solutions

We first conducted detailed assessments of Oxford's buildings to evaluate the existing roof conditions, identify failure risks, and determine whether systems could be renewed rather than replaced. This allowed us to prioritize recovery strategies that avoided unnecessary tear-offs and minimized material use and disposal requirements.

We chose roof recovery assemblies that reused air and vapour barriers, insulation, and overlay boards, minimizing the need for new materials. We also enhanced details at transitions and penetrations to improve building efficiency and roof performance. This approach reduced demolition waste and the carbon emissions from transporting and manufacturing replacements. It also helped manage the project budget by lowering disposal costs and minimizing the need for new materials.

Recognitions: This design approach has earned WSP the following accolades:

- Finalist (Top 3) at the **2024 Professional Engineers Ontario (York Chapter) Engineering Project of the Year Awards**
- Honorable Mentions (2nd Place) at the **2024 Ontario Embodied Carbon Awards** presented by the Carbon Leadership Forum Toronto Chapter

Smart materials designed for the future

To support Oxford's long-term environmental objectives, WSP prioritized durable materials with low-carbon profiles, and a focus on proven performance. The chosen two-ply membrane system is durable, weather-resistant, and capable of supporting a resurfacing or overlaying strategy that can extend overall performance for decades. This membrane system offers a cost-effective and sustainable flexible approach.

Environmental impact meets implementation

WSP managed the project's technical design and procurement processes and provided construction support. This approach achieved real environmental savings by reducing waste generation, limiting emissions from material manufacturing, and conserving the embodied carbon in the existing roof systems.

The two most recently completed projects for Oxford Properties realized the following savings:

600 tons of waste avoided

Approximately 600 tons of waste avoided from being sent to landfill.

500 tons of CO_2e

Embodied carbon emissions reduced by 500 tons of CO_2e,

$7M cost savings

Cost savings of ~$7 million compared to full roof replacement.

We are currently working with Oxford Properties Group to develop a roof recovery approach for the remainder of their portfolio, including ways to achieve additional waste, embodied carbon, and cost savings.

Canada has approximately 1.85 trillion square feet of industrial and logistic space. Interpolating our results and assuming an average roof replacement schedule of 20 years can result in ~7,500M tonnes CO_2e savings.

Rethinking sustainability begins overhead

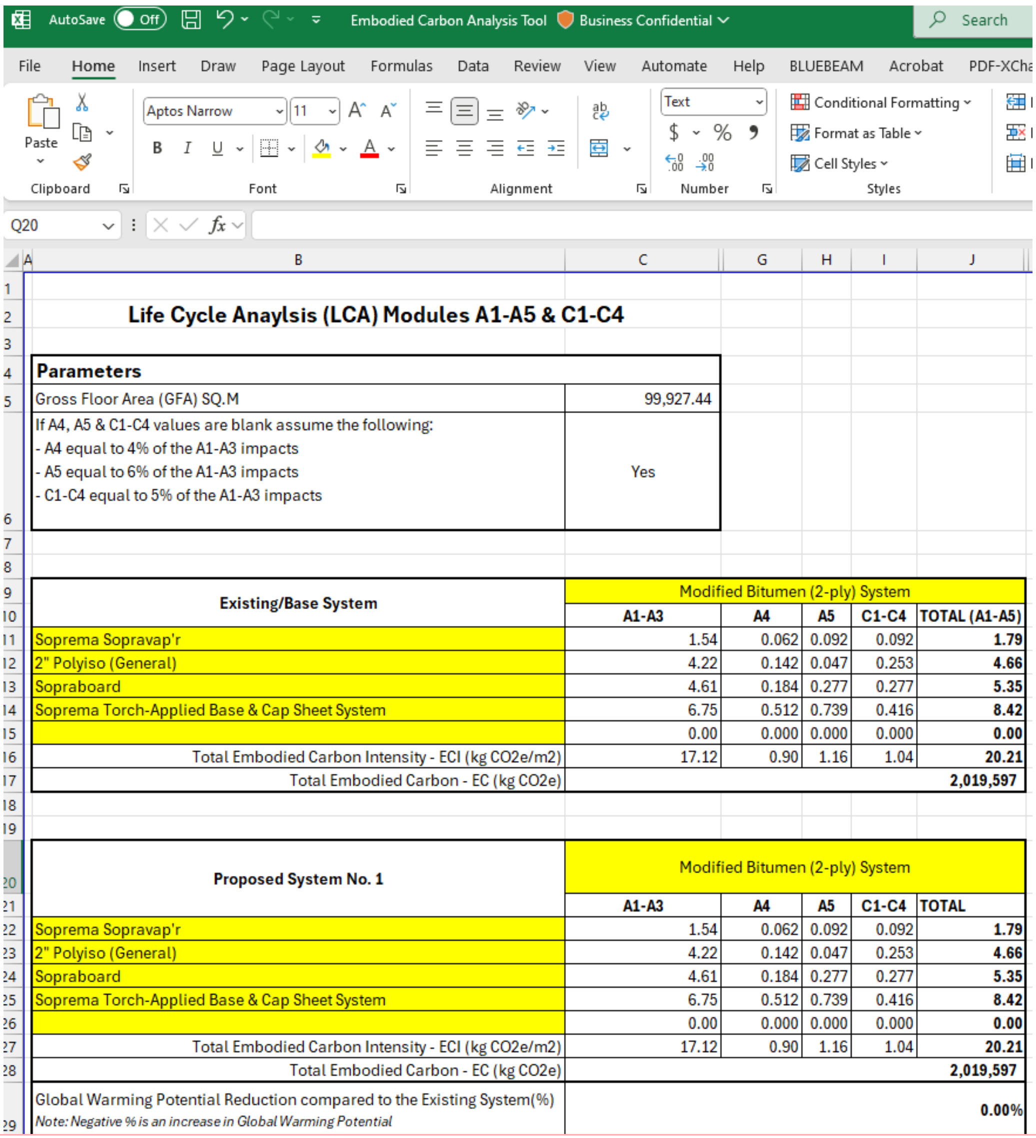
Roofs are not static entities; they must be maintained and eventually replaced, and the waste, embodied carbon, and cost of this work are unavoidable. Using roof recovery instead of roof replacement, WSP helped Oxford Properties extend the lifespan of their buildings and reduce embodied carbon, environmental impact, and project costs.

APPENDIX

SAMPLE IMAGES OF ROOF SYSTEM EMBODIED CARBON CALCULATOR

SAMPLE IMAGES

Photo	Description



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Q20

Life Cycle Anaylsis (LCA) Modules A1-A5 & C1-C4

Parameters	
Gross Floor Area (GFA) SQ.M	99,927.44
If A4, A5 & C1-C4 values are blank assume the following: - A4 equal to 4% of the A1-A3 impacts - A5 equal to 6% of the A1-A3 impacts - C1-C4 equal to 5% of the A1-A3 impacts	Yes

Existing/Base System	Modified Bitumen (2-ply) System				
	A1-A3	A4	A5	C1-C4	TOTAL (A1-A5)
Soprema Sopravap'r	1.54	0.062	0.092	0.092	1.79
2" Polyiso (General)	4.22	0.142	0.047	0.253	4.66
Sopraboard	4.61	0.184	0.277	0.277	5.35
Soprema Torch-Applied Base & Cap Sheet System	6.75	0.512	0.739	0.416	8.42
	0.00	0.000	0.000	0.000	0.00
Total Embodied Carbon Intensity - ECI (kg CO2e/m2)	17.12	0.90	1.16	1.04	20.21
Total Embodied Carbon - EC (kg CO2e)					2,019,597

Proposed System No. 1	Modified Bitumen (2-ply) System				
	A1-A3	A4	A5	C1-C4	TOTAL
Soprema Sopravap'r	1.54	0.062	0.092	0.092	1.79
2" Polyiso (General)	4.22	0.142	0.047	0.253	4.66
Sopraboard	4.61	0.184	0.277	0.277	5.35
Soprema Torch-Applied Base & Cap Sheet System	6.75	0.512	0.739	0.416	8.42
	0.00	0.000	0.000	0.000	0.00
Total Embodied Carbon Intensity - ECI (kg CO2e/m2)	17.12	0.90	1.16	1.04	20.21
Total Embodied Carbon - EC (kg CO2e)					2,019,597
Global Warming Potential Reduction compared to the Existing System(%) *Note: Negative % is an increase in Global Warming Potential*					0.00%

Photo 1:

Roof LCA calculator

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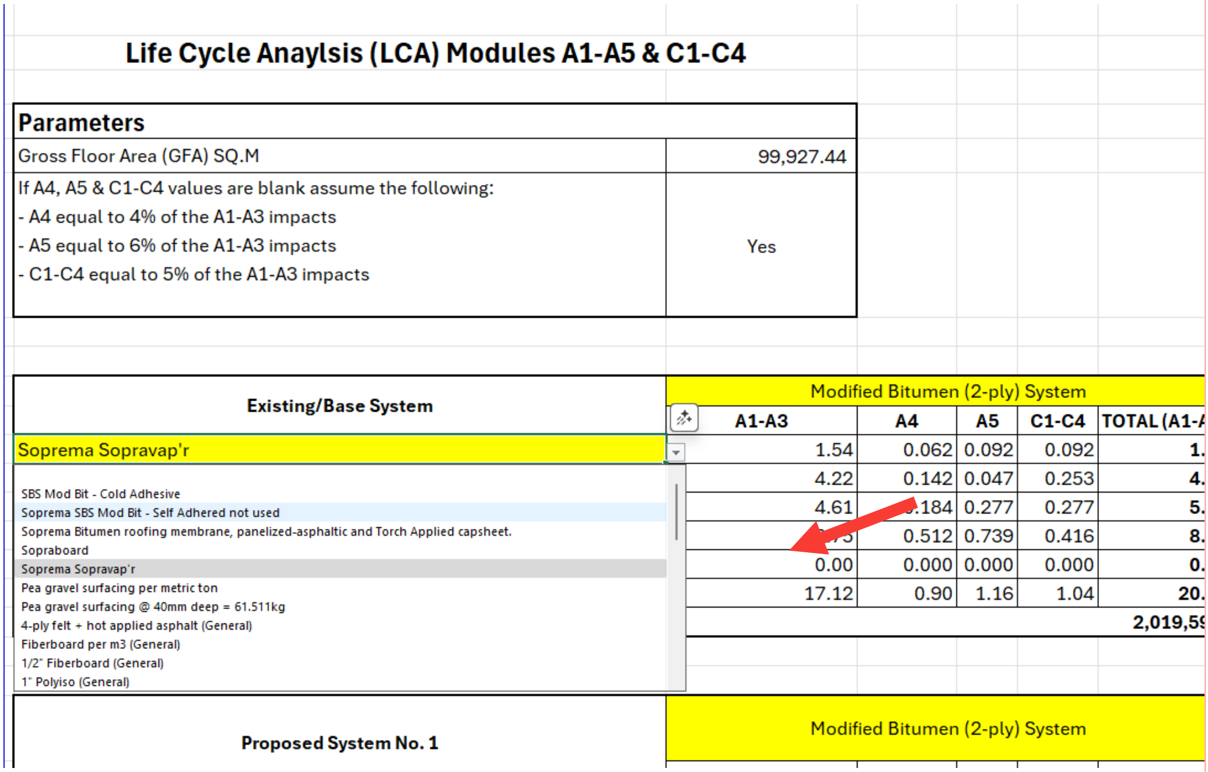
Photo	Description



Life Cycle Anaylsis (LCA) Modules A1-A5 & C1-C4

Parameters	
Gross Floor Area (GFA) SQ.M	99,927.44
If A4, A5 & C1-C4 values are blank assume the following: - A4 equal to 4% of the A1-A3 impacts - A5 equal to 6% of the A1-A3 impacts - C1-C4 equal to 5% of the A1-A3 impacts	Yes

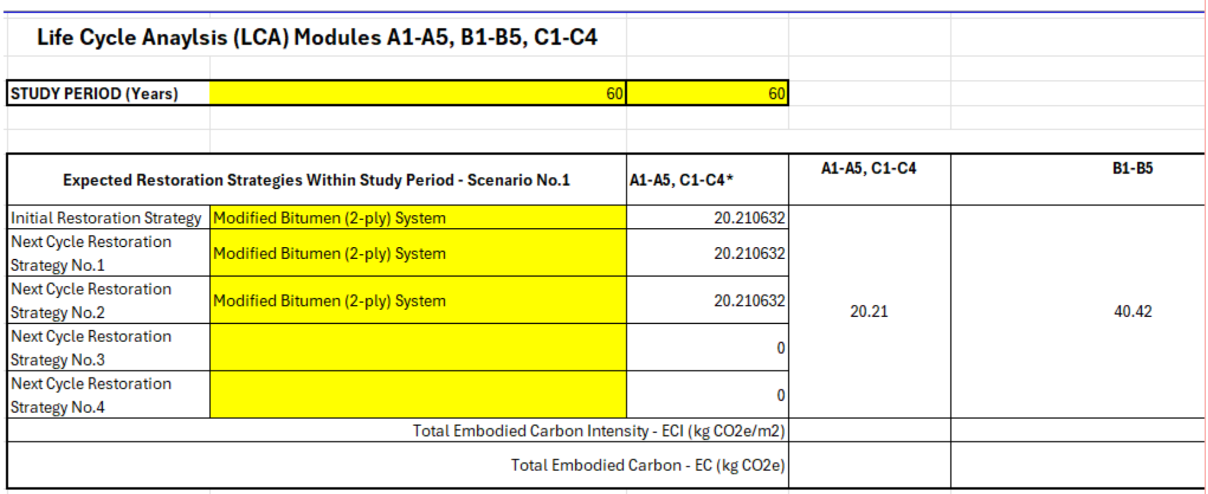
Existing/Base System	Modified Bitumen (2-ply) System				
	A1-A3	A4	A5	C1-C4	TOTAL (A1-A
Soprema Sopravap'r	1.54	0.062	0.092	0.092	1.
	4.22	0.142	0.047	0.253	4.
	4.61	.184	0.277	0.277	5.
		0.512	0.739	0.416	8.
	0.00	0.000	0.000	0.000	0.
	17.12	0.90	1.16	1.04	20.
					2,019,59

SBS Mod Bit - Cold Adhesive
Soprema SBS Mod Bit - Self Adhered not used
Soprema Bitumen roofing membrane, panelized-asphaltic and Torch Applied capsheet.
Sopraboard
Soprema Sopravap'r
Pea gravel surfacing per metric ton
Pea gravel surfacing @ 40mm deep = 61.511kg
4-ply felt + hot applied asphalt (General)
Fiberboard per m3 (General)
1/2" Fiberboard (General)
1" Polyiso (General)

Proposed System No. 1	Modified Bitumen (2-ply) System

Photo 2:

Have options to toggle and choose different roof components from various manufacturers to optimize embodied carbon intensity



Life Cycle Anaylsis (LCA) Modules A1-A5, B1-B5, C1-C4

STUDY PERIOD (Years)	60	60

Expected Restoration Strategies Within Study Period - Scenario No.1		A1-A5, C1-C4*	A1-A5, C1-C4	B1-B5
Initial Restoration Strategy	Modified Bitumen (2-ply) System	20.210632	20.21	40.42
Next Cycle Restoration Strategy No.1	Modified Bitumen (2-ply) System	20.210632		
Next Cycle Restoration Strategy No.2	Modified Bitumen (2-ply) System	20.210632		
Next Cycle Restoration Strategy No.3		0		
Next Cycle Restoration Strategy No.4		0		
Total Embodied Carbon Intensity - ECI (kg CO2e/m2)				
Total Embodied Carbon - EC (kg CO2e)				

Photo 3:

Calculates LCA across various modules and for multiple study periods

APPENDIX

PHOTO APPENDIX OF ROOF RECOVERY CONSTRUCTION PROJECT

SITE PHOTOGRAPHS

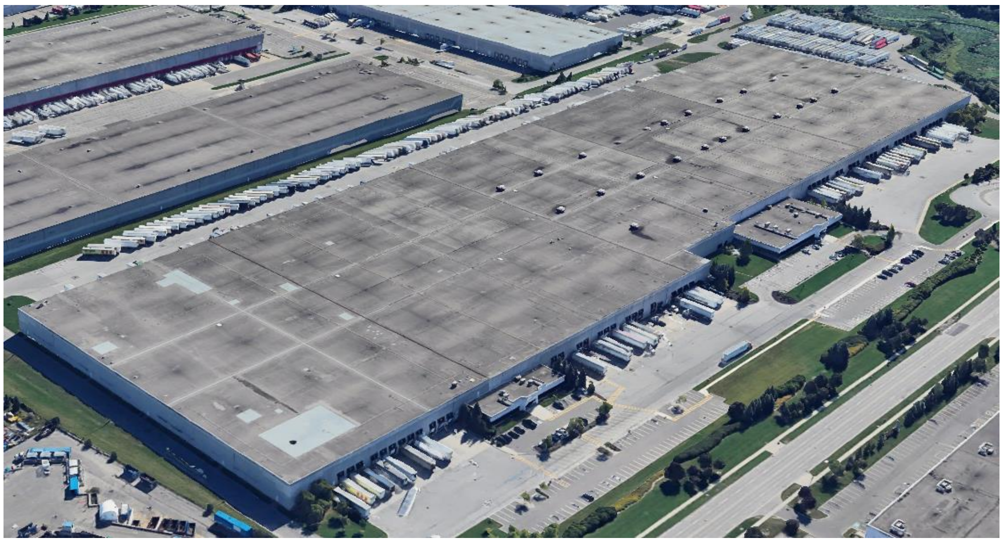
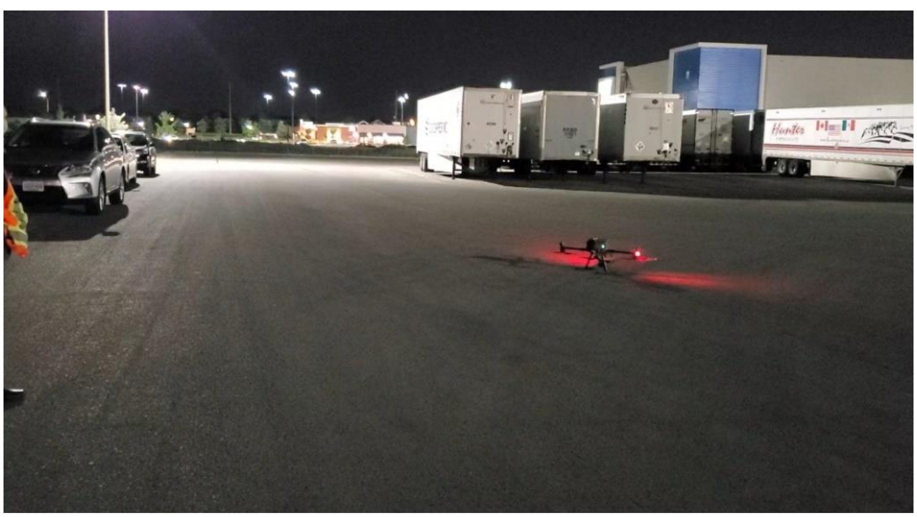
Photo	Description
	**Photo 1:** Project and Building Overview
	**Photo 2:** Aerial Drone used for Roof Infrared (IR) Thermography Scan

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Photo	Description
	**Photo 3:** Existing roofing system overview
	**Photo 4:** Existing roof membrane remove to expose remaining components of the existing roof system. These components will be salvaged.

Photo	Description
	**Photo 5:** Moisture testing thermal anomaly areas previously identified via roof IR scans.
	**Photo 6:** Full roof system replacement at existing wet roofing component areas were previously identified.

Photo	Description
	**Photo 7:** New coverboard installation
	**Photo 8:** New Composite Base Sheet Panel Installation.

Photo	Description
	**Photo 9:** New Cap sheet membrane installation

APPENDIX

EMBODIED CARBON STUDY REPORT

255 CHRYSLER DRIVE, BRAMPTON – ROOF RECOVERY/RENEWAL

EMBODIED CARBON STUDY

wsp

1 INTRODUCTION

WSP's scope involved completing an embodied carbon study for 255 Chrysler Road, Brampton managed by Oxford Properties Group. The building is a one-storey industrial warehouse facility with two single-storey office spaces.

The existing conventional BUR roofing system is at end-of-service life. The study involves the comparative evaluation of multiple roof replacement/recovery scenarios. The purpose of this study is to quantify the embodied carbon emissions associated with each scenario and understand which scenario would yield the lowest emissions as well as summarize approximate square footage costs ($/sq.ft) obtained from recent tender results. Additional calculations were prepared to study the potential to avoid waste as part of each scenario.

The building's main warehouse roof consists of a conventional built-up roof (BUR) system with the following components:

- Pea Gravel Surfacing
- Multi-ply Built-up Asphalt & Felt Membrane
- 0.5" Fiberboard
- 1.5" Polyisocyanurate Insulation
- Kraft Vapour Retarder

2 BOUNDARY

The lifecycle stages included in this study are from cradle-to-grave: upfront carbon (A1-A5), use stage (B1-B5), and end of life (C1-C4), where data is available. Operational (B6 & B7) and beyond lifecycle (D) carbon emissions are excluded from the study. Key project descriptors are summarized below.

Gross Floor Area (sq.ft)	1,075,610
# of Storey (Warehouse)	1
# of Storey (Office)	1
Occupancy Type	Industrial/Office
Study Period	60 years
Lifecycle Stages Assessed	Cradle-to-Grave (A-C Stages)
Components Assessed	Roofing

See Appendix A for a detailed description of the scope and boundary of the LCA model.

3 SCENARIOS

Three (3) roofing restoration scenarios were evaluated as part of this study. Scenario 1 serves as the baseline scenario representing typical roof replacement strategy completed by most Property Owners. Scenarios 2 and 3 explore roof recovery options designed by WSP, which aim to reduce construction costs, schedule, and embodied carbon emissions. Each scenario is described in more detail below.

1.1 SCENARIO 1: ROOF REPLACEMENT WITH A 2-PLY MODIFIED BITUMEN SYSTEM (BASELINE)

This scenario includes a typical full roof system replacement with a new 2-ply modified bitumen system, which is a common strategy for roofs which have reached their end-of-service life stage. This system closely matches the existing assembly in terms of performance and thermal resistance, and consists of the following components:

- 2-Ply Modified Bitumen Membrane
- 0.25" Asphaltic Overlay Board
- 1.5" Polyisocyanurate Insulation
- Self-Adhered Modified Bitumen Air/Vapour Barrier

The assumed service life is approximately 20 years so we have included for two (2) additional replacement cycles over the 60 year study period. Full roof replacement at end-of-service life is typically completed by Property Owners to renew their roofing system.

1.2 SCENARIO 2: ROOF RECOVERY/RENEWAL

This scenario incorporates a roof recovery strategy that maintains some of the existing roof components. Specifically, we've included removal of the existing multi-ply membrane, but leaving the existing overlay board, insulation and vapour retarder materials in place. Localized areas of 'wet' insulation may need to be replaced however we have excluded this scope from our calculations to maintain consistency across all scenarios. Roofing performance and thermal resistance is comparable to full replacement. The roof system consists of the following:

- 2-Ply Modified Bitumen Membrane (New)
- 0.25" Asphaltic Overlay Board (New)
- 0.25" Asphaltic Overlay Board (New)
- 0.5" Fiberboard (Existing)
- 1.5" Polyisocyanurate Insulation (Existing)
- Kraft Vapour Retarder (Existing)

2-ply modified bitumen systems also have the option for 'resurfacing' during the subsequent roof restoration cycles. Resurfacing involves installation a 1-ply cap sheet membrane over top all existing components with no removal of existing materials. Following the objective of exploring low-embodied carbon solution, this scenario assumes one (1) initial roof recovery/renewal and two (2) roof resurfacings over the 60 year study period.

1.3 SCENARIO 3: ROOF RECOVERY/RENEWAL 'V.2'

This Scenario is similar to Scenario 2 and incorporates an overlay board, insulation and vapour retarder salvaging strategy. However, this scenario incorporates roofing materials selected to reduce embodied carbon, while maintaining comparable roofing performance and thermal resistance. More specifically, in lieu of an asphaltic overlay board and base sheet membrane, a gypsum overlay board and base sheet membrane panel are specified. The base sheet membrane panel consists of a factory laminated base sheet membrane onto an asphaltic overlay board. The roof system consists of the following:

- 1-Ply Modified Bitumen Cap Sheet Membrane (New)
- Base Sheet Membrane Panel composed of asphaltic overlay board (New)
- 0.25" Gypsum Overlay Board (New)
- 0.5" Fiberboard (Existing)
- 1.5" Polyisocyanurate Insulation (Existing)
- Kraft Vapour Retarder (Existing)

As with Scenario 2, this scenario assumes one (1) initial roof recovery/renewal with embodied carbon material selection and two (2) roof resurfacings over the 60 year study period.

4 METHODOLOGY

The LCA was prepared in alignment with the NRC's National Whole-Building Life Cycle Assessment Practitioner's Guide. Embodied carbon data was mainly sourced from product-specific Environmental Product Declarations (EPDs), where available. In the absence of product-specific EPDs, industry average EPDs were used. Refer to Appendix B for detailed data inputs for the project materials.

1. WSP developed an embodied carbon model for all scenarios using the following steps:
2. Obtain material quantities, based off roof areas

3. Conduct the analysis using WSP's Embodied Carbon Tool. The tool calculates embodied carbon for a roofing system based on the roof composition, manufacturer EPD data, and expected service life.
4. Generate the results

5 EMBODIED CARBON ANALYSIS RESULTS

1.4 EMBODIED CARBON EMISION & AVOIDED WASTE RESULTS

A summary of the embodied carbon assessment results is presented in the tables & figures below.

Table 1 summarizes the total embodied carbon and the embodied carbon intensity (embodied carbon emission normalized over the GFA) for each scenario. The Upfront Embodied Carbon Emission summarizes results for the initial roof restoration and the Full Life Cycle Embodied Carbon Emissions summarizes results over the total 60 year study period. The results demonstrate that both the total embodied carbon and the embodied carbon intensity is significantly lower for the Roof Recovery scenarios.

Table 1: Embodied Carbon Emissions Results

	ROOF REPLACEMENT (Baseline)	ROOF RECOVERY/RENEWAL	ROOF RECOVERY/RENEWAL V.2
Upfront Embodied Carbon Emissions (LCA Stages A1-A5)			
Embodied Carbon Intensity (~kg CO_2 eq/m²)	**20.5**	**19**	**15.5**
Embodied Carbon (~kg CO_2 eq)	**~2,020,000**	**~1,880,000**	**~1,520,000**
Embodied Carbon Savings compared to Roof Replacement (~%)	**N/A**	**7%**	**24%**
Full Life Cycle Embodied Carbon Emissions (Life Cycle Stages A-C)			
Embodied Carbon Intensity (~kg CO_2 eq/m²)	**61**	**27.5**	**24**
Embodied Carbon (~kg CO_2 eq)	**~6,060,000**	**~2,720,000**	**~2,360,000**
Embodied Carbon Savings compared to Roof Replacement (~%)	**N/A**	**55%**	**61%**

Figure 2 below summarized embodied carbon contribution by building life cycle stage.

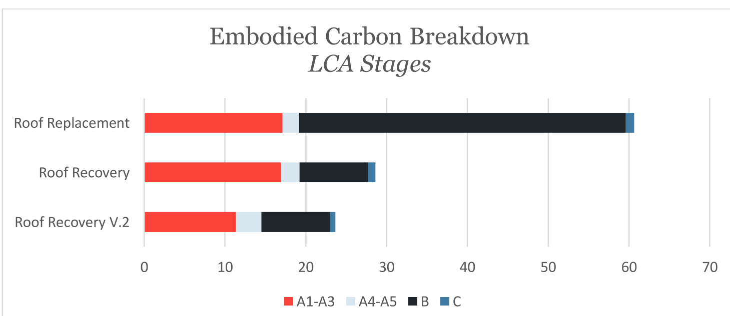


Figure 2. Life Cycle Stages Contribution Breakdown

Figure 3 summarizes the results by roof material type.

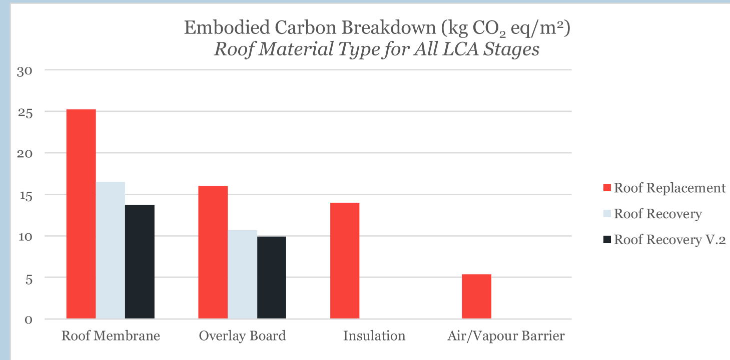


Figure 3. Material Type Contributions to Embodied Carbon

Table 2 summarizes the potential for the project to avoid construction waste with the Roof Recovery scenarios, achieved through salvaging existing materials, as compared to *Scenario 1 - Full Roof Replacement*

Table 2: Avoided Waste

	ROOF REPLACEMENT	ROOF RECOVERY/RENEWAL	ROOF RECOVERY/RENEWAL V.2
Upfront Avoided Waste (LCA Stages A1-A5)			
Waste Diverted compared to Roof Replacement (~Tonnes)	**N/A**	**480**	**480**
Full Life Cycle Avoided Waste (Life Cycle Stages A-C)			
Waste Diverted compared to Roof Replacement (~Tonnes)	**N/A**	**4200**	**4200**

1.5 COST ANAYLSIS & TENDER RESULTS

Bid documents and Specification were prepared by WSP and each scenario was tendered to a group six (6) of roofing contractors in January 2025. Table 3 summarizes the averaged tender results for the lowest three (3) bidders (see attached key plan for phases):

Table 3: Average Tender Results for Lowest 3 Biddgers

	ROOF REPLACEMENT	*ROOF RECOVERY/RENEWAL*	*ROOF RECOVERY/RENEWAL V.2*
	PHASE 1		
Cost per Square Foot (~$/ft)	[redacted]		
Project Cost Savings compared to Roof Replacement			
Project Cost Savings compared to Roof Replacement (~%)	N/A	22%	25%
	PHASE 2		
Cost per Square Foot (~$/ft)	[redacted]		
Project Cost Savings compared to Roof Replacement			
Project Cost Savings compared to Roof Replacement (~%)	N/A	24%	26%

6 KEY FINDINGS

The key findings from the assessment are as follows:

1.6 ROOF RECOVERY CUTS UPFRONT AND LIFE CYCLE EMBODIED CARBON EMISSIONS

Roof recovery scenarios 2 & 3 have lower embodied carbon emissions compared to a typical roof replacement. Scenario 3 had significant upfront carbon emissions savings (24%) however Scenario 2 had lower then expected embodied carbon savings (~7%) compared to full replacement. This was due to the use of multiple asphaltic boards in keeping with standard industry practice, which was found to be a significant contributor to overall embodied carbon emissions.

The most significant embodied carbon savings were noted for *Full Life Cycle Embodied Carbon Emission*s. This is due to the 'resurfacing' strategy which resulted in a 75% embodied carbon intensity reduction, compared to roof replacement, for future roof restoration cycles.

With the extensive roof area, even modest reductions in embodied carbon intensity can lead to substantial overall carbon savings. For instance, in Scenario 3, substituting gypsum overlay board for asphaltic overlay board achieves only a 4% reduction in embodied carbon intensity, yet results in an estimated emissions savings of approximately 75,200 kg CO_2e.

1.7 COST SAVINGS ARE SIGNIFICANT WITH ROOF RECOVERY

The roof recovery scenarios 2 & 3 demonstrate cost savings compared to scenario 1, which aligns with expectations when salvaging existing roofing materials.

Although Roof Recovery V.2 has an expected 10–20% higher roof material cost compared to the base Roof Recovery option — primarily due to the use of gypsum board and base sheet membrane panels — the tender results indicate that Roof Recovery V.2 offers a lower total project cost. [redacted]

[redacted]

1.8 SIGNIFICANT AVOIDED WASTE WITH ROOF RECOVERIES

Roof recoveries help prevent significant waste—approximately 480 tonnes—thanks to the salvaging approach. When considering the full lifecycle impact of the resurfacing method, the waste reduction is even greater, with an estimated 4,200 tonnes avoided, paralleling the savings seen in embodied carbon.

7 CONCLUSIONS

The results demonstrate the opportunity to significantly reduce embodied carbon with Roof Recovery scenarios as well as reduce overall project costs. Roof Recovery V.2 demonstrates that selecting lower embodied carbon roof materials also does not necessarily result in higher project costs. Though these results may not be replicated for all roof systems and configurations, it should be explored for each roof restoration project.

8 RECOMMENDATIONS

Based on the results of the study, we have summarized our recommendation as follows:

[redacted]

1.10 ROOF RESTORATION & NEW CONSTRUCTION PROJECTS

For future roof renewal and new construction projects, we recommend the following:

1. Integrate the use of low-embodied carbon materials on future roof renewal projects. This approach should also be considered for other roofing systems not included in this study (i.e. conventional TPO & ballast EPDM roofs). This strategy has demonstrated cost savings, schedule efficiencies, embodied carbon reductions & landfill diversion.
2. Evaluate low-embodied carbon materials for all new construction and renewal projects, particularly for roofing and other building envelope components. Reducing embodied carbon can contribute toward meeting various industry certification and regulatory standards, including: CaGBC Zero Carbon Building Standing, City of Vancouver Building Bylaw, Toronto Green Standard, LEED and Envision (Institute for Sustainable Infrastructure)

[redacted]

APPENDIX

A BOUNDARY & INPUTS

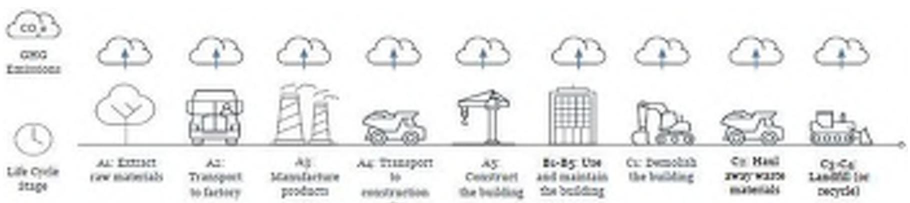
APPENDIX A

A1 SCOPE AND BOUNDARY

WSP completed an embodied carbon assessment using the Environmental Product Declarations (EPDs) produced by roofing manufacturers. The boundary and assumptions are as follows:

- Roof waterproofing system components including membranes, overlay boards, insulation & air/vapour retarders (not including the steel deck).
- A study period of 60 years.
- The GWP of asphaltic board was assumed due to absence of industry sources.
- GWPs related to roof fasteners and adhesives are excluded and assumed to be negligible.
- Embodied carbon related to localized wet insulation replacement has been excluded from the study.
- The life-cycle stages included in the study are from cradle-to-grave. In other words, from extraction of the raw materials for each product through to disposal at the products' end of life. Operational carbon is excluded from LCA consideration.
- B1-B5 only includes for the expected roof renewal cycles during the study period. Other maintenance items are considered to be negligible.
- Quantities of roofing components remain constant between the three (3) scenarios.

Embodied carbon emissions are categorized by lifecycle stages, as shown below:



A3 INPUTS

The roofing materials were matched to material types cataloged in the manufacturer EPDs as summarized in Table 3.

Table 3: Summary of roof materials and their associated EPD

BUILDING LOCATION	MATERIAL NAME	EPD Title	QUANTITY	UNIT
Roofs	Self-Adhered Air/Vapour Barrier	Sopravap'r, by Soprema	1,075,610	ft^2
Roofs	1.5" Insulation	Polyisocyanurate (PIR) roof insulation boards, coated glass faced (CGF), 0.941kg/m2 (2.07 lb/m2), 25 mm (0.984 in) (Atlas Roofing Corporation, Carlisle Construction Materials, Firestone Building Products, GAF, IKO, Johns Manville, Rmax - A Sika Brand, Soprema, Inc. (USA))	1,075,610	ft^2
Roofs	Kraft Vapor Retarder	N/A	1,075,610	ft^2
Roofs	Asphaltic Overlay Board	Sopraboard, by Soprema	1,075,610	ft^2
Roofs	Gypsum Board	Densdeck, by Georgia Pacific	1,075,610	ft^2
Roofs	Self-Adhered Base Sheet & Torch-Applied Cap Sheet System	Sopraply Flam Stick And Sopralene Flam 250 Gr, By Soprema	1,075,610	ft^2
Roofs	Bitumen roofing membrane, panelized-asphaltic base sheet membrane and Torch Applied capsheet.	2-1 Soprasmart Board And Sopralene Flam 250 Gr, By Soprema	1,075,610	ft^2

APPENDIX

B LIMITATIONS

APPENDIX B: LIMITATIONS

ANALYSIS LIMITATIONS

WSP Canada Inc. is the "Consultant" referenced throughout this document.

- The scope of our work and related responsibilities related to our work are defined in our project authorization ("Conditions of Assignment").
- Any user accepts that decisions made or actions taken based upon interpretation of our work are the responsibility of only the parties directly involved in the decisions or actions.
- No party other than the Client shall rely on the Consultant's work without the express written consent of the Consultant, and then only to the extent of the specific terms in that consent. Any use which a third party makes of this work, or any reliance on or decisions made based on it, are the responsibility of such third parties. Any third-party user of this report specifically denies any right to any claims, whether in contract, tort and/or any other cause of action in law, against the Consultant (including Sub-Consultants, their officers, agents and employees). The work reflects the Consultant's best judgement in light of the information reviewed by them at the time of preparation. It is not a certification of compliance with past or present regulations. Unless otherwise agreed in writing by the Consultant, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity; it is written to be read in its entirety.
- Only the specific information identified has been reviewed. No physical or destructive testing and no design calculations have been performed unless specifically recorded. Conditions existing but not recorded were not apparent given the level of study undertaken. Only conditions actually seen during examination of representative samples can be said to have been appraised and comments on the balance of the conditions are assumptions based upon extrapolation. Therefore, this work does not eliminate uncertainty regarding the potential for existing or future costs, hazards or losses in connection with a property. We can perform further investigation on items of concern if so required.
- The Consultant is not responsible for, or obligated to identify, mistakes or insufficiencies in the information obtained from the various sources, or to verify the accuracy of the information.
- No statements by the Consultant are given as or shall be interpreted as opinions for legal, environmental or health findings. The Consultant is not investigating or providing advice about pollutants, contaminants or hazardous materials.
- The Client and other users of this report expressly deny any right to any claim against the Consultant, including claims arising from personal injury related to pollutants, contaminants or hazardous materials, including but not limited to asbestos, mould, mildew or other fungus.
- Any costs for repair in this report are the Consultant's opinions of probable construction costs and quantities, based on current year dollars. These estimates do not include any unforeseen conditions that require repair at the time the repair work is being completed. Any cost estimates provided are subject to confirmation or adjustment at the time competitive bids are obtained from contractors who specialize in the various items of repair work required. The Consultant makes no representation or warranty expressed or implied as to the reliability of these cost estimates.
- Time frames given for undertaking work represent our opinion of when to budget for the work. Failure of the item, or the optimum repair/replacement process, may vary from our estimate.

APPENDIX

INDUSTRY ACCOLADES FOR WSP ROOF RECOVERY PROJECTS

Milirsan Pugalendiran
Building Envelope Engineer, P.Eng., RRO
9mo

Honorable Mention (2nd Place!) 🥈

Our team received an honored mention (2nd Place) at the Carbon Leadership Forum - Toronto's 2024 Embodied Carbon Awards. Our team showcased embodied carbon savings with a recent roof recovery project completed at an Oxford Properties Group managed industrial building.

With a bit of engineering thinking, industrial roofs can become great candidates for a roof recovery strategy which involves salvaging components of the existing roofing system. This project resulted in major savings in the form of embodied carbon (~590 tonCO_2), landfill waste (~216 tons), total construction duration (~20 weeks) as well as construction costs($$$)!

Congrats to the team!

Oxford Properties Group
WSP in Canada
Scott R Armstrong
Sal Alajek
Saul Accetta
Milirsan Pugalendiran, P.Eng
Carbon Leadership Forum
CLF Toronto | Carbon Leadership Forum

#embodiedcarbon
#CLFToronto
#roofing
#existingbuildings

2 0 2 4
Ontario
Embodied
Carbon
Awards
Retrofits & Reuse
Honourable Mention
91 Royal Group Crescent, Vaughan - Roof Renewal
PROJECT TEAM MEMBERS
Sal Alajek, P.Eng., RRO
Scott Armstrong, CET, BSS, LEED AP
Milirsan Pugalendiran P.Eng.
Saul Accetta, AIA, OAA, LEED AP,
PROPERTY MANAGED BY
Oxford Properties Group
SUSTAINABILITY CONSULTANTS & ENGINEERING
WSP Canada Inc.
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Professional Engineers Ontario
York Chapter

WSP Canada Inc.
150 Commerce Valley Drive West
Thornhill, ON L3T 0A9

April 27, 2025

ATTN: Milirsan Pugalendiran

Dear Mr. Pugalendiran,

Re: PEO York Chapter 2024 Engineering Project of the Year Award – Final Results

On behalf of PEO York Chapter and the 2024 Engineering Project of the Year Award Committee, we thank you and your team for submitting your project **100 Royal Group Crescent – Roof Renewal** to the PEO York Chapter 2024 Engineering Project of the Year Award competition in the **Medium Project Category.** This is to inform you that unfortunately, your submission was not selected for a prize. However, as a Finalist in the competition, an award certificate will be mailed to you. Please note that the winners will not be disclosed to the public until the Awards Ceremony to be held on May 24, 2025.

Promotion of Finalists:
We would like to celebrate your project and project team through a spotlight on the PEO York Chapter website.

Please therefore send via email to awards@peoyork.com the following items by **Friday, May 30, 2025**.
1. A photo or graphic representing your project (or provide go-ahead for the Committee to pick one from your project's application package or presentation)
2. A photo of your project team (recommended). This can be a collage of team members pictures

Please note that the PEO York Chapter Engineering Project of the Year Award is intended to recognize engineering projects overseen by licensed Professional Engineers and their contributions to public safety and community advancement and is not intended as, or for any accreditation / certification / endorsement of the company or institution or product, by PEO, PEO York Chapter or the Award judges.

Please also note that if referencing the Award in relation to the project in the future, please ensure to include the Chapter name (**York Chapter)** so that it is very clear that this is a PEO "Chapter" Award competition and not a PEO "the Regulator" Award competition.

Your cooperation in the above matters is greatly appreciated.

We thank you and your team for the time and energy invested in applying for the Award, and in preparing for and presenting as a Finalist in the competition. We hope you will keep the York Chapter in mind and apply for the 2025 Award should you have any eligible project(s).

If there are any questions, please feel free to contact me at awards@peoyork.com.

Sincerely,

Ulf Boehlau, P.Eng.
Director, Awards and Recognition
PEO York Chapter