ROE Highway Logistics Park Carbon Emissions Report

HESPERIAl 28 March 2024

REPORT FOR

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Revision	Revision Details	Author	Approved by	Date Approved
V0.1	First draft	Renata Boff	Sazal Kundu	22 August 2023
V0.2	Second Draft	Renata Boff	Sazal Kundu	06 October 2023
V0.3	Final report	Lilia Caballero	Sazal Kundu	28 March 2024

Executive Summary

ROE Highway Logistics Park (ROE Highway Logistics Park) is an award-winning industrial estate and the largest established in Perth. It has been designed to provide a high degree of lot size flexibility, high-quality amenities and access by road and rail and it has been leading innovative and sustainable initiatives together beside its property development manager, Hesperia. They are on a pathway to be the first net zero industrial park in WA and are also investigating pathways for receiving a carbon neutrality certification. Furthermore, they have received WA's first 6 Star Green Star – Design & As Built industrial facility.

This report presents the calculations methodology, data, and results on embodied carbon emissions and operational energy carbon emission for five completed warehouses developments (Silk, Expro, KTrans, Northline and CHEP).

Results

The main purpose of this study was to calculate embodied and operational carbon emissions for each element of the development. Total embodied carbon emission for the total design life of the development is 25,267 tonne CO_2 eq. meanwhile average yearly embodied carbon emissions per meter square is 8.9 kg CO_2 eq./m^2 year and operational carbon has a value of 18.74 kg CO_2 eq./m^2 year. The graph below shows embodied and operational carbon per warehouse.

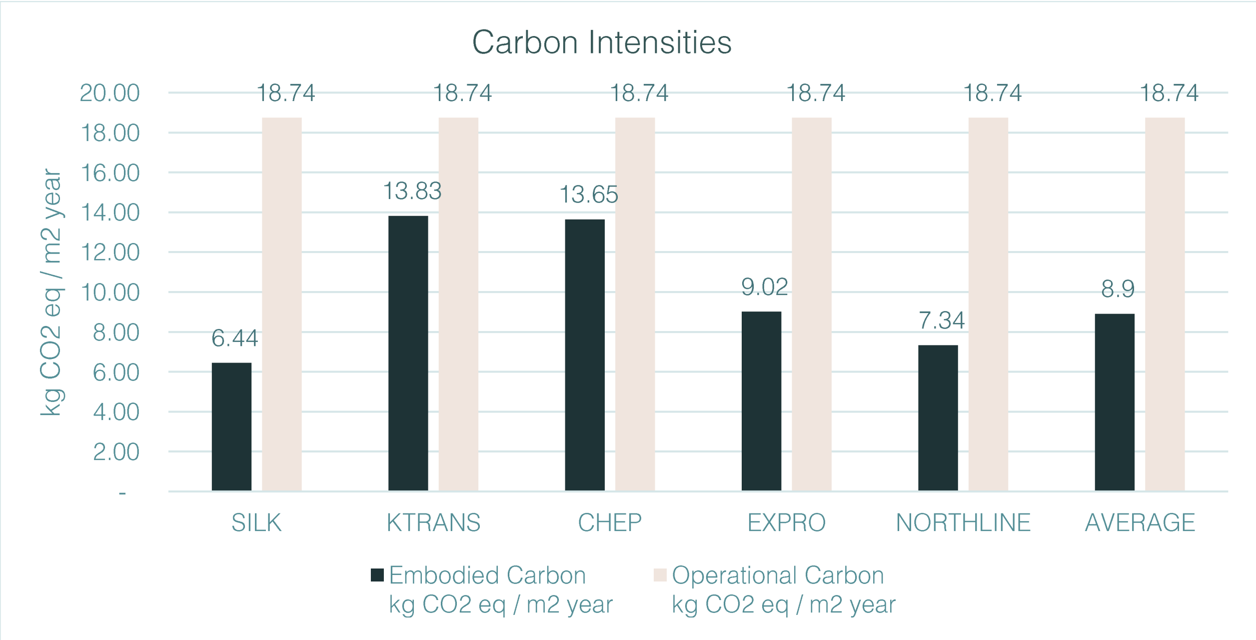

Figure 1 - Embodied and Operational Carbon Intensities

Distribution of carbon emissions per modules was also calculated, as seen on the table below. Operational energy is the main driver of carbon emissions, followed by carbon coming from product stage.

Table 1- Total GWP (tonne CO_2 eq./year) per warehouse by different modules

		A1-A3	A4	A5	B6	B7
		Product Stage	Transport	Construction	Operational Energy Use	Operational Water Use
GWP (tonne CO_2 eq./year)	Silk	101.7	1.9	53.0	442	12.7
	KTrans	65.4	1.3	48.9	152	4.4
	Chep	94.9	1.9	51.1	197	5.7
	Expro	33.4	0.7	20.7	111	3.2
	Northline	102.9	1.9	52.3	389	11.2
	Total	398.3	7.7	225.9	1,292	37.0

The main contributors to embodied carbon were concrete, reaching 46.1% of total, followed construction energy accounting for 18.1% and steel making up to 17.7%. Those items together account for 82% of embodied carbon emissions. The graph below shows the main contributors to embodied carbon emissions.

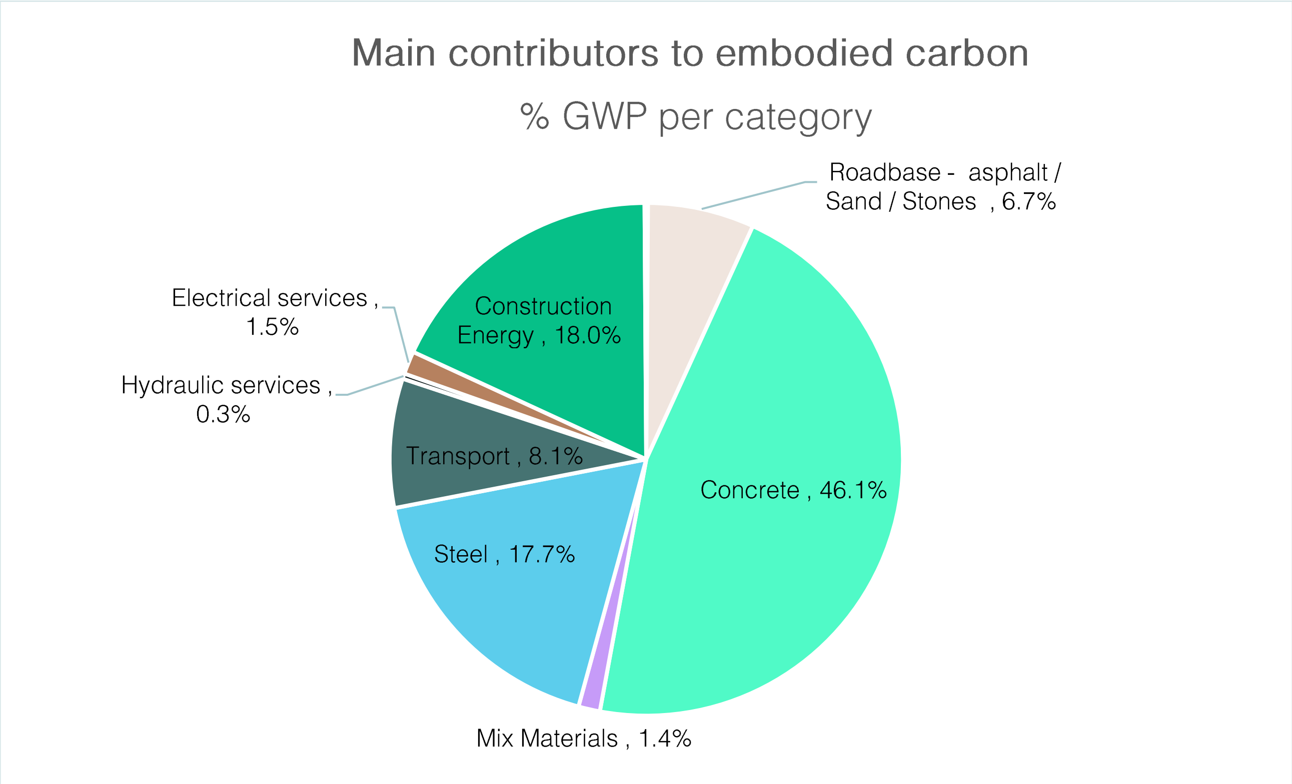

Figure 2 – Main contributors to embodied carbon emissions.

Key findings

The analysis for this study provided the following conclusions:

- The total embodied carbon for the ROE Highway Logistics Park project with a land area of 234,037.00 m^2 and a total built area of 70,930.00m^2 is calculated to be is 25,263.5 tonne CO_2 eq. This value does not include the carbon from operational energy. Embodied carbon emissions per built area accounts for 2.01 tonne CO_2 eq./m^2, of which 62 %

correspond to raw materials, 19% to construction energy, 18% to civil & earth works and 1% to the transportation of the raw materials.

- The operational carbon is calculated annually, which amounts to 1,392 tons CO_2 eq./year or also 3.75 tonnes CO_2 eq./m^2 throughout its entire life project.
- In terms of materials, concrete is the most significant contributor, accounting 71.0% of total embodied carbon, and the second-highest contributor to the embodied carbon is steel with a share of 26.8%.

Recommendations

To reduce related environmental impacts, it is recommended that Hesperia take the following steps:

- Maximize energy efficiency within the warehouse and associated infrastructure;
- Extend the use of onsite renewables;
- Consider utilizing materials with a higher recycling component;
- Increase construction waste recycling;
- Use lower embodied carbon materials for maintenance;
- Considering concrete is the main contributor to the carbon emissions (excluding operation carbon), it is recommended for next developments to use lower embodied carbon alternative;
- Offset remaining emissions.

Contents

1 Introduction

ROE Highway Logistics Park (ROE Highway Logistics Park) is an award-winning industrial estate and the largest established in Perth. It has been designed to provide a high degree of lot size flexibility, high-quality amenities and access by road and rail and it has been leading innovative and sustainable initiatives together beside its property development manager, Hesperia. They are on a pathway to be the first net zero industrial park in WA and are also investigating pathways for receiving a carbon neutrality certification. Furthermore, they have received WA's first 6 Star Green Star – Design & As Built industrial facility.

Edge Environment has calculated embodied carbon emissions and operational carbon for the development containing five warehouses.

Embodied carbon is the carbon dioxide (CO_2) emissions correlated with materials and construction processes during the complete lifecycle of a building or infrastructure. It consists of any CO_2 generated during the manufacturing of building materials, the transport of those materials to the job site, and the construction methods applied. In simple terms, it is the carbon footprint of an infrastructure development prior to when it becomes operational. For the scope of this study, end of life embodied carbon emissions was considered out of boundary.

This report presents the methodology, data, results on embodied carbon and operational energy carbon for five completed warehouses developments (Silk, Expro, KTrans, Northline and CHEP) as well as a brief description on the pathways to achieve carbon neutrality.

2 Project Methodology

The study has been developed to comply with relevant aspects of the standards:

- ISO 14040:2006 and ISO14044:2006+A1:2018: which describe the principles, framework, requirements and provides guidelines for life cycle assessment (LCA).
- EN 15978:2011: which specifies the calculation method, based on LCA and other quantified environmental information, to assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment.

2.1 Background data modelling

Inventory data for the processes are entered in the SimaPro® LCA software (v9.5) and linked to the pre-existing background data for upstream feedstocks and services, which was selected per the standards, in the following order of preference:

1. The Australian Life Cycle Inventory (AusLCI) being compiled by the Australian Life Cycle Assessment Society – this data will comply with the AusLCI Data Guidelines. Version 1.42, 06 March 2023. (Australian Life Cycle Inventory Database Initiative (AusLCI), 2015).
2. Ecoinvent 3.8 database (Ecoinvent Centre, 2017) for all international processes using global average processes
3. The Australasian Unit Process LCI - Australian LCA database developed by Centre for Design from data originally developed with the CRC for Waste Management and Pollution Control as part of an Australian Inventory data project. Version 2014.09.

2.2 Inventory inputs and outputs

The life cycle inventory consists of the input or output flows that cross the system boundary. The application of generic and specific data is outlined in Table 2 below.

Table 2 - Application of generic and specific data

	Module A1-3		A4 & 5	B6
	Production of commodities, raw materials	Product manufacture	Construction processes	Operational - Energy Use
Process type	Upstream processes	Processes the manufacturer has influence over	Downstream processes	Downstream processes
Data type	Primary data	Generic data	Generic data	Primary data

Life cycle data has been sourced from bill of material quantities data and energy readings data provided by Hesperia.

2.3 Data quality and validation

Edge Impact has complied with the set of principles listed below, which are considered best practice when calculating a carbon account.

- Relevance: ensure the greenhouse gas inventory of a precinct appropriately reflects the greenhouse gas emissions attributable to that precinct and serves the decision-making needs of users – both internal and external.
- Completeness: account for and report all greenhouse gas emissions sources and activities within the defined boundary of the precinct. Disclose and justify all exclusions.
- Consistency: use consistent methodologies to allow for meaningful comparisons of greenhouse gas emissions over time. Transparently document any changes to the data, boundary, methods, or any other relevant factors in the time series.
- Transparency: compile, analyse and document greenhouse gas information clearly and coherently so that auditors and the public may evaluate its credibility. Disclose any relevant assumptions and make appropriate references to the calculation methodologies and data sources used.
- Accuracy: ensure the quantification of greenhouse gas emissions is unbiased (not systematically over or under actual emissions) and uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information. Where uncertainty is high, use conservative values and assumptions.

2.4 Environmental Performance Related Information

Most LCA tools have libraries of impact assessment methods that can completely automate the impact assessment. The following potential environmental impacts have been calculated in the SimaPro (v9.4.0.1) tool. The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

Table 3 - Environmental performance assessment method

Impact Category	Abbreviation	Measurement Unit	Assessment Method and Implementation
Potential Environmental Impacts			
Global warming potential (fossil)	GWPF	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2021
Global warming potential (biogenic)	GWPB	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2021

IPCC 2021 is the successor of the IPCC 2013 method, which was developed by the Intergovernmental Panel on Climate Change. It contains the Global Warming Potential (GWP) climate change factors of IPCC with a timeframe of 20 years, including carbon cycle response. This version of the method includes CO_2 uptake and biogenic CO_2 emissions.

3 Goal and Scope Definition

3.1 Goal of Study

The immediate reasons for this project are:

- The purpose of this report is to provide a summary of Edge's life cycle assessment for ROE Highway Logistics Park, measuring the embodied carbon emissions of five completed warehouses (Silk, Expro, KTrans, Northline and CHEP) as well as operations carbon emissions.
- Investigate carbon neutral certification pathways.

3.2 Target Audience

The intended audience for this report is the ROE Highway Logistics Park investor and Development Manager, Hesperia and their subcontractors.

3.3 Scope

The scope of the study is to include embodied and operations energy carbon. A detail definition of the project scope, using the definitions in EN 15978 Sustainability of Construction Work (the best practice LCA standard for buildings), is presented in Table 4.

Table 4 - Scope of Project

Stage	EN 15978 Module	Description
Product Stage	A1	Raw material extraction & supply
	A2	Transport to manufacturing plant
	A3	Manufacturing and fabrication
Construction process stage	A4	Transport to project site
	A5	Construction and installation process
Operational Energy	B6	Operational energy use

For this study, only global warming potential, or carbon is being considered.

3.4 System Boundary

The figure below depicts the system boundary utilised for carbon emissions calculations in this report. Processes for deconstruction and recycling or disposal of construction waste are not included in the scope of this project.

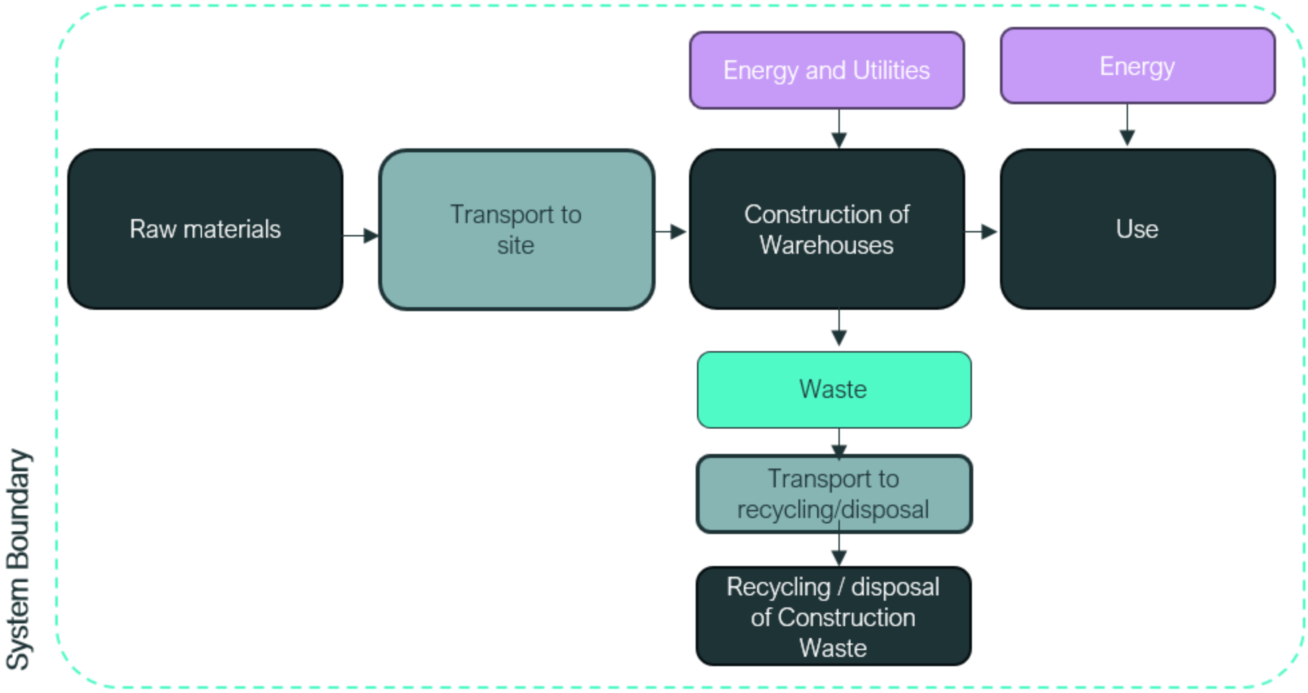

Figure 3 - System boundary for carbon emissions calculations

4 Project description

4.1 Site description

ROE Highway Logistics Park is a 56-hectare industrial estate located on the corner of ROE Highway and Welshpool Road East within 13 kilometres of the Perth CBD and 5 kilometres from Perth Airport.

The development has been configured to provide a high degree of flexibility in lot sizes with the ability to cater to requirements from 2,000m^2 to over 10ha. Featuring manicured streetscapes, high-quality commercial amenity, and entry statements, ROE Highway Logistics Park also offers Restricted Access Vehicle (RAV- 7) access, rail freight access and flexible General Industrial zoning.

A summary of the completed warehouses from the development at ROE Highway Logistics Park is listed in Table 5.

Table 5 - Gross floor and land area for completed warehouses from ROE Highway Logistics Park

Warehouse	Gross Floor Area GFA (m^2)	Land Area (m^2)
SILK	24,261.00	40,344
KTRANS	8,357.00	37,420
CHEP	10,822.00	39,096
EXPRO	6,112.00	16,104
NORTHLINE	21,378.00	39,860
Total area including drainage and roads		**234.037**

4.2 Embodied carbon and operational carbon calculations

4.2.1 Embodied carbon

Edge Impact has calculated embodied carbon per warehouse as well as total. For each warehouse the calculation included emissions related to raw material extraction, transport to site, earth works, civil works, construction energy and transportation to landfill or recycling.

For each warehouse, carbon emissions related to materials were calculated using the bill of quantity sent by Hesperia. Transportations emissions were calculated using average distance values sent by the client. Data for civil and earth works for the whole project was provided and the emissions calculation for each warehouse was conducted considering a proportion of the whole, according to its land area. Ultimately, carbon emissions related to construction energy for each warehouse was calculated using the same proportion of land area. Total values of embodied carbon were achieved and are presented in a variety of forms: for the whole development without operational energy and per annum including/excluding operational energy per warehouse.

4.2.2 Operational carbon

Operational carbon for the scope of this project, only accounts for operational energy emissions. Operational carbon was calculated per annum using consumption, generation, import and exports to grid data provided by Hesperia. The information was provided per year/m^2. Values of operational energy related to each warehouse were calculated as a proportion of gross floor area for each of them.

5 Inventory and assumptions

This section provides a summary of the data used in the modelling carried out for this report.

5.1 Information provided by Hesperia

The client has provided the following information:

- Bill of quantity containing construction materials utilised for five completed warehouses: Silk, KTrans, CHEP, Expro and Northline.
- Earthworks for the entire precinct.
- Civil Works for the entire precinct.
- Average operational energy consumption, generation, imports and exports to grid per m^2 per year basis.
- Total gross floor area and land area for each warehouse.
- Transportation distance estimations from suppliers to site as well as from site to landfill/recycling.

The information is non-exhaustive as some data sets were not yet available, so estimates have been made. Details on the information provided by Hesperia is included in Appendix A.

5.2 Assumptions

The following assumptions were required to complete the calculations.

- Calculations for embodied carbon for all warehouses, civil and earthworks are based on the total land area provided by Hesperia – a total 234,037m^2 for the entire precinct which includes 9 lots, roads and drainage.
- Calculations for carbon resulting only from operational energy are based on the gross floor area for each warehouse. This is due to the majority use of operational energy being expected to be within the warehouse.
- Construction energy per warehouse was based on land area, which accounts for gross floor area plus a proportion of parking and roads.

Table 6 - Assumptions and estimations included in the modelling.

Item	Amount	Unit	Notes
Design life of the property	40	year	This is used to estimate the embodied carbon per annum
Transport distance of materials to construction, landfill and recycling sites-road	20	km	source of data - client. One way trip.
Transport distance of overseas steel to Perth-ship	8,746	km	As per data provided by Hesperia, 22 % of structural steel is sourced from international sources, including UAE, China and South Korea. The average shipping distance from these destinations to Perth is used in the calculations.
Total Land area	234,037	m^2	total area for 9 lots - source client
Land Area - Silk	40,344	m^2	source client
Land Area - Ktrans	37,420	m^2	source client
Land Area - CHEP	39,096	m^2	source client
Land Area - Expro	16,104	m^2	source client
Land Area - Northline	39,860	m^2	source client
Consumption energy	45.9	$kWh/m^2/year$	source of data - client
Generation energy	18.9	$kWh/m^2/year$	source of data - client
Imports of energy	30.6	$kWh/m^2/year$	source of data - client
Exports of energy to grid	3.7	$kWh/m^2/year$	source of data - client
Concrete density	2400	kg/m^3	https://civiltoday.com/civil-engineering-materials/concrete/361-density-of-concrete
Asphalt density	2400	kg/m^3	https://www.omnicalculator.com/construction/asphalt
Aluminium density	2710	kg/m^3	https://www.thyssenkrupp-materials.co.uk/density-of-aluminium.html
Concrete strength (when not specified by Hesperia)	40	MPa	

Virgin bitumen content in asphalt	5.5	%	Since no data was provided by Hesperia on asphalt, standard asphalt mix was assumed
Construction waste	10	%	Although construction waste can be as high as 30 % for project[1], the typical value based on Edge's experience is 5%. Since no data was received from Hesperia regarding this item, a conservative estimate of 10 % has been applied.
Aluminium windows	117.5	kg CO_2 eq./m^2	Assumption for window frame width 45mm-50mm. Source https://api.environdec.com/api/v1/EPDLibrary/Files/11ed9f76-c75b-4817-bd94-483f825dd9fd/Data
	26.81	kg/m^2	
Aluminium double-glazed windows	126	kg CO_2 eq./m^2	Source https://european-aluminium.eu/wp-content/uploads/2022/09/alumil_epd_sd77.pdf
	10.75	kg/m^2	
Motorised roller shutter door, auto roller shutter door and manual roller shutter door	117.5	kg CO_2 eq./m^2	Info on GWP for roller doors from EPD available at https://nassaudoor.com/wp-content/uploads/2019/01/EPD_BVT_Lang_Nassau_eng_final.pdf
	20.27	kg/m^2	
0.48mm trimdeck wall sheeting	4.93	kg/m^2	No information given on steel sheets. We have assumed usage of Colorbond roof sheets
Supplementary Cementitious Materials (SCM) in concrete	0	%	Since no data was provided by Hesperia on the concrete mix, 0% SCM was assumed as conservative estimate.
Reinforcement steel	100	kg/m^3	100kg steel per m3 of concrete assumed
Concrete slab thickness for pathways/ ramps	150	mm	
Standard culvert length	2.4	m	
Standard Reinforced Concrete (RC) pipe length	2.4	m	
Weight of 50 mm Polyvinyl Chloride (PVC) pipe or conduit	1.1	kg/m	

Weight of 150 mm PVC pipe or conduit	6.7	kg/m	
Weight of 200 mm PVC pipe or conduit	10.1	kg/m	
Weight of 150 mm Polyethylene (PE) pipe	5.5	kg/m	
Weight of 16 mm xlpe cable (2 core)	0.061	kg/m	
Weight of 240 mm xlpe cable (2/3 core)	9.15	kg/m	
Weight of 440 mm xlpe cable (2/3 core)	14.4	kg/m	
Construction energy - total[2]	215	MJ/m^2	70: 30 split between diesel and electricity respectively
Construction energy – Diesel	150.5	MJ/m^2	
Construction energy – Electricity	64.5	MJ/m^2	
SimaPro process - Polyethylene, high density, granulate {RoW}| polyethylene production, high density, granulate | Cut-off, U	20	%	An extra 20% was added to account for transport and manufacturing since processes in SP were not to the same level of completeness
SimaPro process - Glass fibre reinforced plastic, polyester resin, hand lay-up {RoW}| glass fibre reinforced plastic production, polyester resin, hand lay-up | Cut-off, U	20	%	An extra 20% was added to total GWP to account for transport and manufacturing since processes in SP were not to the same level of completeness
Total water usage in construction per m^2 built area	507.65	L/m^2	Source: Determining Water Footprint of Buildings During Construction Phase: An Activity-based Approach, (Rajeev Garg, 2022)

5.3 Background data

Appendix B contains detailed background data that was used for this study.

6 Results

6.1 Summary of results

Total embodied carbon emission for the total design life of the development is 25267 tonne CO_2 eq. meanwhile embodied carbon emissions per built area accounts for 50.3 kg CO_2 eq./m^2 year and operational carbon has a value of 18.74 kg CO_2 eq./m^2 year, as displayed on the chart below.

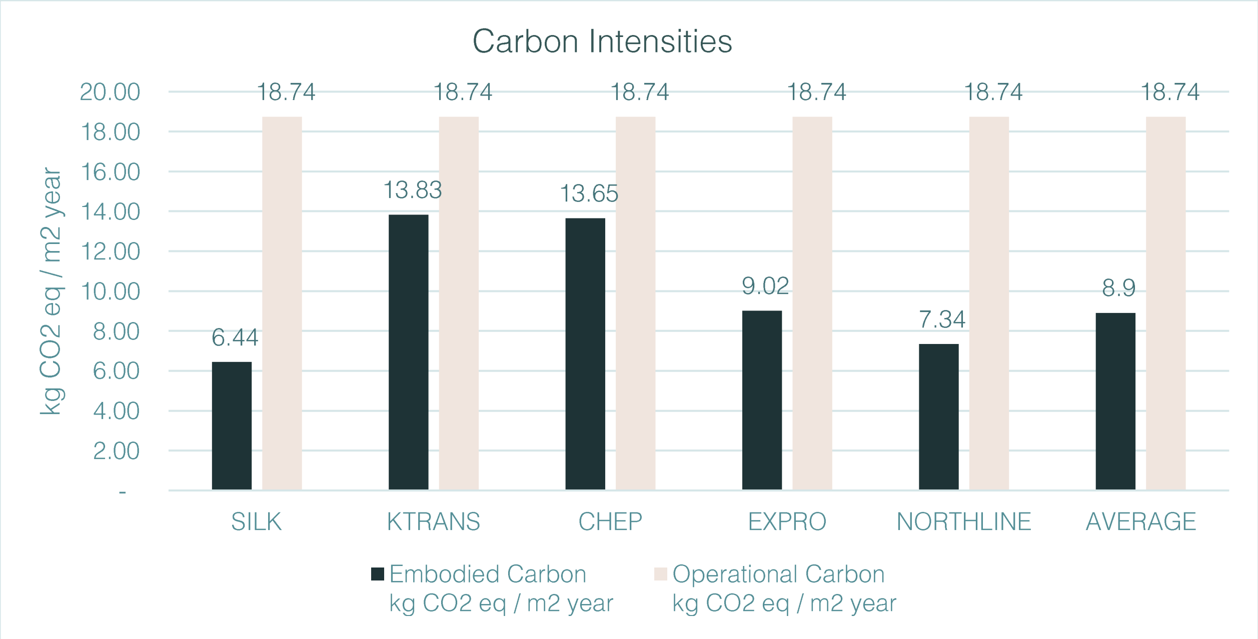

Figure 4 - Embodied and Operational Carbon Intensities

A summary of carbon emissions for all completed ROE Highway Logistics Park warehouses is presented in the next table.

Table 7 – Summary of carbon emissions

Warehouse	Total Embodied Carbon x 40 years (tonne CO_2 eq.)	Gross Floor Area (m^2)	Embodied Carbon (kg CO_2 eq./m^2 year)	Operational Carbon (kg CO_2 eq./m^2 year)
SILK	6,254	24,261	6.44	18.74
KTRANS	4,621	8,357	13.86	18.74
CHEP	5,908	10,822	13.65	18.74
EXPRO	2,205	6,112	10.25	18.74
NORTHLINE	6,278	21,378	7.34	18.74
TOTAL	**25,267**	**70,930**	**50.3**	**93.7**

The total embodied carbon emission for the precinct is 25,267 tonne CO_2 eq., this includes all five warehouses for the total duration of its design life (40 years). Embodied carbon was also calculated as a yearly intensity per built-in area with a value of 50.3 kg CO_2 eq./m^2 year for embodied carbon and 93.7 kg CO_2 eq./m^2 year for operational carbon, which includes energy and water use.

Expro, the smallest warehouse with a GFA of 6,112m^2, had the lowest contribution to total emissions, accounting for 8.7%, with a total value of 2,205 tonne CO_2 eq. Meanwhile, warehouse Silk, the largest of them, with a total GFA of 24,261m^2 presented the lowest carbon intensity for embodied carbon.

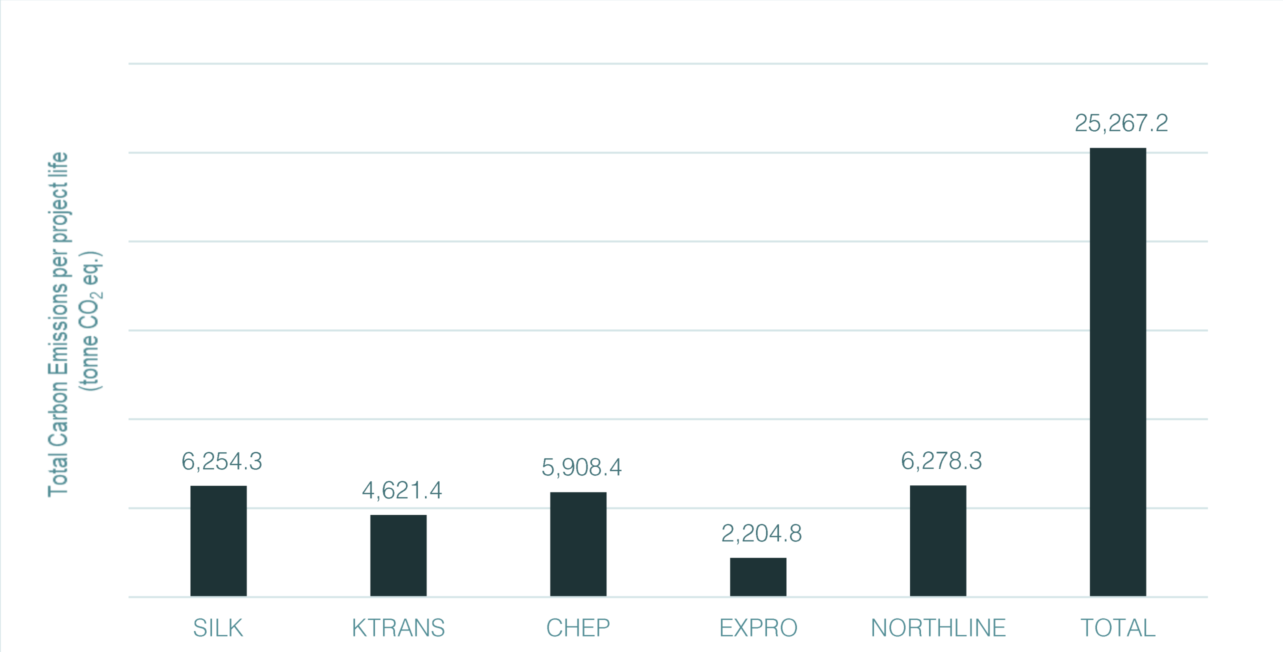

Figure 5 - Total embodied carbon emissions for the whole project life.

6.2 Results per module

The following tables demonstrate the GWP per warehouse expressed per module per full extend of the project and per annum respectively.

Table 8 – GWP expressed in tonne CO_2 eq. per module for the full length of the project per warehouse.

		A1-A3	A4	A5	B6	B7
		Product Stage	Transport	Construction	Operational Energy Use	Operational Water Use
project life GWP tonne CO_2 eq.	SILK	4,066.9	77.3	2,119.0	17,679.4	506.9
	KTRANS	2,615.9	53.6	1,955.0	6,089.9	174.6
	CHEP	3,794.4	73.9	2,044.1	7,886.2	226.1
	EXPRO	1,337.0	26.8	828.0	4,453.9	127.7
	NORTHLINE	4,117.5	77.1	2,091.7	15,578.5	446.7
	TOTAL	15,931.7	308.7	9,037.7	51,687.9	1,482.0

Table 9 - GWP expressed in tonne CO_2 eq. per year per module per warehouse.

		A1-A3	A4	A5	B6	B7
		Product Stage	Transport	Construction	Operational Energy Use	Operational Water Use
GWP tonne CO_2 eq./year	SILK	101.7	1.9	53.0	442	12.7
	KTRANS	65.4	1.3	48.9	152	4.4
	CHEP	94.9	1.9	51.1	197	5.7
	EXPRO	33.4	0.7	20.7	111	3.2
	NORTHLINE	102.9	1.9	52.3	389	11.2
	TOTAL	398.3	7.7	225.9	1,292	37.0

Table 10 – Project life GWP expressed in tonne CO_2 eq. as an intensity per built m^2 expressed across the different modules.

		A1-A3	A4	A5	B6	B7
		Product Stage	Transport	Construction	Operational Energy Use	Operational Water Use
project life GWP tonne CO2 eq / m2	SILK	1.68E-01	3.19E-03	8.73E-02	7.29E-01	2.09E-02
	KTRANS	3.13E-01	6.42E-03	2.34E-01	7.29E-01	2.09E-02
	CHEP	3.51E-01	6.83E-03	1.89E-01	7.29E-01	2.09E-02
	EXPRO	2.19E-01	4.39E-03	1.38E-01	7.29E-01	2.09E-02
	NORTHLINE	1.93E-01	3.60E-03	9.78E-02	7.29E-01	2.09E-02
	TOTAL	1.24E+00	2.44E-02	7.46E-01	3.64E+00	1.04E-01

Table 11 - GWP expressed in tonne CO_2 eq. per year as an intensity per built m^2 expressed across the different modules.

		A1-A3	A4	A5	B6	B7
		Product Stage	Transport	Construction	Operational Energy Use	Operational Water Use
GWP tonne CO_2 eq./m^2 year	SILK	4.19E-03	7.97E-05	2.18E-03	1.82E-02	5.22E-04
	KTRANS	7.83E-03	1.60E-04	5.85E-03	1.82E-02	5.22E-04
	CHEP	8.77E-03	1.71E-04	4.72E-03	1.82E-02	5.22E-04
	EXPRO	5.47E-03	1.10E-04	3.45E-03	1.82E-02	5.22E-04
	NORTHLINE	4.82E-03	9.01E-05	2.45E-03	1.82E-02	5.22E-04
	TOTAL	5.62E-03	1.09E-04	3.19E-03	1.82E-02	5.22E-04

6.3 Most significant contributors to embodied carbon emissions.

The following table exhibits detailed information on each category of emissions for a more in-depth examination. Values of GWP (tonne CO_2 eq.) are expressed per category of activity.

Table 12 – Embodied carbon for materials and transportation for the entire project

GWP (tonne CO_2 eq.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Aluminium	6.4	-	1.7	-	19.0	27.2
Asphalt	11.9	71.5	15.8	37.4	-	136.6
Concrete	2,899.0	1,907.8	2,971.7	501.2	2,921.0	11,200.7
Mix	76.4	47.9	43.3	59.8	115.8	343.2
Steel	1,073.2	588.7	761.9	738.6	1,061.7	4,224.0
Transport of materials to site	77.3	53.6	73.9	26.8	77.1	308.7
Total	**4,144.2**	**2,669.5**	**3,868.3**	**1,363.8**	**4,194.6**	**16,240.4**

Table 13 – Embodied carbon for civil and earthworks for the entire project.

GWP (tonne CO_2 eq.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Concrete	105.01	97.40	101.77	26.92	103.75	434.9
Reinforcement steel	56.92	52.80	55.16	22.72	56.24	243.8
Hydraulic services	19.58	18.16	18.98	7.82	19.35	83.9
Electrical services	85.83	79.61	83.18	34.26	84.80	367.7
Roadbase, asphalt etc.	363.71	337.35	352.46	145.18	359.35	1,558.0
Transport Civil	408.12	378.54	395.50	162.91	403.23	1,748.3
Total	**1,039.18**	**963.87**	**1,007.04**	**399.81**	**1,026.72**	**4,436.6**

Table 14 – Embodied carbon for construction energy and water for the entire project

GWP (tonne CO_2 eq.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Construction energy-Electricity	459.3	426.0	445.1	183.3	453.8	1,967.5
Construction energy-Diesel	602.6	559.0	584.0	240.6	595.4	2,581.5
Construction Water	8.9	3.1	4.0	2.3	7.9	26.1
Total	**1,070.9**	**988.0**	**1,033.1**	**426.1**	**1,057.1**	**4,575.2**

The next graph demonstrates the main contributors to embodied carbon for each category as a percentage. Concrete accounts for most emissions, reaching 46.1% of total contributions, followed construction energy accounting for 18.1% and steel making up to 17.7%. The successive table demonstrates those values in detail.

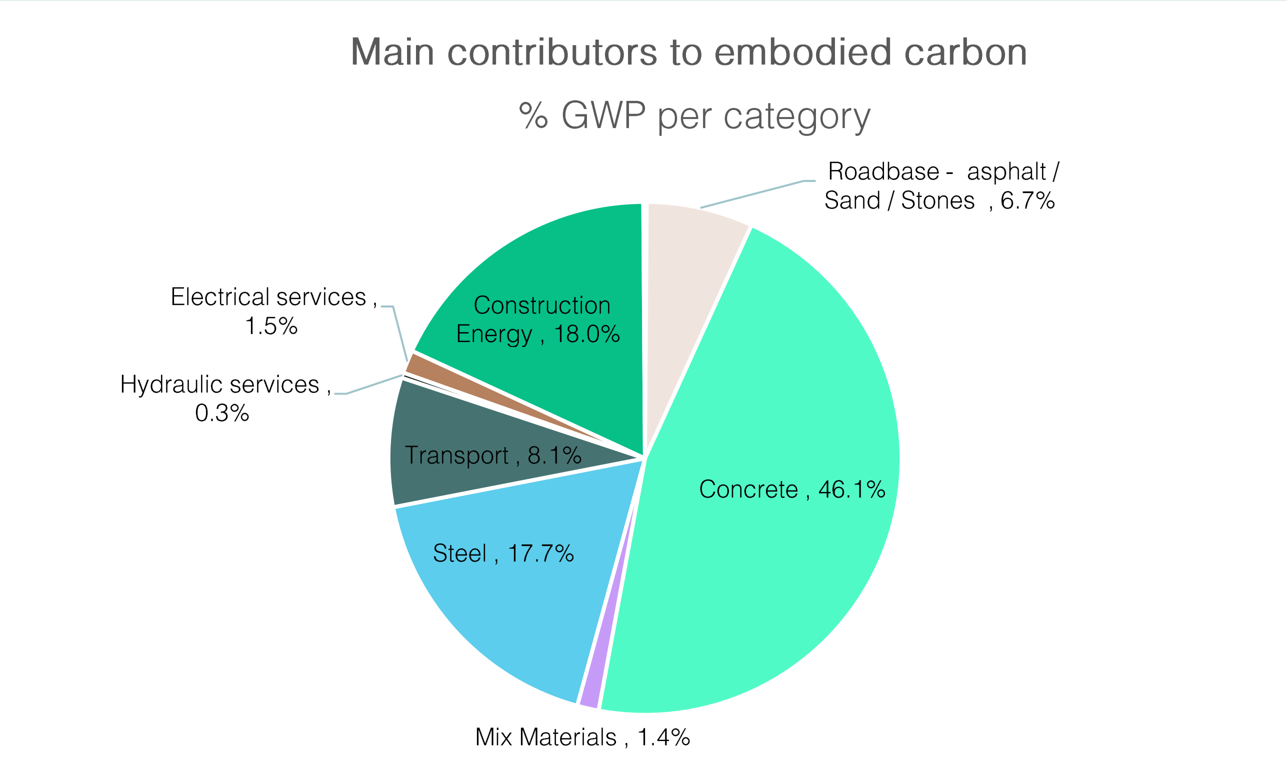

Figure 6 – Main Contributors to Embodied Carbon

Table 15 - Percentage of total embodied carbon per category

% of total Embodied Carbon (kg CO_2 eq.) per category	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Aluminium	0.1%	0.0%	0.0%	0.0%	0.3%	0.1%
Road base - Asphalt / Sand / Stones	6.0%	8.8%	6.2%	8.3%	5.7%	6.7%
Concrete	48.0%	43.4%	52.0%	24.0%	48.1%	46.1%
Mix Materials	1.2%	1.0%	0.7%	2.7%	1.8%	1.4%
Steel	18.0%	13.9%	13.8%	34.8%	17.8%	17.7%
Transport to site/landfill/recycling	7.8%	9.3%	7.9%	8.7%	7.6%	8.1%
Hydraulic services	0.3%	0.4%	0.3%	0.4%	0.3%	0.3%
Electrical services	1.4%	1.7%	1.4%	1.6%	1.3%	1.5%
Construction Energy	17.1%	21.4%	17.5%	19.5%	16.8%	18.0%
Construction Water	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%

The table above displays embodied carbon as an intensity, per built area (kg CO_2 eq./m[2]) for the project duration. The main contributors were the same as the ones identified for absolute embodied carbon values: concrete (164.0 kg CO_2 eq./m[2]) construction energy (64.5 kg CO_2 eq./m[2]) and steel (63 kg CO_2 eq./m[2]). The subsequent table presents detailed information on embodied carbon as an intensity, per built area for each warehouse.

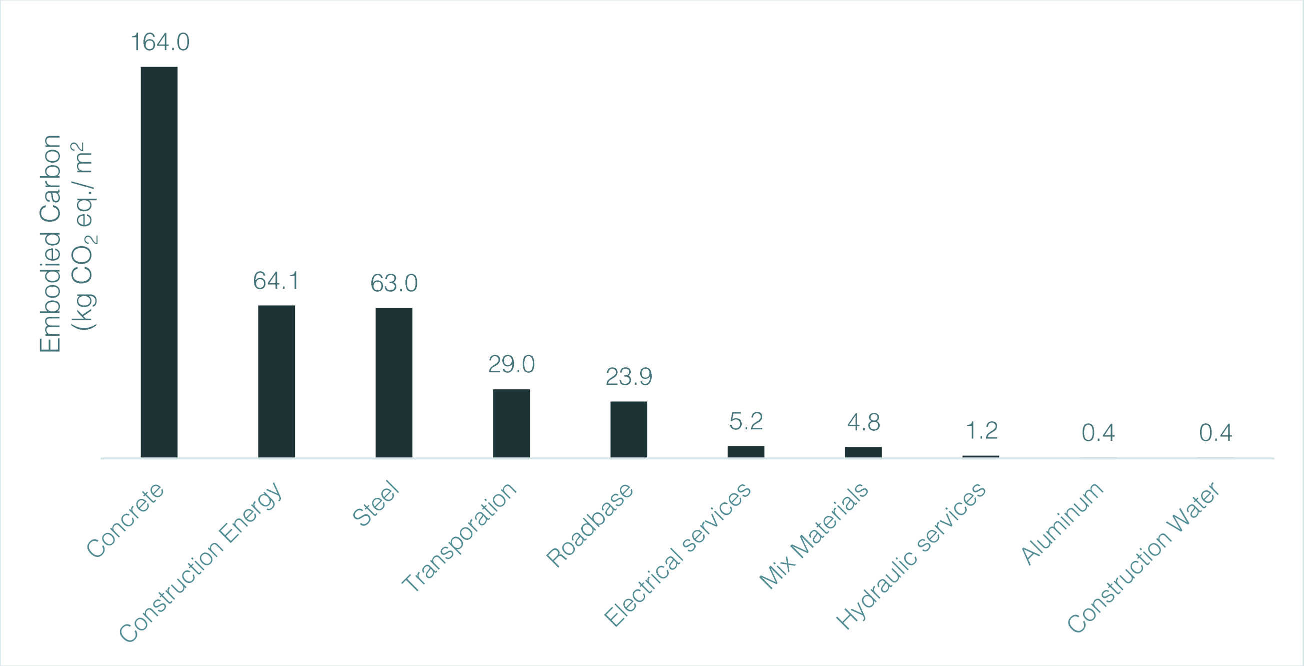

Figure 7 - Embodied carbon as intensity of built-in area

Table 16 - Embodied carbon per category expressed as an intensity, per built-in area.

Embodied Carbon kg CO_2 eq./m^2 per category	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	Total
Aluminium	0.3	-	0.2	-	0.9	0.4
Road base - Asphalt / Sand / Stones	15.5	48.9	34.0	29.9	16.8	23.9
Concrete	123.8	239.9	284.0	86.4	141.5	164.0
Mix Materials	3.1	5.7	4.0	9.8	5.4	4.8
Steel	46.6	76.8	75.5	124.6	52.3	63.0
Transport to site/landfill/recycling	20.0	51.7	43.4	31.0	22.5	29.0
Hydraulic services	0.8	2.2	1.8	1.3	0.9	1.2
Electrical services	3.5	9.5	7.7	5.6	4.0	5.2
Construction Energy	43.8	117.9	95.1	69.4	49.1	64.5
Construction Water	0.4	0.4	0.4	0.4	0.4	0.4

6.4 Embodied + Operational Carbon

The table below exhibits information on emissions for operational carbon from energy for the whole duration of the project (40 years).

Table 17 – Operational carbon per category for the full design life of the project

GWP x 40 years (tonne CO_2 eq.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Grid Electricity	16,649	5,735	7,427	4,194	14,671	48,675
Onsite Solar Electricity	1,030	355	460	260	908	3,012
Water Use	507	175	226	128	447	1,482
Total Operational Carbo	18,186	530	686	387	1,355	21,143

Table 18 – Operational carbon from yearly operational energy and water

GWP x 1 years (tonne CO_2 eq.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Grid Electricity	416.2	143.4	185.7	104.9	366.8	1,216.9
Onsite Solar Electricity	25.8	8.9	11.5	6.5	22.7	
Water Use	12.7	4.4	5.7	3.2	11.2	37.0
Total Operational Carbo	454.7	156.6	202.8	114.5	400.6	1,329.2

Table 19 – Operational carbon intensity from yearly operational energy and water.

GWP x 1 years (kg CO_2 eq/m^2.)	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	TOTAL
Grid Electricity	17.2	17.2	17.2	17.2	17.2	85.8
Onsite Solar Electricity	1.1	1.1	1.1	1.1	1.1	5.3
Water Use	0.5	0.5	0.5	0.5	0.5	2.6
Total Operational Carbon	18.7	18.7	18.7	18.7	18.7	93.7

The graph below demonstrates the total contribution to carbon emissions for each category as a percentage and includes embodied and operational carbon. Operations energy accounts for most emissions, reaching 67% of total contributions, followed by use of concrete, accounting for 15.5%, construction energy 5.9% and steel another 5.8%. Those items together account for 94% of total carbon emissions.

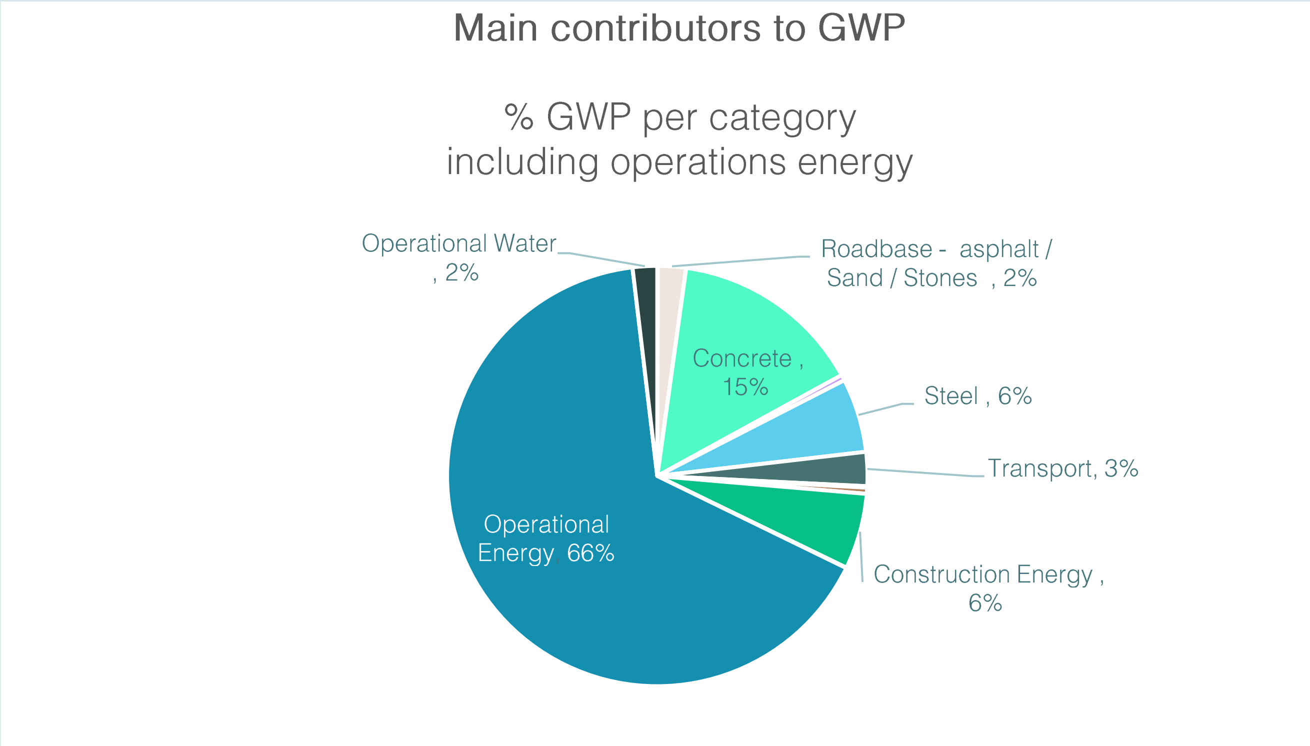

Figure 8 - Main contributors to carbon emissions – Embodied carbon + Operational carbon.

Table 20 - Percentage of total GWP per category, including operations energy

% GWP (kg CO_2 eq.) / per category including operations energy	SILK	KTRANS	CHEP	EXPRO	NORTHLINE	Total
Aluminium	0%	0%	0%	0%	0%	0%
Road base - Asphalt / Sand / Stones	2%	4%	3%	3%	2%	2%
Concrete	12%	18%	22%	8%	14%	15%
Mix Materials	0%	0%	0%	1%	1%	0%
Steel	5%	6%	6%	11%	5%	6%
Transport to site/landfill/recycling	2%	4%	3%	3%	2%	3%
Hydraulic services	0%	0%	0%	0%	0%	0%
Electrical services	0%	1%	1%	1%	0%	0%
Construction Energy	4%	9%	7%	6%	5%	6%
Construction Water	0%	0%	0%	0%	0%	0%
Operations Energy (x40years)	72%	56%	56%	66%	70%	66%
Operations Water (x40years)	2%	2%	2%	2%	2%	2%

7 Sustainability Pathways

Climate Active partners with the Australian Government and businesses to steer voluntary climate action and reduce carbon emissions, lowering negative impact on the environment. The Climate Active Carbon neutral certification is a rigorous process that includes third party verification and is built on best-practice standards covering GHG protocols, ISO 14040, Australian Standard (AS) ISO 14064 series and Australian Standard (AS) ISO 14064 series.

Climate Active Carbon Neutral Standard for Precincts

The Precinct Standard accommodates precincts from large-scale mixed-use developments with several offices and dwellings to smaller university or sporting precincts. According to (Australia, Climate Active Carbon Neutral Standard for Precincts, 2022), a precinct is an evident area that is 'more than a building and less than a city' and is primarily defined by its geographic boundaries, which, at a minimum, must incorporate infrastructure beyond a single building. For an isolated building, the Standard for Buildings must be referred.

Carbon neutral claims alongside this standard only relate to a precinct's operational emissions, therefore the sustainability pathways in this study are divided into two sections: Embodied Carbon Offsetting and Operational Carbon Offsetting.

7.1 Embodied Carbon Offsetting

Hesperia has completed 5 of the 19 warehouses it plans to have at ROE Highway Logistics Park. The results for the total embodied carbon emissions from the modules A1-A5 are presented in Table 21 the results for the total embodied carbon emissions per m^2 of the same modules are presented in Table 22.

Table 21 - Total Embodied Carbon (Modules A1-A5)

Stage	Warehouse	GFA	Land Area	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY	TOTAL EMBODIED CARBON EMISSIONS
		(m2)	(m2)	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq
1	SILK	24,261	40,344	4066.9	77.3	1039.2	1070.9	6254.3
1	KTRANS	8,357	37,420	2615.9	53.6	963.9	988.0	4621.5
3	CHEP	10,822	39,096	3794.4	73.9	1007.0	1033.1	5908.5
2	EXPRO	6,112	16,104	1333.3	26.8	399.6	426.1	2185.9
1	NORTHLINE	21,378	39,860	4117.5	77.1	1026.7	1057.1	6278.4
TOTAL		**70,930**	**172,824**	**15928.0**	**308.7**	**4436.4**	**4575.2**	**25248.7**

Table 22-Total Embodied Carbon per m2 (Modules A1-A5)

Stage	Warehouse	GFA	Land Area	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY	TOTAL EMBODIED CARBON EMISSIONS
		(m^2)	(m^2)	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2
1	SILK	24261	40344	0.168	0.003	0.043	0.044	0.258
1	KTRANS	8357	37420	0.313	0.006	0.115	0.118	0.553
3	CHEP	10822	39096	0.351	0.007	0.093	0.095	0.546
2	EXPRO	6112	16104	0.218	0.004	0.065	0.070	0.358
1	NORTHLINE	21378	39860	0.193	0.004	0.048	0.049	0.294
TOTAL		**70930**	**172824**	**1.242**	**0.024**	**0.365**	**0.377**	**2.008**

By extrapolating the results from the warehouses SILK, KTRANS, CHEP and NORTHLINE, we can predict the total embodied carbon emissions for the remaining 14 warehouses if they were built using regular concrete with exception of Lot 43, Lot 52 and Lot 53 that use ENVISIA concrete. This was done by finding the factors between the results obtained for modules A1-A5 and the GFA. And later multiplying those factors by the GFA of the warehouses to be built.

Table 23- Upfront Embodied Carbon (Modules A1-A5)

Stage	Warehouse	GFA	Land Area	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY	TOTAL EMBODIED CARBON EMISSIONS
		(m^2)	(m^2)	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq	tonne CO_2 eq
2	Lot 43	5,768	11,536	862.5	21.0	286.3	305.4	1475.2
2	Lot 23	21,755	43,509	4036.2	79.0	1112.5	1151.7	6379.4
3	Lot 26	22,794	45,587	4228.9	82.7	1165.6	1206.7	6684.1
5	Lot 27	12,848	25,695	2383.6	46.6	657.0	680.2	3767.5
2	Lot 52	8,036	16,071	1201.6	29.2	398.8	425.4	2055.1
3	Lot 53	10,622	21,243	1588.3	38.6	527.1	562.3	2716.5

3	Lot 49	1,214	2,428	225.2	4.4	62.1	64.3	356.1
3	Lot 62	1,937	3,874	359.4	7.0	99.1	102.5	568.1
3	Lot 61	2,509	5,018	465.5	9.1	128.3	132.8	735.8
4	Lot 10	2,000	7,575	702.7	13.7	193.7	200.5	1110.7
4	Lot 11	7,460	20,310	1884.1	36.9	519.3	537.6	2977.9
4	Lot 12-13	5,080	17,844	1655.3	32.4	456.3	472.3	2616.4
4	Lot 14-16,18	21,330	40,774	3782.5	74.0	1042.6	1079.3	5978.4
4	Lot 4, 21-23	25,395	42,515	3944.0	77.2	1087.1	1125.4	6233.6
TOTAL		148,748	303,979	27,320	552	7,736	8,046	43,655

Table 24 - Upfront Embodied Carbon per m2 (Modules A1-A5)

Stage	Warehouse	GFA	Land Area	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY	TOTAL EMBODIED CARBON EMISSIONS
		(m^2)	(m^2)	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2	tonne CO_2 eq / m^2
2	Lot 43	5768	11536	0.150	0.004	0.050	0.053	0.256
2	Lot 23	21755	43509	0.186	0.004	0.051	0.053	0.293
3	Lot 26	22794	45587	0.186	0.004	0.051	0.053	0.293
5	Lot 27	12848	25695	0.186	0.004	0.051	0.053	0.293
2	Lot 52	8036	16071	0.150	0.004	0.050	0.053	0.256
3	Lot 53	10622	21243	0.150	0.004	0.050	0.053	0.256
3	Lot 49	1214	2428	0.186	0.004	0.051	0.053	0.293
3	Lot 62	1937	3874	0.186	0.004	0.051	0.053	0.293

3	Lot 61	2509	5018	0.186	0.004	0.051	0.053	0.293
4	Lot 10	2000	7575	0.351	0.007	0.097	0.100	0.555
4	Lot 11	7460	20310	0.253	0.005	0.070	0.072	0.399
4	Lot 12-13	5080	17844	0.326	0.006	0.090	0.093	0.515
4	Lot14-16,18	21330	40774	0.177	0.003	0.049	0.051	0.280
4	Lot 4, 21-23	25395	42515	0.155	0.003	0.043	0.044	0.245
TOTAL		**148748**	**303979**	**2.824**	**0.057**	**0.804**	**0.837**	**4.522**

The total avoided emissions during the constructions of the warehouses using low carbon concrete are 1184.4 t CO_2 eq, the table below describes these achievements per warehouse.

Table 25 - Summary of the reductions achieved in embodied carbon at ROE.

Warehouse	Low carbon construction mechanism	Low Embodied carbon (Cubes poured)	Details	Estimated Carbon Reduction (t CO2e)
Expro – Lot 64	Portland Cement Reduction and use of captured or reclaimed water	590	BGC concrete, as the concrete supplier for the warehouse confirms compliance with Green Star standards.	301.6
Sinopec – Lot 43	Portland Cement Reduction and use of captured or reclaimed water	2,701	ENVISIA® allows less cement to be used in the concrete manufacturing process without impacting on performance.	207.6
Sandvik – Lot 52	Portland Cement Reduction and use of captured or reclaimed water	2,570	ENVISIA® allows less cement to be used in the concrete manufacturing process without impacting on performance.	289.2
Sandvik – Lot 53	Portland Cement Reduction and use of captured or reclaimed water	4,210	ENVISIA® allows less cement to be used in the concrete manufacturing process without impacting on performance.	382.3
TOTALS		10071		1184.4

The avoided emissions using low carbon concrete for the construction of the warehouses would be in average to 24% less for ENVISIA and 19% less for BGC concrete.

LOW CARBON CONCRETE	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY & WATER	TOTAL AVOIDED CARBON EMISSIONS
ENVISIA	20.9%	0.0%	3.1%	0.0%	**24.0%**
BGC	16.0%	0.0%	3.1%	0.0%	**19.1%**

On the same note the avoided emissions per m2 are in average 0.65 tonnes for warehouses built with ENVISIA concrete and 0.5 for warehouses that use BGS concrete for their construction.

LOW CARBON CONCRETE	MATERIALS	TRANSPORT	CIVIL & EARTH WORKS	CONSTRUCTION ENERGY & WATER	TOTAL AVOIDED CARBON EMISSIONS
ENVISIA	0.63	0.00	0.02	0.00	**0.65**
BGC	0.48	0.00	0.02	0.00	**0.50**

7.2 Operational Carbon Offsetting

Climate Active (2022) states that to achieve and maintain a valid and credible carbon neutral claim against either the Precinct or Building Standard, the organisation must:

- Calculate emissions, including:
    - Stationary energy and fuels used within the geographic boundary of the precinct, for example in buildings, machinery, or vehicles.
    - Electricity used within the geographic boundary of the precinct.
    - All other emissions identified as arising as a consequence of precinct operating, must be assessed for relevance.[1]
- Develop and implement an emissions reduction strategy.
- Purchase offsets to compensate for remaining emissions.
- Arrange independent validation.
- Publish a public statement of the carbon neutral claim.

[1] Source: (Climate Active, 2022)

8 Conclusions and recommendations

8.1 Key findings

The LCA provided the following conclusions regarding the ROE Highway Logistics Park development:

- The total embodied carbon for the ROE Highway Logistics Park project with a land area of 234,037.00m^2 and a total built area of 70,930.00 m^2 is calculated to be 25,267 tonne CO_2 eq. This value does not include the carbon from operational energy. Embodied carbon emissions per built area accounts for 8.9 kg CO_2 eq./m^2 year.
- Operational carbon is calculated on a yearly basis, which amounts to 1,329 tonne CO_2 eq./year for the entire project or also 93.7 CO_2 eq./m^2 year per built area.
- In terms of materials, concrete is the most significant contributor, accounting 71.0% of total embodied carbon, and the second-highest contributor to the embodied carbon is steel with a share of 26.8%

8.2 Recommendations

To reduce related environmental impacts, it is recommended that Hesperia take the following steps:

- Maximize energy efficiency within the warehouse and associated infrastructure.
- Extend the use of onsite renewables.
- Consider utilizing materials with a higher recycling component.
- Increase construction waste recycling.
- Use lower embodied carbon materials for maintenance.
- Considering concrete is the main contributor to the carbon emissions (excluding operation carbon), it is recommended for next developments to use lower embodied carbon alternative.
- Offset remaining emissions.

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Appendix A – Information provided by Hesperia

Table 26 - Earth and civil works quantities provided by the client.

Category	Item	Quantity	Unit	Info
Concrete	900 x 900 culvert	43	m^3	Data provided by Hesperia was in meters of culverts used for each type. Methodology to calculate volume of concrete is detailed in the 'Assumptions' section.
	450 x 1200 culvert	136	m^3	
	1200 x 600 culvert	241	m^3	
	1200 x 300 Culvert	73	m^3	
	Pathways/ ramps	949	m^3	Data provided by Hesperia was in m^2. This was multiplied by the thickness of the slab to estimate the volume of concrete used
	RC drainage pipe 300mm	61	m^3	Data provided by Hesperia was in meters of RC drainage pipes used. Methodology to calculate volume of concrete is detailed in the 'Assumptions' section.
	RC drainage pipe 375mm	15	m^3	
	RC drainage pipe 450mm	15	m^3	
	RC drainage pipe 525mm	2	m^3	
	RC drainage pipe 600mm	11	m^3	
Reinforcement steel	Reinforcement steel	155	tonne	Estimated by Edge. Reinforcement of 100kg steel per m^3 of concrete assumed
Hydraulic services	PVC water pipe 150 mm	19	tonne	Data provided by Hesperia was in meters of pipes and cables used. This was multiplied by the weight of the pipe/ cable per meter to estimate the total weight
	PE water pipe 180 mm	1	tonne	
	PVC subsoil drainage pipes 150 mm	16	tonne	
	PVC irrigation ducting 200mm	1	tonne	

Electrical services	PVC conduit 50mm	1	tonne	Data provided by Hesperia was in meters of pipes and cables used. This was multiplied by the weight of the pipe/ cable per meter to estimate the total weight
	PVC conduit 100mm	5	tonne	
	PVC conduit 150mm	7	tonne	
	UG cable 16mm xlpe street light	3	tonne	
	240mm xlpe LV	44	tonne	
	400mm xlpe HV	48	tonne	
Roadbase, asphalt etc.	Roadbase 180mm	10,515	tonne	Data provided by Hesperia was in m^2 This was multiplied by the thickness to get the volume, which was further multiplied by the material density to determine the total weight
	Subbase 130mm	9,835	tonne	
	Asphalt 30mm thick black	1,030	tonne	
	Asphalt 40mm thick black	706	tonne	
	Asphalt 40mm red asphalt	167	tonne	
	Pitching stones	177	tonne	
	Sand	590,090	tonne	

Table 27 - Information on operational energy provided by Hesperia.

Operational Energy		
Consumption	45.9	kWh/m^2 year
Generation	18.9	kWh/m^2 year
Imports	30.6	kWh/m^2 year
Exports	3.7	kWh/m^2 year

Appendix B – Background Data

Table 28 – Simapro Processes used on the project and linked GWP.

Process	Library	GWP kg CO_2 eq	Units
asphalt, standard hot mix, 5.5% virgin bitumen, at plant/AU U	AusLCI unit processes	0.071	kg
concrete 40 MPa, at batching plant/AU U	AusLCI unit processes	475.268	m^3
concrete 32 MPa, at batching plant/AU U	AusLCI unit processes	393.925	m^3
Reinforcing steel {RoW}I reinforcing steel production I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	2.135	kg
Aluminium, wrought alloy {GLO}I market for aluminium, wrought alloy I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	13.827	kg
Steel, low-alloyed {RoW}I steel production, converter, low-alloyed I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	2.182	kg
Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}I market for I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	0.191	tkm
Transport, freight, sea, bulk carrier for dry goods {GLO}I market for transport, freight, sea, bulk carrier for dry goods I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	0.007	tkm
Polyvinylchloride, emulsion polymerised {GLO}I market for polyvinylchloride, emulsion polymerised I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	3.008	kg
Copper {GLO}I market for copper I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	4.847	kg
Gravel, crushed {RoW}I gravel production, crushed I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	0.010	kg
Sand, at mine/AU U	Australasian Unit Process LCI	0.003	kg
recycled aggregate, at plant/AU U	AusLCI unit processes	0.005	kg
Diesel, burned in building machine {GLO}I diesel, burned in building machine I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	0.099	MJ
electricity, low voltage, Western Australia/AU U	AusLCI unit processes	0.177	MJ
Electricity, production mix photovoltaic, at plant/AU U	Ecoinvent unit processes	0.016	MJ
Polyethylene, high density, granulate {RoW}I polyethylene production, high density, granulate I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	2.687	kg
Glass fibre reinforced plastic, polyester resin, hand lay-up {RoW}I glass fibre reinforced plastic production, polyester resin, hand lay-up I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	4.231	kg
tap water, at user, Western Australia/AU U	AusLCI unit processes	0.00073	L
Glass fibre reinforced plastic, polyester resin, hand lay-up {RoW}I glass fibre reinforced plastic production, polyester resin, hand lay-up I Cut-off, U	Ecoinvent 3 - allocation, cut-off by classification - unit	4.231	kg

Appendix C – Detailed Carbon Footprint Results

Table 29 Carbon emissions for raw materials

	GWP kg CO2 eq.				
Warehouse	ALUMINIUM	ASPHALT	CONCRETE	MIX	STEEL
SILK	6,408.64	11,929.13	2,898,977.62	76,412.25	1,073,177.60
KTRANS	-	71,518.40	1,907,781.86	47,923.40	588,659.43
CHEP	1,742.15	15,816.69	2,971,728.67	43,293.00	738,605.40
EXPRO	-	37,381.01	501,204.97	59,810.38	738,605.40
NORTHLINE	19,034.83	-	2,921,003.18	115,750.94	1,061,722.93

Table 30 Carbon emissions for transport of raw materials

	GWP kg CO2 eq.		
Warehouse	transport to construction site - road	transport to construction site - ship	transport to landfill - road
SILK	64,063.23	6,811.33	6,448.38
KTRANS	45,343.92	3,739.70	4,557.48
CHEP	62,740.44	4,842.42	6,303.94
EXPRO	20,097.25	4,668.21	2,038.55
NORTHLINE	63,880.11	6,742.17	6,429.64

Table 31 Carbon emissions for civil and earth works per category.

	GWP kg CO2 eq.				
Warehouse	Concrete	Reinforcement steel	Hydraulic services	Electrical services	Road base, asphalt etc.
SILK	105,014.78	56,923.35	19,581.43	85,830.55	363,710.00
KTRANS	97,403.66	52,797.73	18,162.24	79,609.84	337,349.50
CHEP	101,766.26	55,162.49	18,975.70	83,175.47	352,459.00
EXPRO	26,922.30	22,721.93	7,816.27	34,260.74	145,181.09
NORTHLINE	103,754.94	56,240.45	19,346.52	84,800.86	359,346.63

Table 32 - Carbon emissions for construction energy

	GWP kg CO_2 eq.			
Warehouse	DIESEL	ELECTRICITY	WATER	TOTAL
SILK	602,633	459,296	8,935	1,070,864
EXPRO	240,551	183,336	2,251	426,138
KTRANS	558,957	426,007	3,078	988,042
Northline	595,404	453,786	7,873	1,057,062
CHEP	583,992	445,088	3,986	1,033,065

Table 33 - Carbon emissions for operations energy per year

	GWP kg CO2 eq.		
Warehouse	Grid GWP	PV GWP	Total GWP
SILK	416,225	25,759	441,985
KTRANS	143,374	8,873	152,247
CHEP	185,664	11,490	197,154
EXPRO	104,858	6,489	111,348
NORTHLINE	366,764	22,698	389,463

Table 34 - Carbon emissions for water usage.

Category /Warehouse	Water Usage (L/year)	GWP kg CO_2 eq./year
SILK	17,467,920	12,672
KTRANS	6,017,040	4,365
CHEP	7,791,840	5,653
EXPRO	4,400,640	3,192
NORTHLINE	15,392,160	11,166