Compliance Checklist

Performance Summary

Global Warming Potential, GWP (Life Cycle)

65% Saving against a target of 50%

Net use of fresh water, FW (Life Cycle)

50% Saving against a target of 50%

Performance Detail

	Initial Material & Construction	Use Stage Materials & Construction	Integrated Energy Use	Plug Load Energy Use	Water Supply & Treatment	End of Life	Recycling & Energy Export	Total
Global Warming Potential, GWP (kg CO_2 eq / occupant / year)								
Benchmark	838.2	505.5	939.5	822	120.6	119.4	-75.82	3269
Proposed Design	274.1	410.5	6.781	793.2	105.9	117.4	-558.2	1149
Difference	564	95	932.8	28.83	14.71	1.984	482.4	2119
Life Cycle Savings	17%	3%	29%	1%	0%	0%	15%	65%
Net use of fresh water, FW (kg / occupant / year)								
Benchmark	3721	1747	1202	1757	93693	592.8	-286	102430
Proposed Design	1637	1616	14.49	1696	47512	186	-1527	51135
Difference	2084	130.8	1188	61.64	46181	406.8	1241	51294
Life Cycle Savings	2%	0%	1%	0%	45%	0%	1%	50%

Building Attributes

Highlighted information denotes that changes were made from the “baseline design” and should be an area of focus for compliance checks.

33a Smith St, Highgate, WA

Dwellings:	2
Bedrooms:	5
Bathrooms:	5
Car parks:	2
Floors:	2
Type of carpark:	Car Port
Ceiling Height:	2.6
Gross Floor Area:	237
Occupancy Date:	01/10/2023

Energy Supply and Efficiency Attributes

Electricity Supply:	Mains Connected
Thermal Rating:	NatHERS 6.0 Star
Energy Monitoring:	No Energy Monitoring
Natural Lighting:	Normal

Water Supply and Efficiency Attributes

Water Supply:	Mains Supply
Water Treatment:	Mains Connected
Shower Heads:	3 Star (greater than 6.0 and less than or equal to 7.5 L/m)
Toilets:	5 star (4.7L/flush, 3.2/half flush, 3.0L/average flush)
Tapware:	4 Star (greater than 6.0 and less than or equal to 7.5 L/m)
Washing Machine:	4.5 star (9.5L/kg clothing washed)
Dishwasher:	5.0 star (8.57L/wash for 10 place setting dishwasher)
Garden Type:	Dripper garden bed and no lawn
Rainwater Pump Type:	Medium or high pressure and flow with pressure vessel

Building Components

Highlighted information denotes that changes were made from the “baseline design” component type, or changes were made to the default quantities and should be an area of focus for compliance checks.

Integrated Services

Component Type	Quantity
Cooking Appliances	
Cooking, Res Electric Oven Induction Stove	2 Households cooking energy
Hot Water System	
Standard Heat Pump (HWS_App)	2 240L Electric heat pump h...
Indoor Lighting Fitout	
LED Residential Lighting (Standard Efficiency)	2 Household
Cooling System	
Split System Air Source Heat Pump for Cooling, Average Efficiency (COP/EER 3.65), R32 Refrigerant	3 heat pump(s) 5kW
Heating System	
Split System Air Source Heat Pump for Heating, Average Efficiency (COP/EER 3.65), R32 Refrigerant	3 heat pump(s) 5kW

Plug Loads

Component Type	Quantity
Refrigeration	
Refrigeration, Residential Well Ventilated Fridge Recess	2 Refrigeration Energy Use
Dwellings	
Appliances Residential Average (AUS)	2 eTool: Average Household ...

Outdoor Services

Component Type	Quantity
Renewable Generation	
Solar PV System Residential - Zone 3 (Perth Sydney etc)	5 kW
Outdoor Lighting Fitout	
LED Outdoor Lighting (Residential - Standard Efficiency), m2	129.53 m2 of outdoor lit area
Swimming Pool Temperature Control	
Swimming Pool Seasonal Temperature Control - No Pool Cover - Gas	0 Pool Surface Area
Swimming Pool Filtering	
Swimming Pool - Pumps and Filters Ultra Efficient	0 m2 surface area
Swimming Pool Structure	
Pool Structure - Concrete	0 m2 pool surface area

Structure

Component Type	Quantity
Ground Floor Area	
Concrete Floor - 100mm slab on ground 30MPa 3.8% reo (Portland Cement)	129.9 eTool: m2 of floor slab -...
Upper Floor Area	
Elevated Floor, Timber Frame 300mm Bearers and Joists, <6m Span, particle board sheeting, insulated	223 m2 of elevated floor
Stairs	
Staircase, Timber frame and timber treads	2 2.4m Rise
External Wall Area	
Wall External Type 1, Masonry, double brick 110-50-110 insulated with foundations and finishes	70.6
Glazed Area	
Windows Residential Aluminium Single Glaze fly screen	46.4
Roof Area	
Roof - TimberTruss/SteelSheeting/25degreePitch	149.39
Entry Doors	
Door - Glazed Timber Frame Timber Jamb	4 Door (1.93m2)
Internal Doors	
Door - HollowCoreTimber/WoodenJam/painted	12 x 1.68m2 Door
External Wall Area	
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, coloured steel sheet cladding external	19.8
Internal Wall Area	
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	91.75
Internal Wall Area	
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	75.08
External Wall Area	
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, fibre cement clad (9mm)	108.5

Finishes

Component Type	Quantity
Living Areas	
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	66.74
Kitchens Dining Areas	
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	81.75
Wet Areas	
Floor Covering - Tiles (ceramic/5mm)	18.34 eTool: m2 of internal flo...
Bedroom Areas	
Floor Covering - Carpet (glue down/Nylon)	62.23 eTool: m2 of internal flo...

Compliance Checklist

Performance Summary

Global Warming Potential, GWP (Life Cycle)

67% Saving against a target of 50%

Net use of fresh water, FW (Life Cycle)

52% Saving against a target of 50%

Performance Detail

	Initial Material & Construction	Use Stage Materials & Construction	Integrated Energy Use	Plug Load Energy Use	Water Supply & Treatment	End of Life	Recycling & Energy Export	Total
Global Warming Potential, GWP (kg CO_2 eq / occupant / year)								
Benchmark	838.2	505.5	939.5	822	120.6	119.4	-75.82	3269
Proposed Design	223.3	342.3	29.05	751.8	102.4	93.29	-477.8	1064
Difference	614.9	163.1	910.5	70.22	18.15	26.11	402	2205
Life Cycle Savings	19%	5%	28%	2%	1%	1%	12%	67%
Net use of fresh water, FW (kg / occupant / year)								
Benchmark	3721	1747	1202	1757	93693	592.8	-286	102430
Proposed Design	1402	1362	62.11	1607	46135	146.5	-1307	49408
Difference	2319	385.6	1140	150.1	47558	446.3	1021	53021
Life Cycle Savings	2%	0%	1%	0%	46%	0%	1%	52%

Building Attributes

Highlighted information denotes that changes were made from the “baseline design” and should be an area of focus for compliance checks.

33b Smith St, Highgate, WA

Dwellings:	4
Bedrooms:	12
Bathrooms:	10.5
Car parks:	5
Floors:	2
Type of carpark:	Car Port
Ceiling Height:	2.6
Gross Floor Area:	489
Occupancy Date:	01/10/2023

Energy Supply and Efficiency Attributes

Electricity Supply:	Mains Connected
Thermal Rating:	NatHERS 6.0 Star
Energy Monitoring:	No Energy Monitoring
Natural Lighting:	Normal

Water Supply and Efficiency Attributes

Water Supply:	Mains Supply
Water Treatment:	Mains Connected
Shower Heads:	3 Star (greater than 6.0 and less than or equal to 7.5 L/m)
Toilets:	5 star (4.7L/flush, 3.2/half flush, 3.0L/average flush)
Tapware:	4 Star (greater than 6.0 and less than or equal to 7.5 L/m)
Washing Machine:	4.5 star (9.5L/kg clothing washed)
Dishwasher:	5.0 star (8.57L/wash for 10 place setting dishwasher)
Garden Type:	Dripper garden bed and no lawn
Rainwater Pump Type:	Medium or high pressure and flow with pressure vessel

Building Components

Highlighted information denotes that changes were made from the “baseline design” component type, or changes were made to the default quantities and should be an area of focus for compliance checks.

Integrated Services

Component Type	Quantity
Cooking Appliances	
Cooking, Res Electric Oven Induction Stove	4 Households cooking energy
Hot Water System	
Standard Heat Pump (HWS_App)	4 240L Electric heat pump h...
Indoor Lighting Fitout	
LED Residential Lighting (Standard Efficiency)	4 Household
Cooling System	
Split System Air Source Heat Pump for Cooling, Average Efficiency (COP/EER 3.65), R32 Refrigerant	7 heat pump(s) 5kW
Heating System	
Split System Air Source Heat Pump for Heating, Average Efficiency (COP/EER 3.65), R32 Refrigerant	7 heat pump(s) 5kW

Plug Loads

Component Type	Quantity
Refrigeration	
Refrigeration, Residential Well Ventilated Fridge Recess	4 Refrigeration Energy Use
Dwellings	
Appliances Residential Average (AUS)	4 eTool: Average Household ...

Outdoor Services

Component Type	Quantity
Renewable Generation	
Solar PV System Residential - Zone 3 (Perth Sydney etc)	10 kW
Outdoor Lighting Fitout	
LED Outdoor Lighting (Residential - Standard Efficiency), m2	229.21 m2 of outdoor lit area
Swimming Pool Temperature Control	
Swimming Pool Seasonal Temperature Control - No Pool Cover - Gas	0 Pool Surface Area
Swimming Pool Filtering	
Swimming Pool - Pumps and Filters Ultra Efficient	0 m2 surface area
Swimming Pool Structure	
Pool Structure - Concrete	0 m2 pool surface area

Structure

Component Type	Quantity
Ground Floor Area	
Concrete Floor - 100mm slab on ground 30MPa 3.8% reo (Portland Cement)	313 eTool: m2 of floor slab -...
Upper Floor Area	
Elevated Floor, Timber Frame 300mm Bearers and Joists, <6m Span, particle board sheeting, insulated	225 m2 of elevated floor
Stairs	
Staircase, Timber frame and timber treads	4 2.4m Rise
External Wall Area	
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, fibre cement clad (9mm)	329
Glazed Area	
Windows Residential Aluminium Single Glaze fly screen	95.73
Roof Area	
Roof - TimberTruss/SteelSheeting/25degreePitch	300.08
Entry Doors	
Door - SolidCoreTimber/WoodenJam/Painted	8 Door (1.68m2)
Internal Doors	
Door - SolidCoreTimber/WoodenJam/Painted	24.5 Door (1.68m2)
External Wall Area	
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, coloured steel sheet cladding external	178.9
Internal Wall Area	
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	189.3
Internal Wall Area	
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	154.91
External Wall Area	
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, fibre cement clad (9mm)	67.8

Finishes

Component Type	Quantity
Living Areas	
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	123.03
Kitchens Dining Areas	
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	150.71
Wet Areas	
Floor Covering - Tiles (ceramic/5mm)	33.8 eTool: m2 of internal flo...
Bedroom Areas	
Floor Covering - Carpet (glue down/Nylon)	144 eTool: m2 of internal flo...

Life Cycle Assessment

33a Smith St, Highgate, WA

City of Vincent

Date : 25 October 2022

Authors : Robin Campbell (Lead)

Phone : 0411 141 246

Address : 99 Loftus St, Leederville

Email : info@email.com

Report Id : 30450

eToolLCD Software Disclaimer

The LCA predictions of embodied and operational impacts (including costs) conducted in eToolLCD software, by their very nature, cannot be exact. It is not possible to track all the impacts associated with a product or service back through history, let alone do this accurately. eToolLCD software has been built and tested to enable informed decisions when comparing design options. Generic cost and environmental impact coefficients do not necessarily correspond to those of individual brands of the same product or service due to differences within industries in the way these products and services are delivered.

This LCA study has not been reviewed and as such does not meet the relevant section of the ISO14044 requirements. Caution should be taken when interpreting the LCA study report.

eTool PTY LTD cannot make assurances regarding the accuracy of these reports for the above reasons.

Executive Summary

This Life Cycle Assessment has been completed for a number of design scenarios for the Low Density Dwelling, located at 33a Smith St, Highgate, WA. The Author of the study is Robin Campbell of eTool and no critical review has been conducted.

The goal of this study is to profile and improve the environmental performance of the construction works at 33a Smith St, Highgate, WA. The life cycle performance of the project is compared to other designs. The study has been conducted in accordance with ISO 14044 and EN15978.

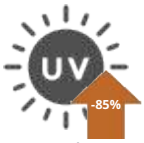
Characterised Impacts Per Occupant Per Year		Benchmark Design	Improved Design	Improved Design Savings Against Benchmark Design
Environmental Impacts				
Global Warming Potential, GWP	kg CO_2 eq	3.31e+3	1.15e+3	65%
Ozone Depletion Potential, ODP	kg CFC-11 eq	1.24e-4	2.29e-4	-85%
Acidification Potential for Soil and Water, AP	kg SO_2 eq.	8.92e+0	5.14e+0	42%
Eutrophication potential, EP	kg PO_4 eq	2.95e+0	2.32e+0	21%
Photochemical Ozone Creation Potential, POCP	kg ethylene	5.92e-1	3.96e-1	33%
Abiotic Depletion Potential - Elements, ADPE	kg antimony	1.07e-1	8.52e-2	20%
Abiotic Depletion Potential - Fossil Fuels, ADPF	MJ	44873	15518	65%

Table 1: Summary of Results

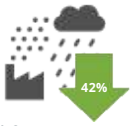
The Improved Design shows an expected performance improvement against Business as Usual for 6 of the 7 environmental indicators.

Improved Design Performance against Benchmark

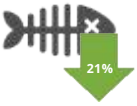
Global Warming Potential, GWP



Ozone Depletion Potential, ODP



Acidification Potential for Soil and Water, AP



Eutrophication potential, EP

Photochemical Ozone Creation Potential, POCP

Abiotic Depletion Potential - Elements, ADPE

Abiotic Depletion Potential - Fossil Fuels, ADPF

Table of Contents

1 Introduction

Managing the environmental impacts that arise from the construction and operation of Building is of key importance in mitigating the damage caused directly and indirectly on the biosphere. Life Cycle Assessment (LCA) is the leading industry standard in clearly identifying optimum strategies for reducing environmental impacts. This report presents the results of the LCA completed for the Improved Design, City of Vincent Project located at 33a Smith St, Highgate, WA. eToolLCD software has been used to model the infrastructure's environmental impacts.

The study has been conducted in accordance with the following standards:

- International Standards 14040 and 14044.
- European Standard EN 15978: *Sustainability of Construction Works – Assessment of Environmental Performance of Buildings – Calculation Method*

The Author of the study is Robin Campbell of eTool and no critical review has been conducted.

2 Goal of the study

The goal of this study is to provide profile and improve the environmental performance of the construction works at 33a Smith St, Highgate, WA. The life cycle performance of the project is compared to other designs and as such this is a comparative study. The results of the study are intended to be made public.

3 Scope of the study

The LCA study has been conducted in accordance with the EN 15978 standard to assess the direct and indirect potential environmental impacts associated with the construction works at 33a Smith St, Highgate, WA as part of the City of Vincent project.

3.1 Functional Unit

The function of the Building must reflect the core purpose of the asset such that it can be compared accurately to different designs. In this case, the functional focus is the Residence and the chosen functional unit is the provision of this function for one Occupant over one year.

The estimated design life of the design is 55 years which has been adopted for the LCA study period. This takes into consideration the structural service life limit (150 years), as well as redevelopment pressure on the asset such as surrounding density, asset ownership structures, and the architectural design quality.

Note that products with expected service lives of less than the life span of the project are assumed to be replaced at increments reflecting their service life.

3.2 System Boundary

The system boundary, shown in Figure 1, follows guidance given in EN15978.

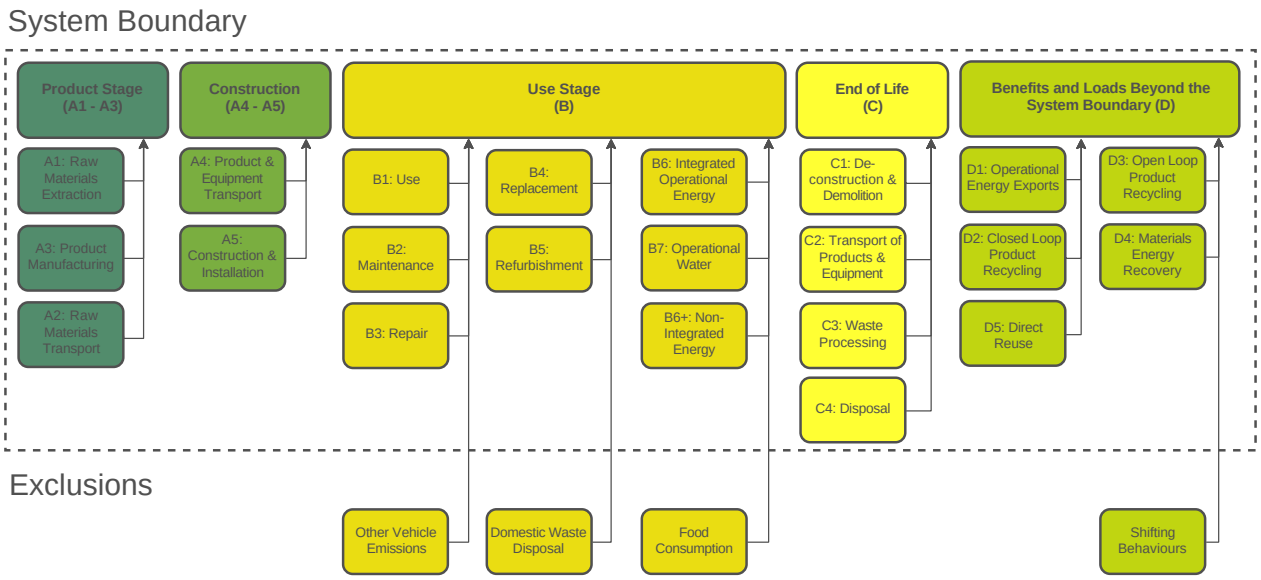


Figure 1: System Boundary Diagram

3.3 Environmental Indicators

The environmental indicators have been included in the study are detailed in Table 2. For further information regarding the environmental indicators please refer to Appendix A.

Environmental Indicator	Unit	Abbreviation	Characterisation Method
Environmental Impacts			
Global Warming Potential, GWP	kg CO_2 eq	GWP	CML-IA baseline V4.5
Ozone Depletion Potential, ODP	kg CFC-11 eq	ODP	CML-IA baseline V4.5
Acidification Potential for Soil and Water, AP	kg SO_2 eq.	AP	CML-IA baseline V4.5
Eutrophication potential, EP	kg PO_4 eq	EP	CML-IA baseline V4.5
Photochemical Ozone Creation Potential, POCP	kg ethylene	POCP	Institute of Environmental Sciences (CML)
Abiotic Depletion Potential - Elements, ADPE	kg antimony	ADPE	CML-IA baseline V4.5
Abiotic Depletion Potential - Fossil Fuels, ADPF	MJ	ADPF	CML-IA baseline V4.5

Table 2: Environmental Indicators Included in LCA study.

3.4 System Description

The object of the assessment is the Low Density Dwelling, located at 33a Smith St, Highgate, WA. The assessment includes all the upstream and downstream processes needed to provide the primary function of the structure from construction, maintenance, operation, and finally demolition and disposal associated with the low density dwelling. The inventory includes the extraction of raw materials or energy and the release of substances back to the environment or to the point where inventory items exit the system

boundary either during or at the end of the project life cycle.

The area of the project is the City of Vincent local government in Western Australia. This local government authority covers an area of approximately 10.4 square kilometres in metropolitan Perth, the capital of Western Australia, and lies about 3 km from the Perth CBD. It includes the suburbs of Highgate, Leederville, Mount Hawthorn, North Perth, as well as parts of Coolbinia, East Perth, Mount Lawley, Osborne Park, Perth and West Perth. The City of Vincent maintains 139 km of roads and 104 ha of parks and gardens.

New developments in the area must comply with the city's built form policy released in 2020.

The project location is shown in figures 2 and 3.

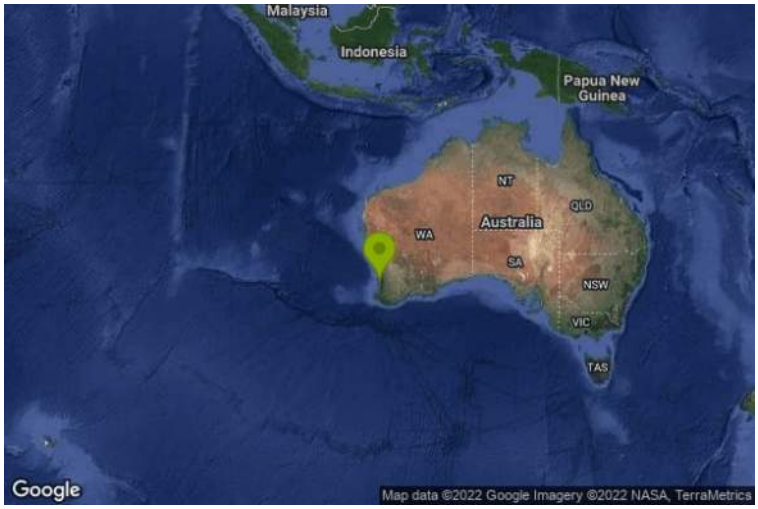


Figure 2: Location of the project - Global View.

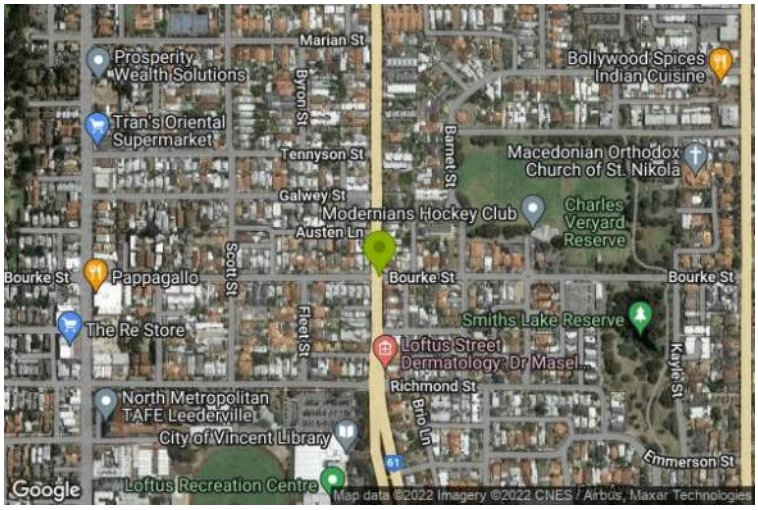


Figure 3: Location of the project - Locality View.

2 Townhouses. U1 is 3br, 2 bath plus powder room. U2 us 2br, 2 bath plus powder room. Parking on the ground level (7 bays in total for the whole site, which includes 4 more townhouses).

Table 3 below shows the key characteristics of the design.

	Business as Usual	Improved Design
Design Details		
Design Name	AU WA Res Ave Code Compl CZ 5 (10 dwellings)	33a Smith St, Highgate, WA

	Business as Usual	Improved Design
Stories (#)	2	2
Functional Focus	Single Family Residence	Residence
Structural Service Life Limit	100	150
Predicted Design Life	54	55
Functional Characteristics		
Dwellings	10	2
Bedrooms	30	5
Occupants	24	4
Vehicle Spaces	0	2
Total Floor Areas		
Usable Floor Area	2,140	201
Net Lettable Area	0	0
Fully Enclosed Covered Area	3,010	201
Unenclosed Covered Area	0	36
Gross Floor Area	3,010	237
Usable and Lettable Yield	71 %	85 %

Table 3: Design Characteristics Compared

Table 4 and 5 show the scope (structural and operational) of the inventory collection for the LCA. For further details on structure scope please refer to Appendix B.

Summary Structure Scope Diagram

Key: ✓ In Scope ✓ Partial ✗ Out of Scope

Category Name	Benchmark Design	Improved Design
Substructure	✓	✗
Superstructure	✓	✗
Internal finishes	✓	✗
Fittings, furnishings and equipment	✓	✗
Services equipment	✓	✗
Prefabricated buildings and building units	✗	✗
Work to existing building	✗	✗
External works	✓	✗
Facilitating works	✓	✗
Project/design team	✓	✗
Undefined	✗	✗

Table 4: Structural scope of LCI collection

Operational Scope diagram

Key: ✓ In Scope ✗ Out of Scope

Category Name	Benchmark Design	Improved Design
Appliances | Dishwashers	✓	✗
Appliances | Entertainment	✓	✗
Appliances | Laundry Appliances	✓	✗
Appliances | Office Workstations	✓	✗
Communications	✓	✗
Cooking and Food Preparation	✓	✗
Domestic Water Heating	✓	✗
Electrical Parasitic Loads	✓	✗
Fire Protection	✗	✗
HVAC	✓	✗
Industrial & Manufacturing Equipment	✗	✗
Lifts, Elevators and Conveying	✗	✗
Lighting	✓	✗
Miscellaneous	✗	✗
Monitoring, Control and Automation	✓	✗
Power Generation and Storage	✓	✗
Refrigeration	✓	✗

Category Name	Benchmark Design	Improved Design
Safety and Security	✓	✗
Swimming Pools	✓	✗
Water Pumping	✓	✗
Water Removal and Treatment	✓	✗
Water Supply	✓	✗
Workshops, Garage & Misc	✓	✗

Table 5: Operational scope of LCI collection

3.5 Cut off Criteria

The EN15978 cut-off criteria were used to ensure that all relevant potential environmental impacts were appropriately represented:

- Mass – if a flow is less than 1% of the mass at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not of concern.
- Energy – if a flow is less than 1% of the energy at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not a concern.
- The total of neglected input flows per module, e.g. per module A1-A3, A4-A5, B1-B5, B6-B7, C1-C4 and module D shall be a maximum of 5% of energy usage and mass.
- Environmental relevance – if a flow meets the above criteria for exclusion, but is considered to potentially have a significant environmental impact, it has been included. All material flows which leave the system (emissions) and whose environmental impact is higher than 1% of an impact category, have been included.

The Operational Guidance for Life Cycle Assessment Studies (Wittstock et al. 2012) states:

The apparent paradox is that one must know the final result of the LCA (so one can show that the omission of a certain process is insignificant for the overall results) to be able to know which processes, elementary flows etc. can be left out.

The approach taken in this study is to continue modelling smaller inputs until confidence is gained that the criteria is safely met.

3.6 Allocation

Allocation rules follow those of EN15804 as given below:

- Allocation will respect the main purpose of the studied processes. If the main purpose of combined processes cannot be defined (e.g. combined mining and extraction of nickel and precious metals), economic allocation may be used to divide resources and emissions between the products.
- The principle of modularity is maintained. Where processes influence the product's environmental performance during its life cycle, they will be assigned to the module where they occur.
- The sum of the allocated inputs and outputs of a unit process are equal to the inputs and outputs of the unit process before allocation. This means no double counting of inputs or outputs is permissible.

3.7 Independent Review

No independent review has been conducted of this study.

4 Inventory Analysis

The design has been modelled using the available eToolLCD elements, templates and EPDs as shown in Table 6.

eToolLCD Item Type	Count in Design	
	Benchmark	Improved Design
Design Templates	24	134
Equipment and People Elements	495	195
Material Elements	841	344
Energy Elements	38	30
Water Elements	12	13
EPDs	0	0

Table 6: Count of elements, templates and EPDs in the design

The eToolLCD library templates are customisable and users may submit templates for validation. The template validation process is undertaken by experienced LCA practitioners and is a process of checking the user inputs and ensuring the assumptions are adequately referenced. Table 7 shows the extent to which validated templates were used in the model.

eToolLCD Item Type	Validated (%)	
	Benchmark	Improved Design
Total Design Templates	8.33	53.73
Equipment and People Elements	1.01	56.92
Material Elements	.48	40.41
Energy Elements	0	0
Water Elements	0	0

Table 7: Use of validated templates

4.1 Templates Comparison

The eToolLCD templates found in each design are provided in Table 8.

Parent Template Name	Units	Quantity
		Improved Design
Fittings, furnishings and equipment		
Appliances Residential Average (AUS)	#	2
Cooking, Res Electric Oven Induction Stove	#	2
Kitchen Medium sized (incl Equipment)	#	2
Refrigeration, Residential Well Ventilated Fridge Recess	#	2
Standard 1st Bathroom - WC/Shower-bath/Basin/WallTiles	#	5
Substructure		
Concrete Floor - 100mm slab on ground 30MPa 3.8% reo (Portland Cement)	m2	129.902
Staircase, Timber frame and timber treads	Other	2
Facilitating works		
Demolition - Residential (End-of-Life)	#	2
Superstructure		
Door - Glazed Timber Frame Timber Jamb	#	4
Door - HollowCoreTimber/WoodenJam/painted	#	12
Elevated Floor, Timber Frame 300mm Bearers and Joists, <6m Span, particle board sheeting, insulated	m2	223
Roof - TimberTruss/SteelSheeting/25degreePitch	m2	149.3873
Wall External Type 1, Masonry, double brick 110-50-110 insulated with foundations and finishes	m2	70.6
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, coloured steel sheet cladding external	m2	19.8
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, fibre cement clad (9mm)	m2	108.5
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	m2	166.83
Windows Residential Aluminium Single Glaze fly screen	m2	46.3960030684931
Services equipment		
Electrical Fittings - sockets power points wiring embodied only (m2)	m2	372
LED Outdoor Lighting (Residential - Standard Efficiency), m2	m2	129.533946065403
LED Residential Lighting (Standard Efficiency)	#	2

Parent Template Name	Units	Quantity
		Improved Design
Solar PV System Residential - Zone 3 (Perth Sydney etc)	Other	5
Split System Air Source Heat Pump for Cooling, Average Efficiency (COP/EER 3.65), R32 Refrigerant	#	3
Split System Air Source Heat Pump for Heating, Average Efficiency (COP/EER 3.65), R32 Refrigerant	#	3
Standard Heat Pump (HWS_App)	#	2
Swimming Pool - Pumps and Filters Ultra Efficient	m2	0.001
Utilities Connection to Site Residential	#	2
Water tank - steel (embodied)	Other	7E-06
Water Use and Treatment (eTool Turbo)	#	2
Internal finishes		
Floor Covering - Carpet (glue down/Nylon)	m2	62.2285714285714
Floor Covering - Tiles (ceramic/5mm)	m2	18.335449385052
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	m2	148.49
External works		
Pool Structure - Concrete	m2	0.001
Swimming Pool Seasonal Temperature Control - No Pool Cover - Gas	m2	0.001

Table 8: Templates Comparison (showing master templates only)

4.2 eToolLCD software

eToolLCD software was used to model life cycle impacts of the project. eToolLCD uses third party background processes aggregated as mid-point indicators and stored in a number of libraries within the software which are coupled with algorithms and user inputs to output the environmental impact assessment. A map of user inputs, data sources and algorithms (outputs) is given in Figure 4.

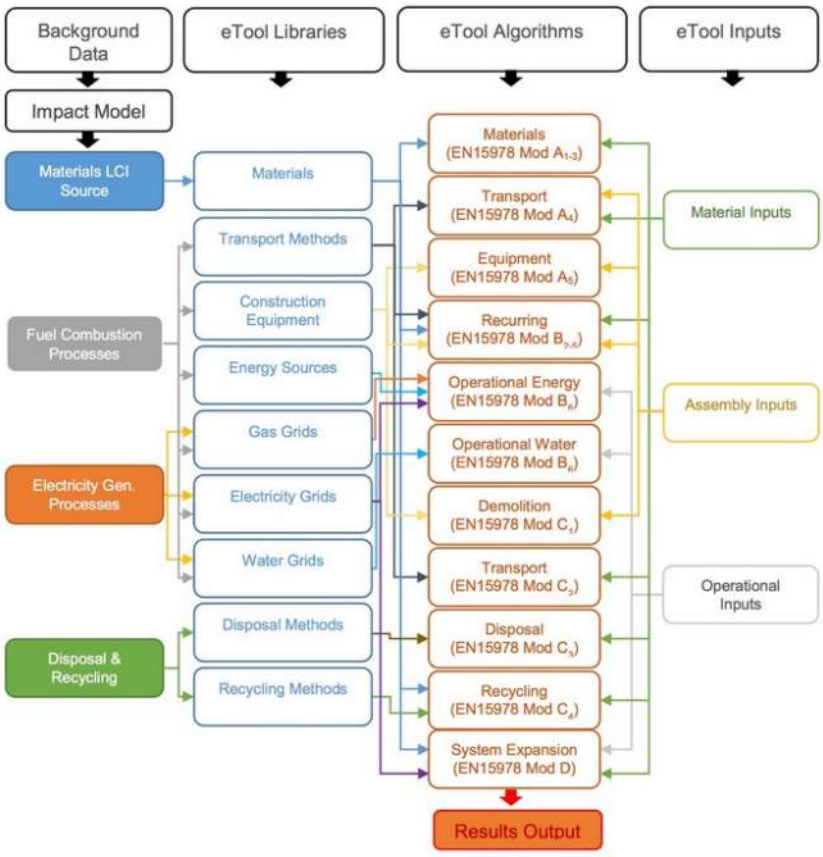


Figure 4: Relationship between LCI background data, eToolLCD software library, inputs and algorithms.

4.3 Data Quality

The data quality requirements for the background data are detailed in Table 9. Each of the criteria has been assessed for compliance and results presented below.

Criteria	Background Data Requirement	Compliance	
		Benchmark	Improved Design
Temporal Relevancy	For annually fluctuating processes like Grid electricity fuel mixes the datasets must have been updated within the last 2 years. More static processes like materials production must have been updated within the last 10 years. Product specific EPDs must have been updated in the last 5 years.	Failed Grid Passed Materials	Failed Grid Passed Materials
Geographical Relevancy	The background data should be specifically compiled for the same country (preferable) or continent as the project location.	Passed (Same Continent)	Passed (Same Country)
Precision	No requirement specified however a qualitative review undertaken to ensure no erroneous values	Passed	Passed
Completeness	Qualitative assessment of the process to ensure no obvious exclusions	Passed	Passed
Technological Relevancy	Ensure that technology assumptions are representative for the product or product group.	Passed	Passed
Consistency	The study methodology holds for the background data.	Passed	Passed
Reproducibility	The information available about the methodology and the data values reported should allow an independent practitioner to reproduce the results reported in the study.	Passed	Passed

Table 9: Summary of data quality requirements for the study.

Criteria	Inventory Collection Requirement (eToolLCD User Inputs)	Compliance	
		Benchmark	Improved Design
Temporal Relevancy	All inputs into eToolLCD to be reflective of the project being assessed and if assumptions are made these are to be based on industry practices that are consistent with the project commissioning date.	Passed 0/5 Checks	Passed 0/1 Checks
Geographical Relevancy	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these are based on the current practices employed in the project country.	Passed 0/5 Checks	Passed 0/2 Checks
Precision	To avoid aggregated errors a high level of precision is expected inputs into eToolLCD software, being either to 3 significant figures or: • Two significant figures or nearest 10 hours for equipment run time • Two significant figures or nearest 10kg for material quantities • Two significant figures or nearest 100MJ / annum for operational energy • Two significant figures or nearest 100kL / annum for operational water use	Passed 0/4 Checks	Passed 0/1 Checks
Completeness	Inputs to cover all life cycle phases and elements identified in the system boundary. The link between background data, eToolLCD algorithms and subsequent LCA results is not to introduce significant gaps in the data.	Passed 0/9 Checks	Passed 0/2 Checks
Technological Relevancy	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these must be drawn from appropriate examples of like technology.	Passed 0/5 Checks	Passed 0/1 Checks
Consistency	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these are drawn from the same reference library.	Passed 0/9 Checks	Passed 0/0 Checks
Reproducibility	The information available about the methodology and the data values reported should allow an independent practitioner to reproduce the results reported in the study.	Passed 0/9 Checks	Passed 0/1 Checks

Table 10: Summary of data quality requirements for the study.

4.4 Completeness

The study aims to follow EN15804 procedures for exclusion of inputs and outputs:

- All inputs and outputs to a (unit) process shall be included in the calculation, for which data are available.
- Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be documented.
- In case of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1 % renewable and non-renewable primary energy usage and 1 % of the total mass input of that unit process.
- The total of neglected input flows per module, e.g. per module shall be a maximum of 5 % of energy usage and mass.
- Conservative assumptions in combination with plausibility considerations and expert judgement can be used to demonstrate compliance with these criteria.

- Particular care should be taken to include material and energy flows known to have the potential to cause significant emissions into air and water or soil related to the environmental indicators.

Two major tests were run to determine the compliance with the above cut-off rules.

4.3.1 Inventory Mass Quantities

The cumulative mass of inventory entries is shown in Figure 5. Given that 192 material elements within the LCA base design make up the last 1% of mass inventory entries a high level of confidence exists that the cut off rules have been upheld.

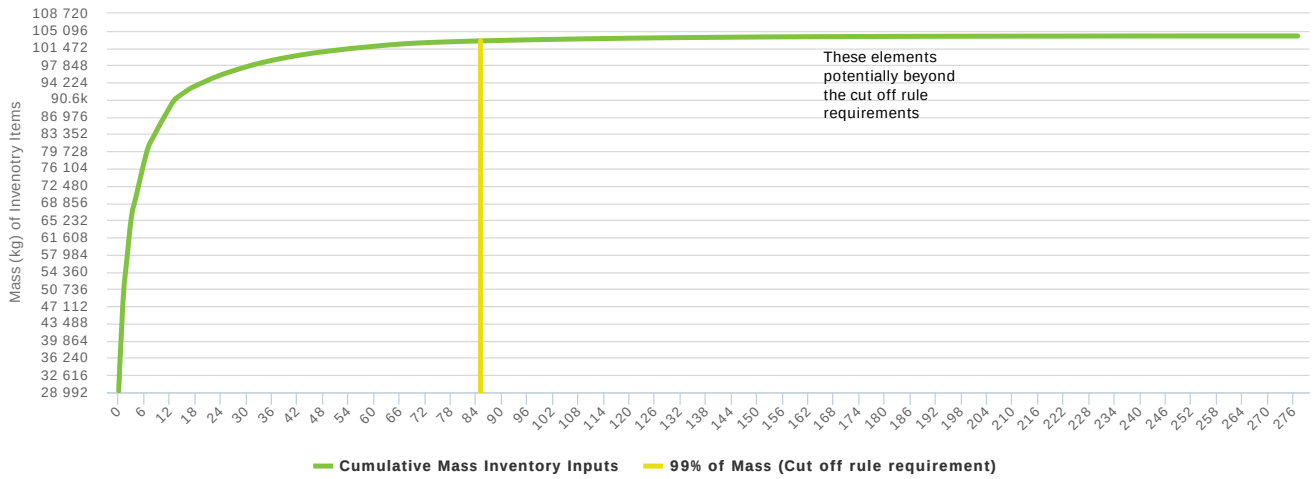


Figure 5: Cumulative Mass Inventory Entries. In this case 69.06% make up the last 5% of mass inventory entries.

4.3.2 Inventory Energy Analysis

The cumulative embodied energy of inventory entries is shown in Figure 6. Given that 329 elements within the LCA base design make up the last 1% of embodied energy inventory entries a high level of confidence exists that the cut off rules have been upheld.

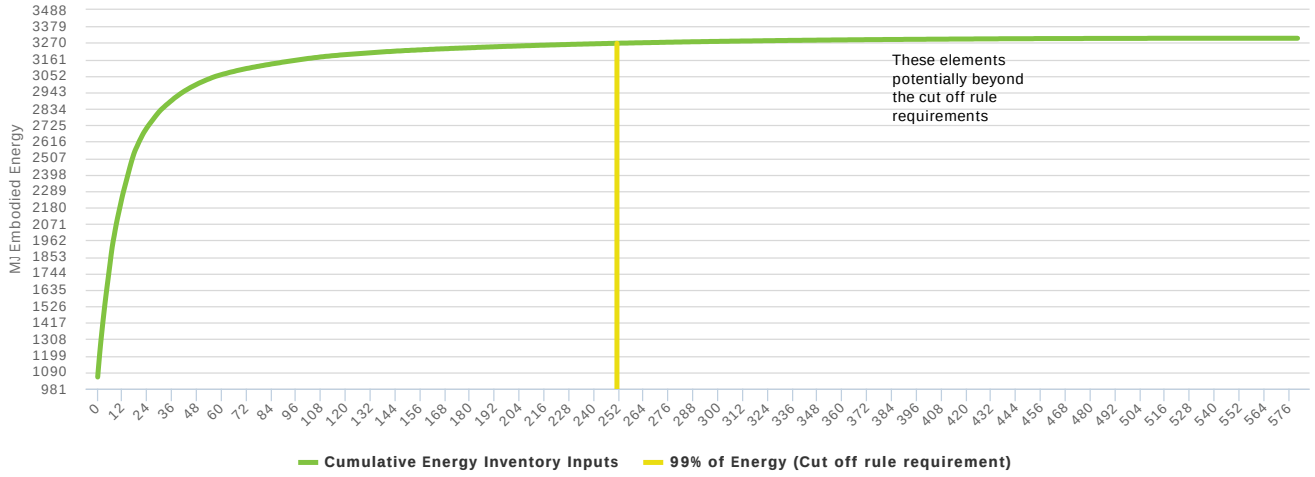


Figure 6: Cumulative Energy Inventory Entries. In this case 56.63% make up the last 5% of energy inventory entries.

5 Life Cycle Impact Assessment

The Life Cycle Impact Assessment (LCIA) results are provided in Table 11 and subsequent tables in the EN15978 reporting format. The heat map highlights the highest impacts for each indicators assessed and conversely in the comparison tables the highest savings observed. For further details on the LCIA please refer to interpretation.

5.1 Improved Design Environmental Impacts Indicators

Characterised Impacts Per Occupant Per Year		Materials and Construction			Use Stage								End of Life Stage				Benefits and Loads Beyond the System Boundary	Total
		A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B6+	B7	C1	C2	C3	C4	D	
Benchmark																		
GWP	kg CO_2 eq	6.18e+2	1.24e+2	95.742	0	0	MNA	5.06e+2	0	9.40e+2	8.22e+2	1.66e+2	0	50.083	0	69.335	-75.873	3.31e+3
ODP	kg CFC-11 eq	3.00e-5	1.91e-5	1.47e-5	0	0	MNA	3.44e-5	0	4.88e-6	6.59e-6	3.61e-6	0	7.97e-6	0	4.61e-6	-2.26e-6	1.24e-4
AP	kg SO_2 eq.	3.5093	0.3927	0.2682	0	0	MNA	2.4678	0	1.1599	1.5239	0.3678	0	0.1555	0	0.0906	-1.0128	8.9228
EP	kg PO_4 eq	1.28e+0	9.64e-2	4.67e-2	0	0	MNA	8.26e-1	0	3.81e-1	5.09e-1	2.43e-1	0	3.47e-2	0	1.94e-2	-4.85e-1	2.95e+0
POCP	kg ethylene	2.24e-1	2.51e-2	3.61e-2	0	0	MNA	1.67e-1	0	8.29e-2	4.24e-2	2.40e-2	0	1.03e-2	0	1.40e-2	-3.41e-2	5.92e-1
ADPE	kg antimony	5.86e-2	3.61e-3	2.61e-4	0	0	MNA	4.79e-2	0	4.21e-3	6.09e-3	2.88e-3	0	2.02e-3	0	1.11e-4	-1.88e-2	1.07e-1
ADPF	MJ	7674.4	1899.3	1298.7	0	0	MNA	7168.8	0	1.38e+4	1.06e+4	2002.3	0	779.5	0	464	-826.2	44873
Improved Design																		
GWP	kg CO_2 eq	193.02	53.535	29.832	-0.421	4.543	MNA	4.08e+2	0	6.782	7.93e+2	1.06e+2	11.326	13.298	2.14	90.659	-5.58e+2	1.15e+3
ODP	kg CFC-11 eq	4.71e-5	8.18e-6	2.96e-6	0	5.54e-7	MNA	1.59e-4	0	5.43e-8	6.36e-6	2.44e-6	1.96e-6	2.12e-6	4.30e-7	1.06e-6	-2.78e-6	2.29e-4
AP	kg SO_2 eq.	2.52e+0	1.74e-1	0.0637	0	1.60e-2	MNA	2.14e+0	0	1.26e-2	1.47e+0	2.40e-1	3.30e-2	4.10e-2	5.17e-3	2.21e-2	-1.59e+0	5.14e+0
EP	kg PO_4 eq	1.29e+0	4.64e-2	9.64e-3	0	0.0049	MNA	9.12e-1	0	0.0042	4.91e-1	1.78e-1	0.0067	0.0091	1.13e-3	4.78e-3	-6.32e-1	2.32e+0
POCP	kg ethylene	1.79e-1	1.10e-2	1.40e-2	0	1.04e-3	MNA	1.66e-1	0	3.50e-4	4.09e-2	1.56e-2	2.55e-3	2.72e-3	1.95e-4	1.37e-2	-5.06e-2	3.96e-1
ADPE	kg antimony	3.64e-2	1.44e-3	6.14e-5	0	1.88e-4	MNA	4.93e-2	0	5.02e-5	5.88e-3	2.04e-3	8.76e-5	4.96e-4	1.85e-5	2.47e-5	-1.08e-2	8.52e-2
ADPF	MJ	3956	813.4	275.6	0	65.5	MNA	5286.7	0	87.6	1.03e+4	1263.3	170.2	206	27.3	104.8	-6988.8	15518
Savings (Improved Design Compared to Benchmark)																		
GWP	kg CO_2 eq	4.25e+2	70.476	65.911	0.421	-4.543	MNA	97.81	0	9.33e+2	28.832	59.665	-11.326	36.785	-2.14	-21.323	4.82e+2	65.2%
ODP	kg CFC-11 eq	-1.71e-5	1.10e-5	1.18e-5	0	-5.54e-7	MNA	-1.24e-4	0	4.82e-6	2.31e-7	1.17e-6	-1.96e-6	5.85e-6	-4.30e-7	3.56e-6	5.20e-7	-85.22%
AP	kg SO_2 eq.	9.94e-1	2.19e-1	2.04e-1	0	-1.60e-2	MNA	3.31e-1	0	1.15e+0	5.34e-2	1.28e-1	-3.30e-2	1.14e-1	-5.17e-3	0.0685	5.77e-1	42.39%
EP	kg PO_4 eq	-5.43e-3	5.00e-2	3.70e-2	0	-0.0049	MNA	-8.61e-2	0	3.77e-1	1.79e-2	6.57e-2	-0.0067	2.55e-2	-1.13e-3	1.47e-2	1.47e-1	21.35%
POCP	kg ethylene	4.53e-2	1.41e-2	2.21e-2	0	-1.04e-3	MNA	1.73e-3	0	8.26e-2	1.49e-3	8.43e-3	-2.55e-3	7.58e-3	-1.95e-4	2.94e-4	1.65e-2	33.13%
ADPE	kg antimony	2.22e-2	2.16e-3	2.00e-4	0	-1.88e-4	MNA	-1.41e-3	0	4.16e-3	2.14e-4	8.36e-4	-8.76e-5	1.53e-3	-1.85e-5	8.64e-5	-8.02e-3	20.28%
ADPF	MJ	3718.4	1085.9	1023.1	0	-65.5	MNA	1882.1	0	1.37e+4	372.6	739	-170.2	573.5	-27.3	359.2	6162.5	65.42%

Table 11: Environmental Impacts Impact of Each Life Cycle Phase.
INA: Indicator Not Assessed. MNA: Module Not Assessed.
Impact Key: Top 10% Top 20% Top 30%
Savings Key: Top 10% Top 20% Top 30%

6 Life Cycle Interpretation

The following sections provide more detailed results of the life cycle impact assessment for each environmental indicator with the aim of identifying the largest areas of impact. A one page profile for each indicator is provided on the subsequent pages giving detailed information about the indicator. Each chart provided is explained below.

Impact Time Series Chart:

A chart displaying when impacts occur during the life of a design. This enables users to gain insights such the “environmental payback period” of a design compared to alternatives, or when there are jumps in an impact value during the life of the project (for example, relating to a large replacement item).

Top Five Charts

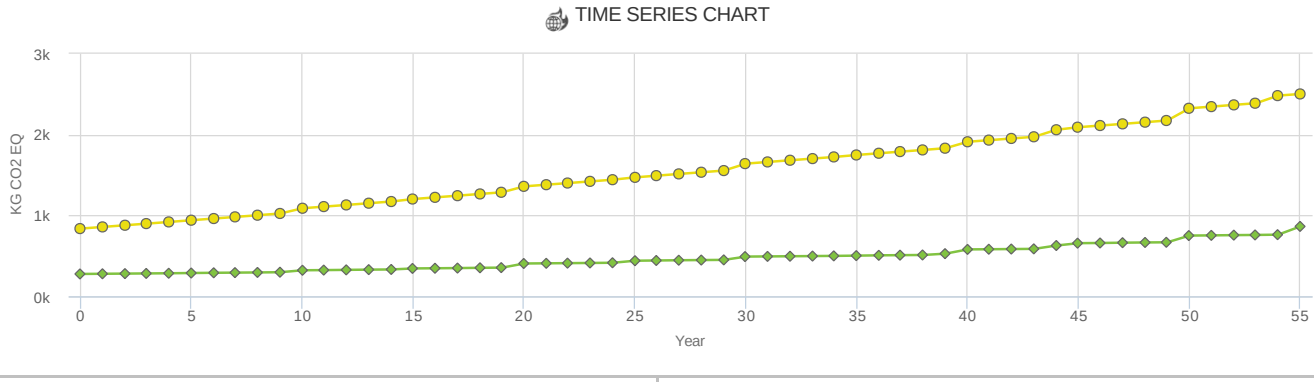
Each top 5 chart categorises the buildings and expresses the environmental impacts by these categories. This enables a detailed understanding of what is responsible for the greatest environmental burdens and also compares these burdens between designs. The pie chart associated with each bar chart shows the proportion of the building that is represented in the bar chart. A brief description of the categories is provided below:

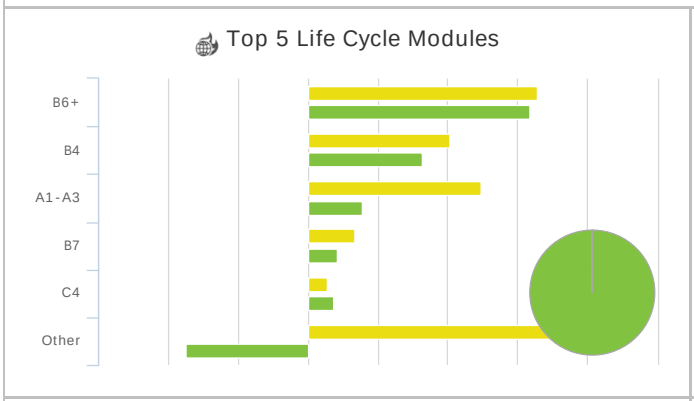
- **LC Module Impacts:** The EN15978 Life Cycle Modules. Generally 100% building impacts will be included in the bar chart.
- **Construction Category:** The breakdown of the impacts by construction category. The bar chart will generally only part of the total building impacts.
- **Operational Demand:** The building end use demands that are driving environmental impacts.
- **Energy Supply:** The supply of fuels to the building, in effect the upstream fuel sources supplying energy for on site use during construction, operational and demolition.
- **Materials:** The materials (grouped into common categories) that are driving the environmental impacts.
- **Equipment and People:** The equipment and people required during construction, maintenance and demolition and all associated transport trips that are driving the environmental impacts

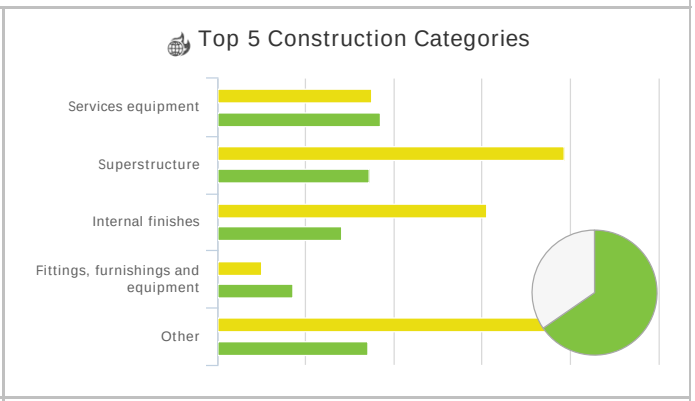
All impact figures are quoted per the functional unit selected for the study.

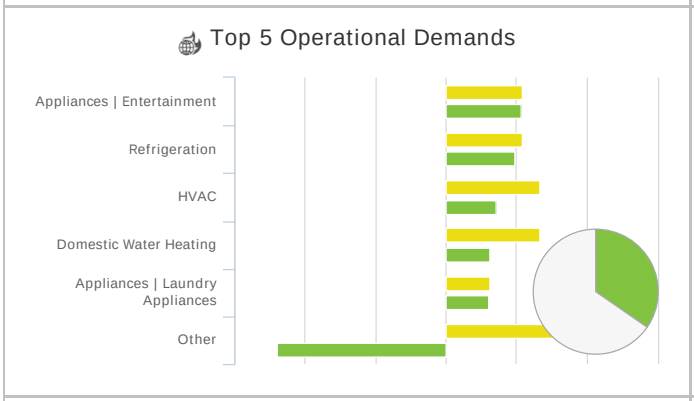
6.1 Global Warming Potential, GWP Profile

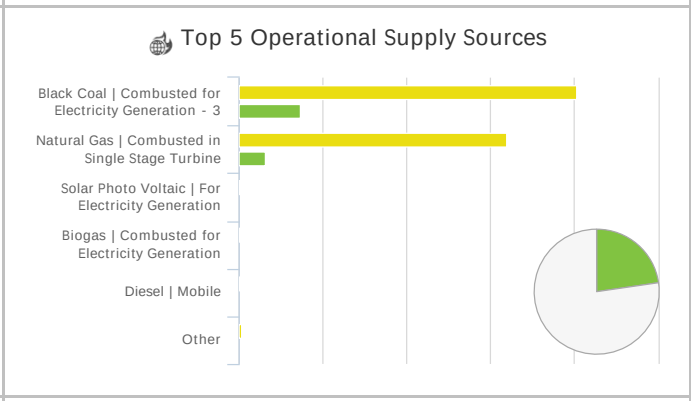
Business as Usual Improved Design

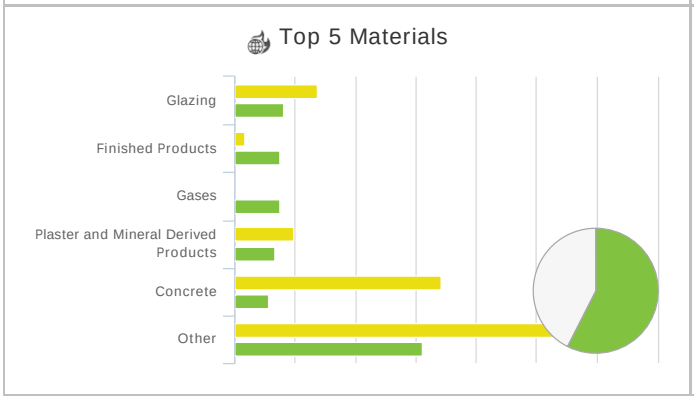


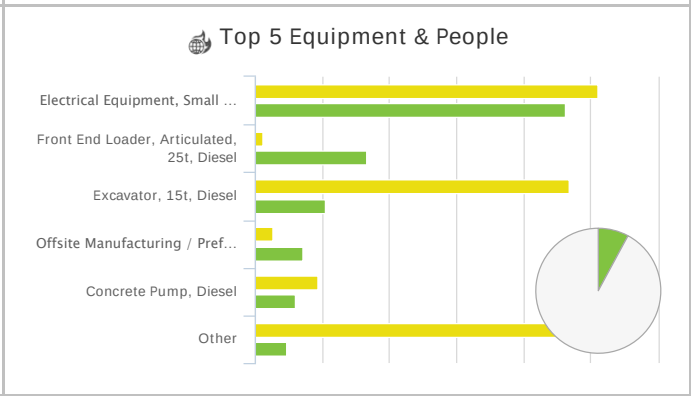






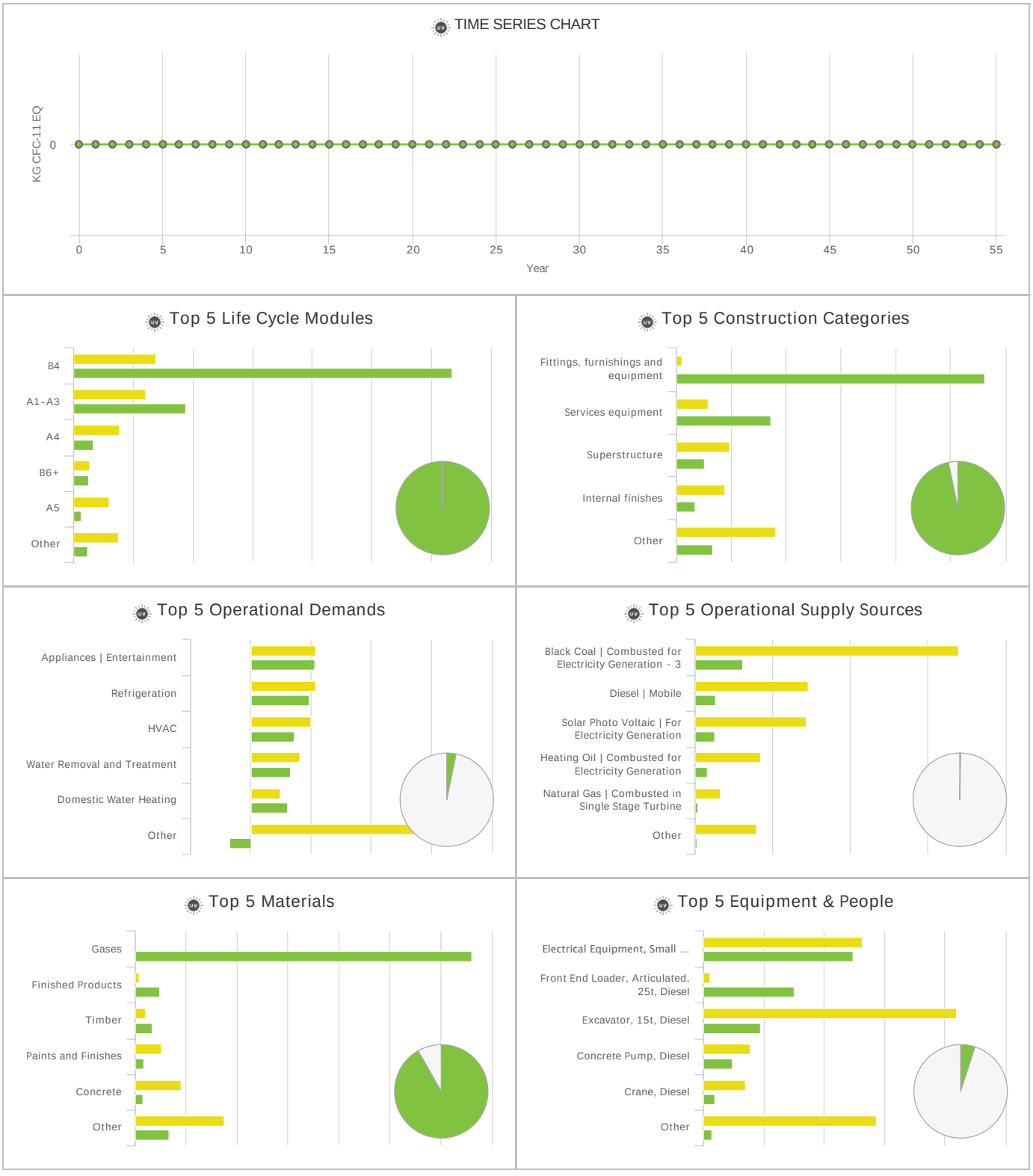






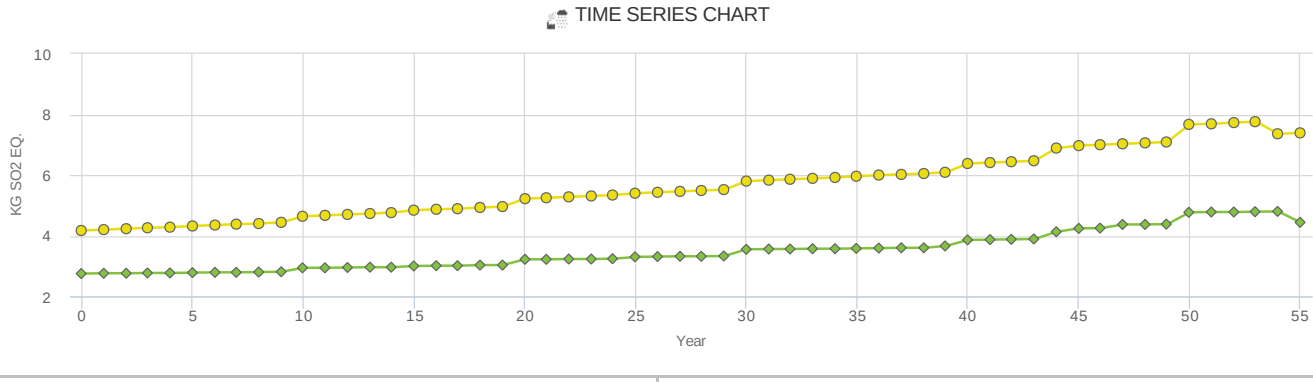
6.2 Ozone Depletion Potential, ODP Profile

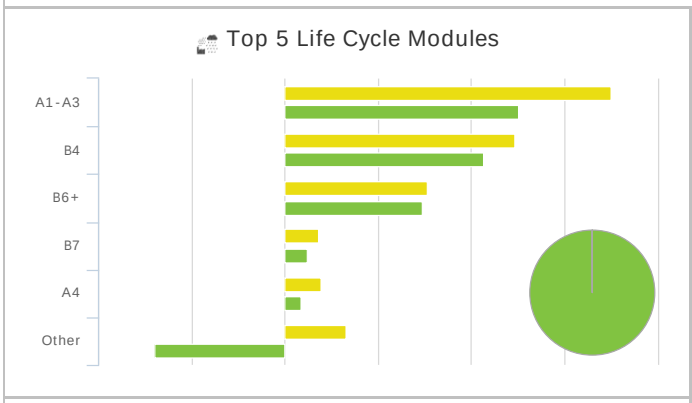
Business as Usual Improved Design

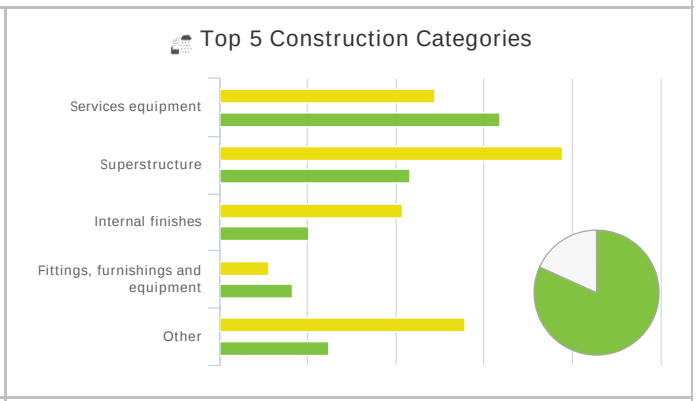


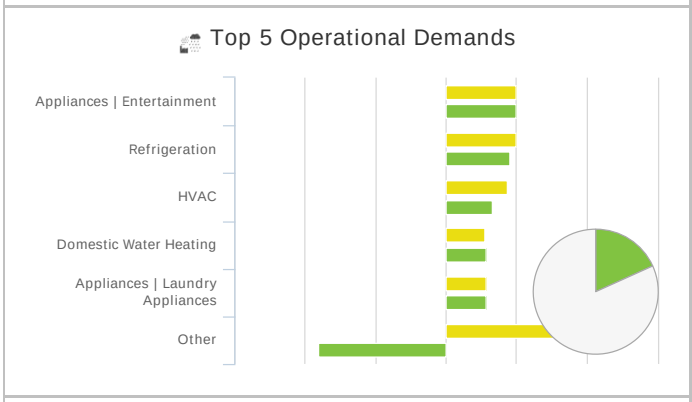
6.3 Acidification Potential for Soil and Water, AP Profile

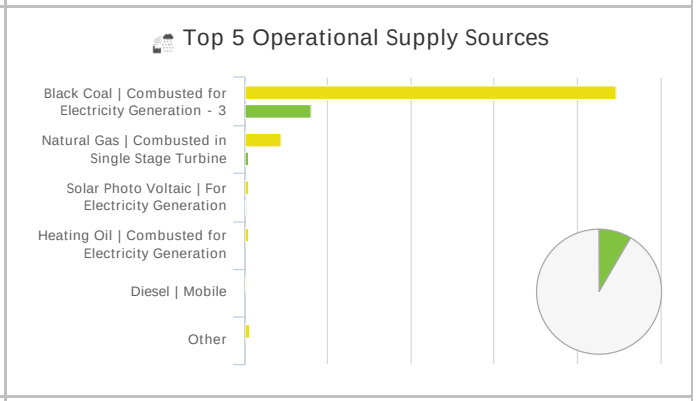
Business as Usual Improved Design

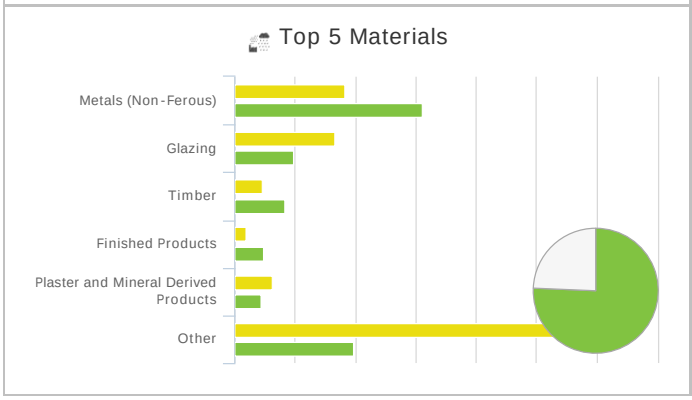


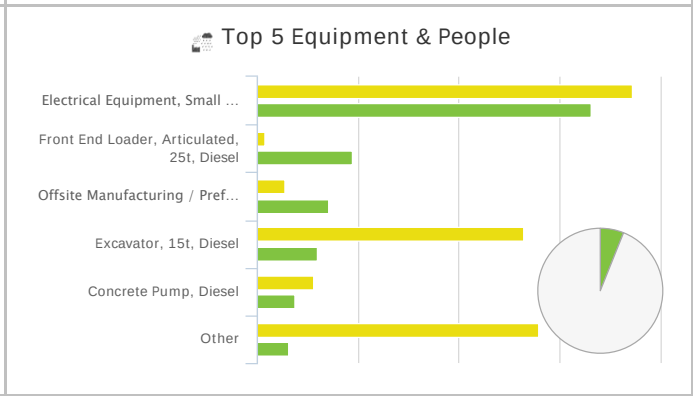






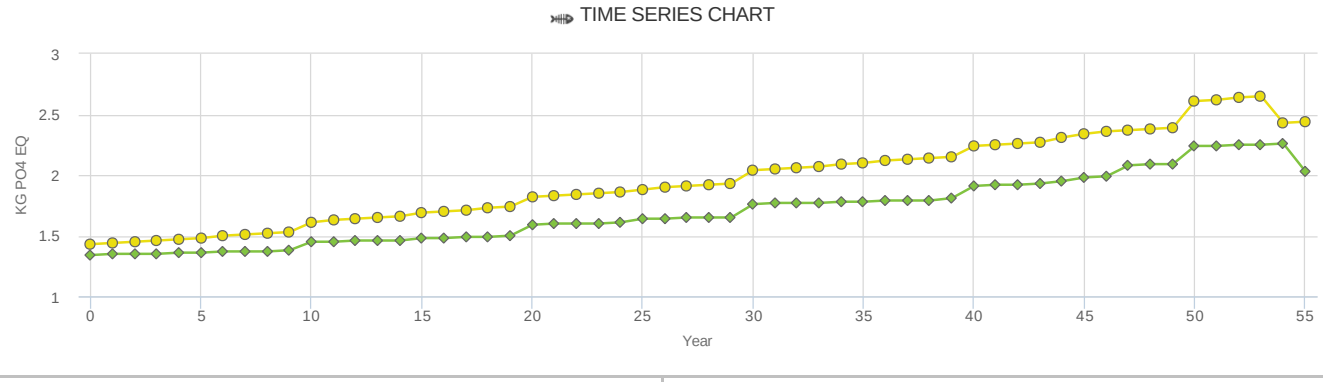


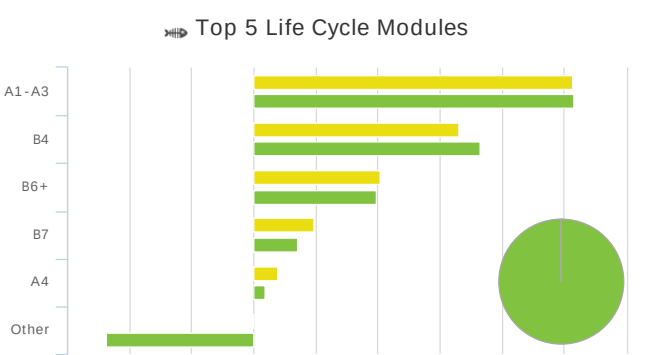


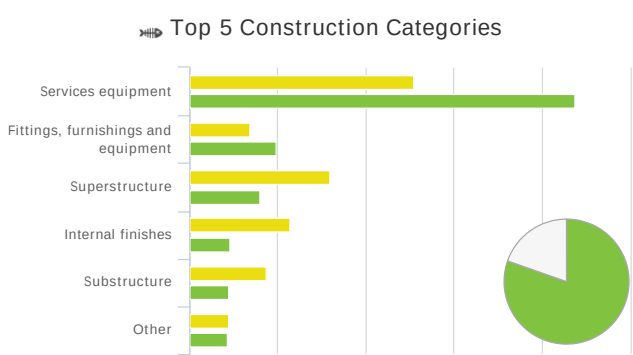


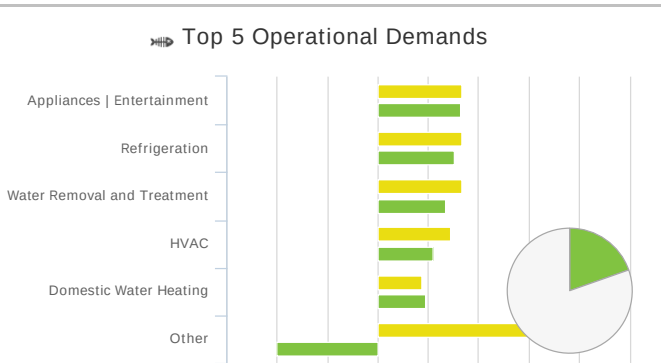
6.4 Eutrophication potential, EP Profile

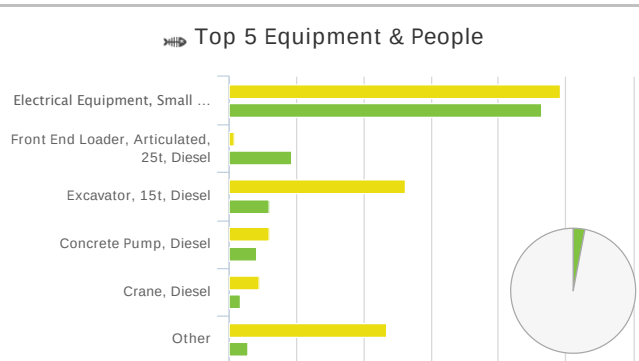
Business as Usual Improved Design





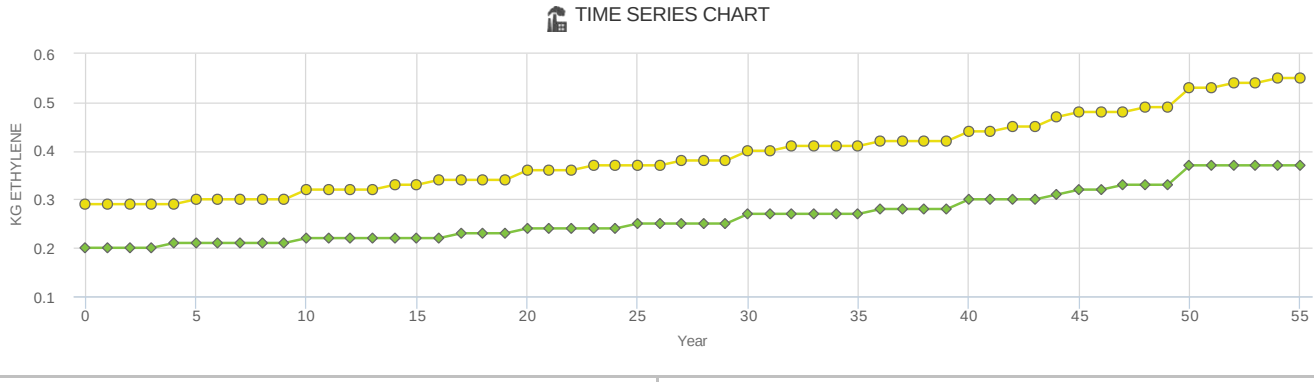


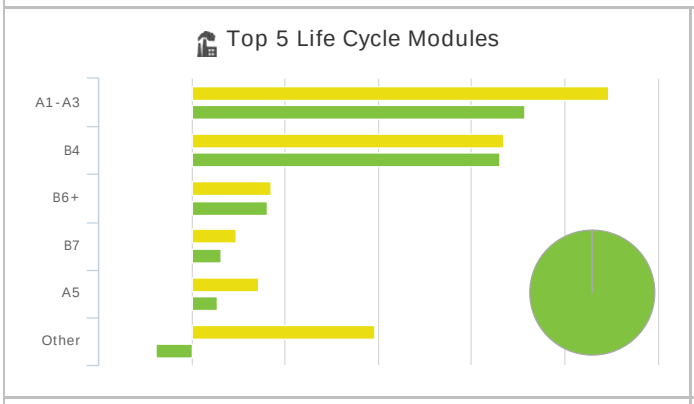


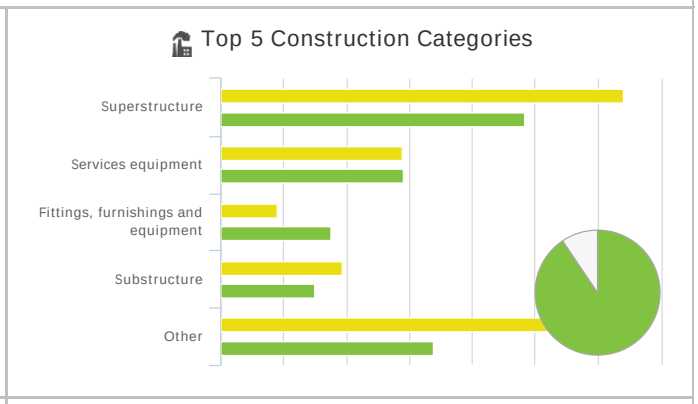


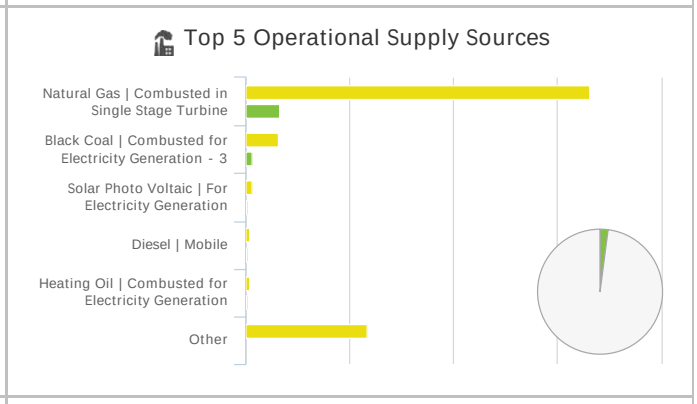
6.5 Photochemical Ozone Creation Potential, POCP Profile

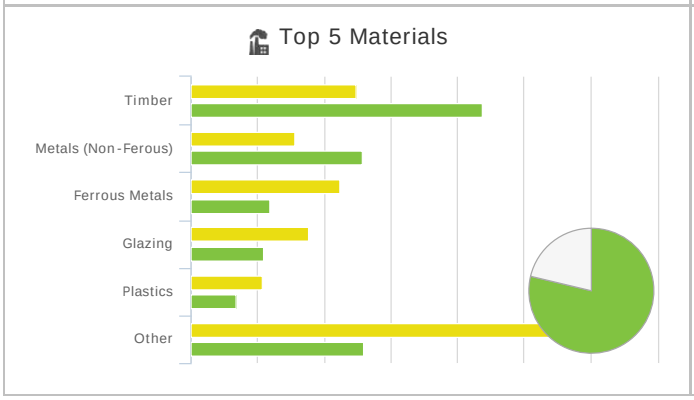
Business as Usual Improved Design

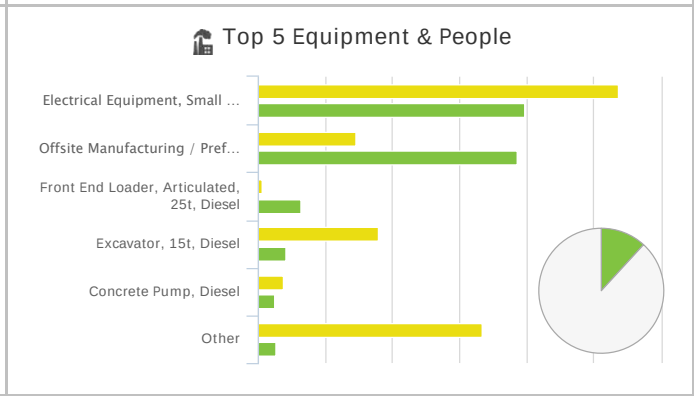






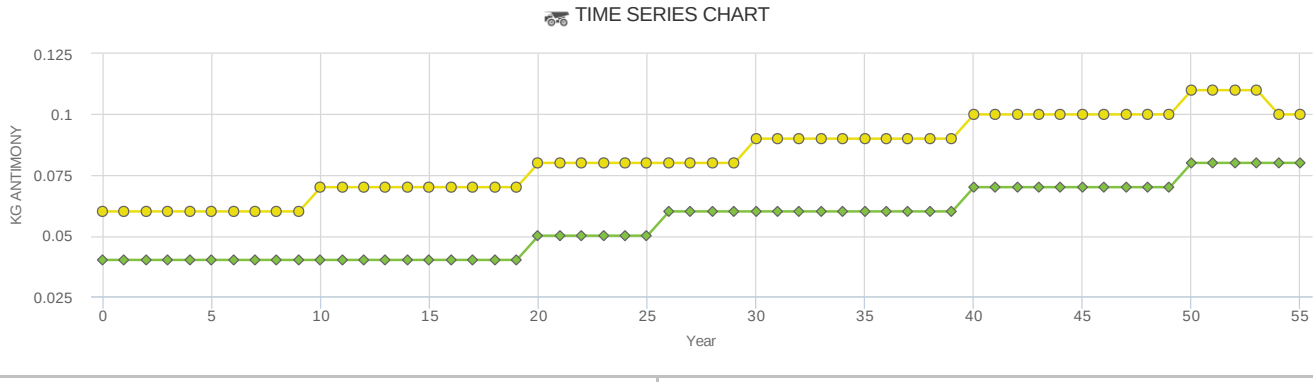


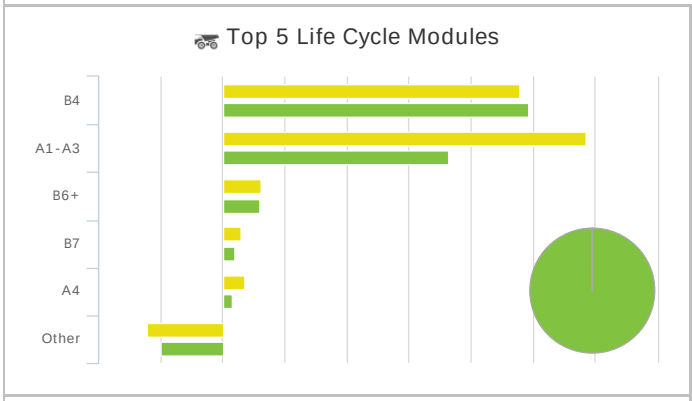


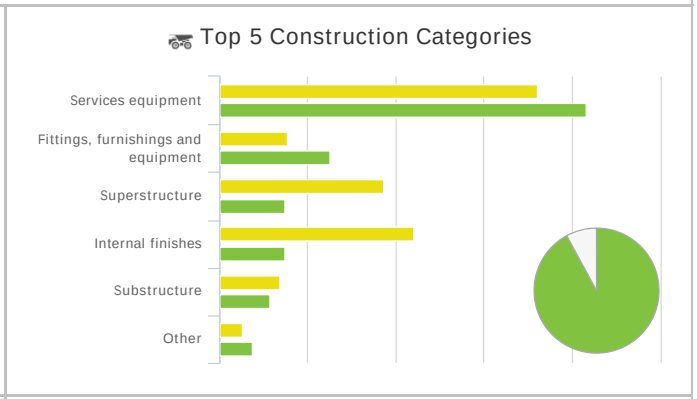


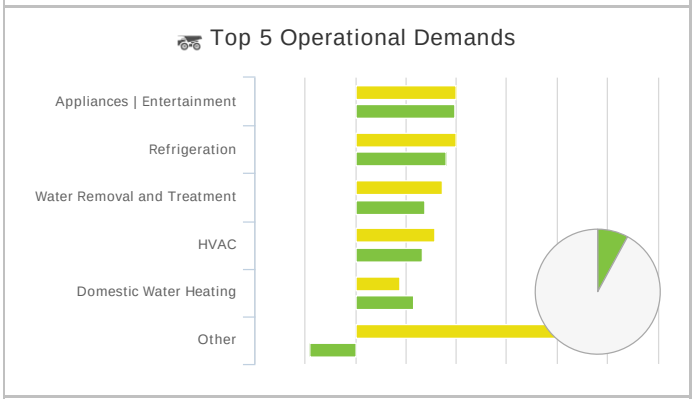
6.6 Abiotic Depletion Potential - Elements, ADPE Profile

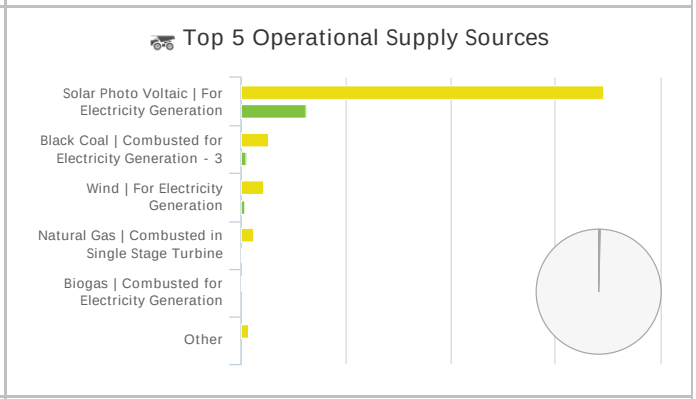
Business as Usual Improved Design

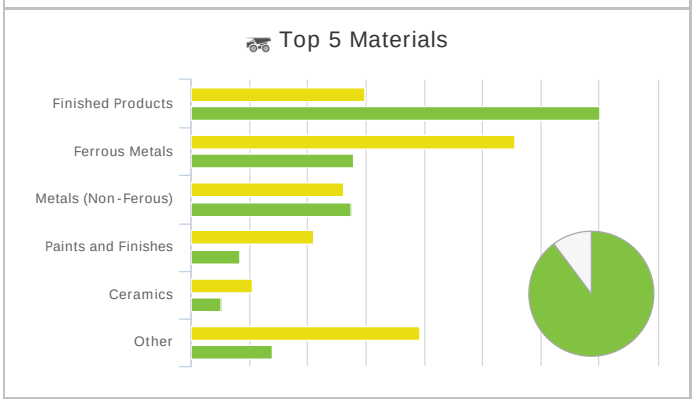


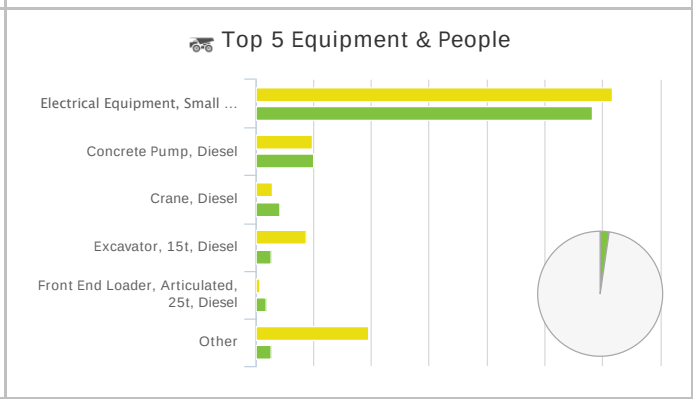








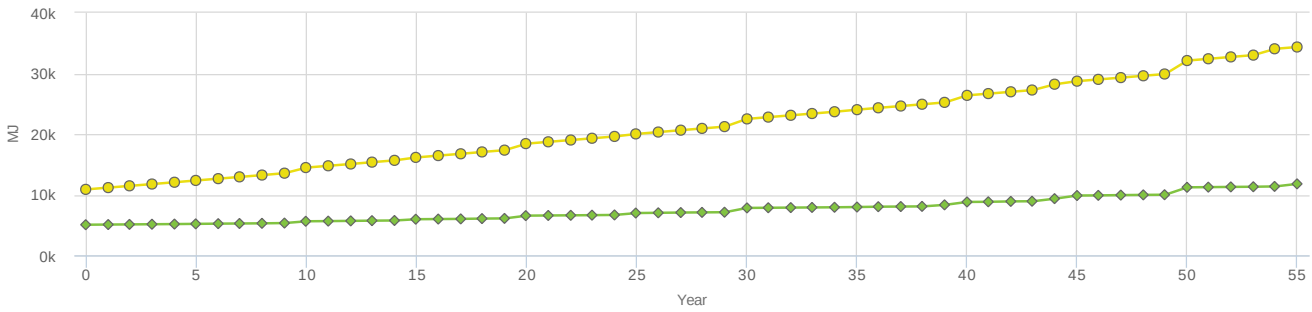




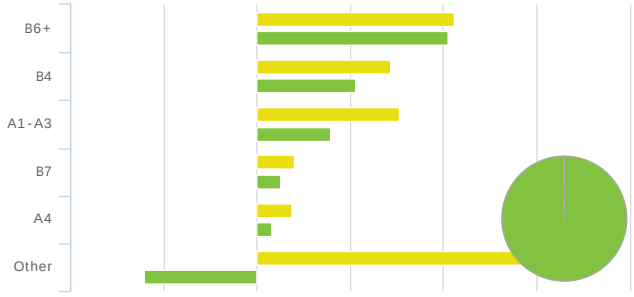
6.7 Abiotic Depletion Potential - Fossil Fuels, ADPF Profile

Business as Usual Improved Design

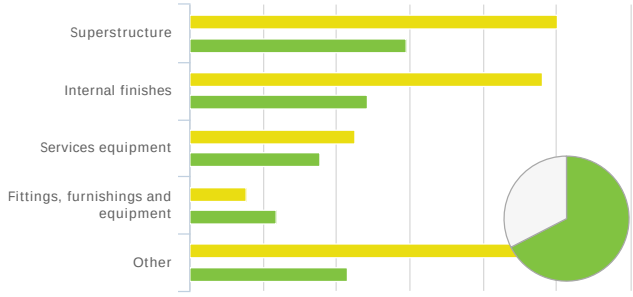
TIME SERIES CHART



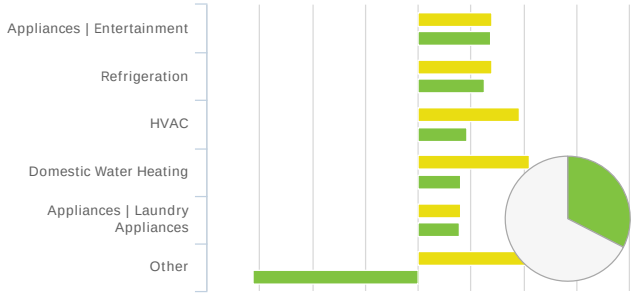
Top 5 Life Cycle Modules



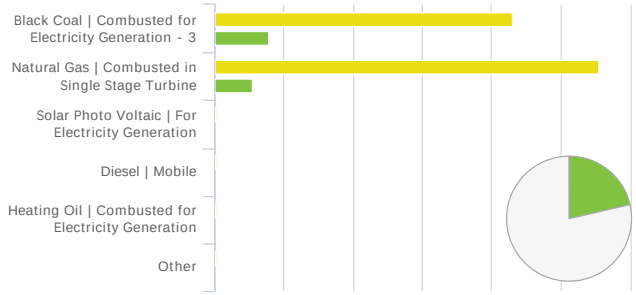
Top 5 Construction Categories



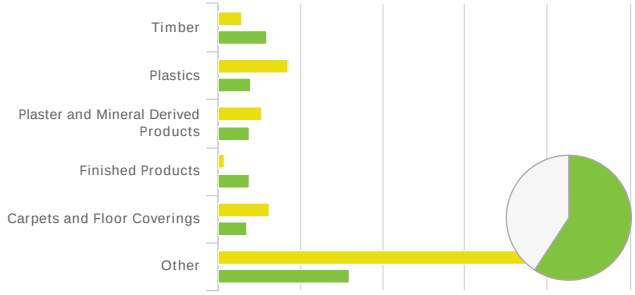
Top 5 Operational Demands



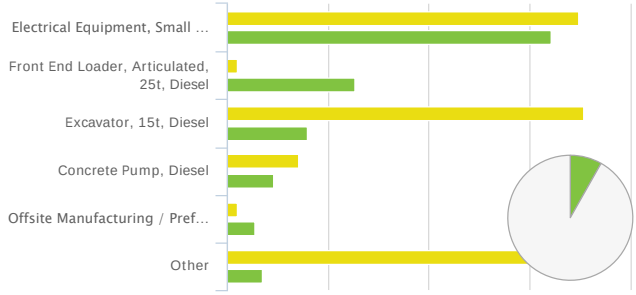
Top 5 Operational Supply Sources



Top 5 Materials



Top 5 Equipment & People



7 Low Impact Strategies

The following potential low impact design strategies were modelled in the LCA study to determine the relative benefits and aid the design decision making process.

For each design strategy, the relative savings for all indicators is provided and given in context to the other strategies. A basic description of the strategy is also provided.

8 Conclusions

The Improved Design shows an expected performance improvement against Business as Usual for 6 of the 7 environmental indicators.

9 References

9.1 Background LCI Data

Life Cycle Strategies, 2015, Australasian LCI - V15 - Life Cycle Strategies (BETA)

9.2 Inventory - Design Documentation

No design documents were recorded.

9.3 Inventory - Assumptions

, 2008, Energy Use in the Australian Residential Sector 1986 To 2020 (Report),
Super Efficient Equipment and Appliance Deployment, Clean Energy Ministerial, 2013, Heat Pump Water Heaters: Summary and Comparison of International Test Standards, Web Link.
2006, Life Expectancy of Building Components, https://costmodelling.com/lifespans, Web Link.
2007, Study of Life Expectancy of Home Components, Web Link.
2013, Truck-mounted concrete pump 47 M5 XXT with optimised boom and innovative support, Web Link.
2018, Rawlinsons Construction Cost Guide 2019, Perth, WA, Web Link.
Australian Government, Equipment Energy Efficiency, 2018, Decision Regulation Impact Statement: Swimming pool pumps, Web Link.
Bauer Marc, Bödeker Jan Maurice, International Aluminium Institute, Pehnt Dr. Martin, 2010, Aluminium and Renewable Energy Systems – Prospects for the Sustainable Generation of Electricity and Heat, Heidelberg, Web Link.
BlueScope Steel, 2013, Lysaght Products, Web Link.
BlueScope Steel, Colorbond Steel Warranty, Port Kembla, NSW, Web Link.
Commonwealth of Australia , 2012, Air-Source Heat Pump Water Heaters in Australia and New Zealand, Canberra, Web Link.
Cost Modelling, 2012, Typical Life Expectancy of Building Components - Floor & Ceiling Finishes, Web Link.
Cost Modelling, 2012, Typical Life Expectancy of Building Components - Wall Finishes, Web Link.
Daisy Pool Covers, 2020, The Facts about Pool Blankets, Web Link.
DEFRA, Energy Saving Trust, 2008, Measurement of Domestic Hot Water Consumption in Dwellings, Web Link.
Estimating Demolition Costs for Single Residential Buildings, Deakin University, Web Link.
Field F, Gregory J, Kirchain R, Nicholson A, Olivetti E, 2009, End of Life Allocation Methods: Open Loop Recycling Impacts on Robustness of Material Selection Decisions,
General Information (Door hinge loads), Web Link.
Graedel Thomas E, 2011, Recycling Rates of Metals, Web Link.
Grant Tim, Pears Alan, 2006, Allocation Issues in Life Cycle Assessment - Benefits of Recycling and the Role of Environmental Rating Schemes,
Home Interiors, Tile Adhesive and Grout Calculator, Web Link.
Malabago Nolasco K. , 2016, Refrigerant Recovery and Recycling Machine: An Innovation, Cebu, Web Link.
PACIA, 2007, Plastic Recycling Rates,
Rawlinsons, 2011, Rawlinsons Australian Construction Handbook, Perth,
Reinforcing Steel Bars Weights and Dimensions, Web Link.
Reinforcing Steel Bars Weights and Dimensions, Web Link.
The Roofing Professionals, THE DIFFERENCE BETWEEN COLORBOND AND ZINCALUME, Web Link.
Tiles LTP, Tile Coverage Calculator, Web Link.
Villaume Gayle, 2011, 2010 Recycling Data - Australian Packaging Covenant,

9.4 Environmental Product Declarations

No EPD references were recorded.

Appendix A: Environmental Indicators Description

Global Warming Potential, GWP

Anthropogenic global warming is caused by an increase of greenhouse gasses (GHG) in the earth's atmosphere. These gasses reflect some of the heat radiated from the earth's surface that would normally escape into space back to the surface of the earth. Overtime this warms the earth. Common GHGs include CO2, N2O, CH4 and volatile organic compounds (VOCs). Global Warming Potential (GWP) is expressed in equivalent GHGs released, usually in kgCO2e.

Ozone Depletion Potential, ODP

Ozone is formed and depleted naturally in the earth's stratosphere (between 15-40 km above the earth's surface). Halocarbon compounds are persistent synthetic halogen containing organic molecules that can reach the stratosphere leading to more rapid depletion of the ozone. As the ozone in the stratosphere is reduced more of the ultraviolet rays in sunlight can reach the earth's surface where they can cause skin cancer and reduced crop yields. Ozone Depletion Potential (ODP) is expressed in equivalent ozone depleting gasses (normally kgCFC11e).

Acidification Potential for Soil and Water, AP

Acidification is a consequence of acids (and other compounds which can be transformed into acids) being emitted to the atmosphere and subsequently deposited in surface soils and water. Increased acidity can result in negative consequences for flora and fauna in addition to increased corrosion of manmade structures (buildings vehicles etc.). Acidification Potential (AP) is an indicator of such damage and is usually measured in kgSO_2e

Eutrophication potential, EP

Over enrichment of aquatic ecosystems with nutrients leading to increased production of plankton, algae and higher aquatic plants leading to a deterioration of the water quality and a reduction in the value and/or the utilisation of the aquatic ecosystem. Eutrophication is primarily caused by surplus nitrogen and phosphorus. Sources of nutrients include agriculture (fertilisers and manure), aquaculture, municipal wastewater, and nitrogen oxide emissions from fossil fuel combustion.

Photochemical Ozone Creation Potential, POCP

Photochemical Ozone Creation Potential (POCP), commonly known as smog, is toxic to humans in high concentration. Although ozone is protective in the stratosphere at low levels it is problematic from both a health and nuisance perspective. Plant growth is also effected through damaged leaf surfaces and reduced photosynthesis. POCP is formed when sunlight and heat react with Volatile Organic Compounds (VOCs).

Abiotic Depletion Potential - Elements, ADPE

Abiotic Resource Depletion of energy (ADPM) is a measure of the extraction and consumption of primary resources from the earth. Such exploitation reduces resources available to future generations and as such must be managed.

Abiotic Depletion Potential - Fossil Fuels, ADPF

Abiotic Resource Depletion of energy (ARDE) is a measure of the extraction and consumption of non-renewable energy sources (primarily fossil fuels, but also inclusive of other energy sources such as uranium). Primary energy content of non-renewable energy sources including the embodied energy to extract, process and deliver the non renewable fuels, or manufacture, transport and install the renewable generator. Hence there is usually and non-renewable energy content associated with renewable fuels also.

Appendix B: Detailed Structure Scope Diagram

Key: ✓ In Scope, In Design ✓ In Scope, Not In Design ✓ Partial ✗ Out of Scope

Parent Name	Sub Category Name	Benchmark Design	Improved Design
Substructure	Substructure	✓	✗
	Standard foundations	✓	✗
	Specialist foundations	✓	✗
	Lowest floor construction	✓	✗
	Insulation	✓	✗
	Basement excavation	✓	✗
	Basement retaining walls	✓	✗
Superstructure	Frame	✓	✗
	Frame	✓	✗
	Upper floors	✓	✗
	Floors	✓	✗
	Insulation	✓	✗
	Balconies	✓	✗
	Drainage to balconies	✓	✗
	Roof	✓	✗
	Insulation	✓	✗
	Roof structure	✓	✗
	Roof coverings	✓	✗
	Specialist roof systems	✓	✗
	Roof drainage	✓	✗
	Rooflights, skylights and openings	✓	✗
	Roof features	✗	✗
	Stairs and ramps	✓	✗
	Stair/ramp structures	✓	✗
	Stair/ramp finishes	✓	✗
	Stair/ramp balustrades and handrails	✓	✗
	Ladders/chutes/slides	✓	✗
	External walls	✓	✗
	External Paint, Textures and Renders	✓	✗
	External enclosing walls above ground level	✓	✗
	Insulation	✓	✗
	External enclosing walls below ground level	✓	✗
	Solar/rain screening	✓	✗
	External soffits	✓	✗
	Subsidiary walls, balustrades and proprietary balconies	✓	✗
	Façade access/cleaning systems	✓	✗
	Windows and external doors	✓	✗
	External windows	✓	✗
	Security and Fly Screens	✓	✗
	External doors	✓	✗
	Internal walls and partitions	✓	✗
	Walls and partitions	✓	✗
	Insulation	✓	✗
	Balustrades and handrails	✓	✗
	Moveable room dividers	✓	✗
	Cubicles	✓	✗
	Internal doors	✓	✗
	Internal doors	✓	✗
Internal finishes	Wall finishes	✓	✗
	Wall finishes	✓	✗
	Cornices & Shadowlines	✓	✗
	Paint - Walls	✓	✗
	Wet Area Walls	✓	✗
	Floor finishes	✓	✗
	Finishes to floors	✓	✗
	Wet Area Floors	✓	✗
	Raised access floors	✓	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	Ceiling finishes	✓	✗
	Finishes to ceilings	✓	✗
	False ceilings	✓	✗
	Demountable suspended ceilings	✓	✗
Fittings, furnishings and equipment	Fittings, furnishings and equipment	✓	✗
	General fittings, furnishings and equipment	✓	✗
	Domestic kitchen fittings and equipment	✓	✗
	Special purpose fittings, furnishings and equipment	✗	✗
	Signs/notices	✗	✗
	Works of art	✗	✗
	Non-mechanical and non-electrical equipment	✗	✗
	Internal planting	✗	✗
	Bird and vermin control	✗	✗
Services equipment	Sanitary installations	✓	✗
	Sanitary appliances	✓	✗
	Sanitary ancillaries	✓	✗
	Services equipment	✓	✗
	Services equipment	✓	✗
	Disposal installations	✓	✗
	Foul drainage above ground	✓	✗
	Chemical, toxic and industrial liquid waste disposal	✗	✗
	Refuse disposal	✓	✗
	Water installations	✓	✗
	Mains water supply	✓	✗
	Cold water distribution	✓	✗
	Hot water distribution	✓	✗
	Local hot water distribution	✓	✗
	Steam and condensate distribution	✗	✗
	Heat source	✓	✗
	Heat source	✓	✗
	Space heating and air conditioning	✓	✗
	Central heating	✓	✗
	Local heating	✓	✗
	Central cooling	✓	✗
	Local cooling	✓	✗
	Central heating and cooling	✓	✗
	Local heating and cooling	✓	✗
	Central air conditioning	✓	✗
	Local air conditioning	✓	✗
	Ventilation systems	✓	✗
	Central ventilation	✓	✗
	Local and special ventilation	✓	✗
	Smoke extract/control	✓	✗
	Electrical installations	✓	✗
	Electric mains and sub-mains distribution	✓	✗
	Power installations	✓	✗
	Lighting installations	✓	✗
	Specialist lighting installations	✓	✗
	Local electricity generation systems	✓	✗
	Earthing and bonding systems	✓	✗
	Fuel installations	✗	✗
	Fuel storage	✗	✗
	Fuel distribution systems	✗	✗
	Lift and conveyor installations	✓	✗
	Lifts and enclosed hoists	✓	✗
	Escalators	✓	✗
	Moving pavements	✓	✗
	Powered stairlifts	✗	✗
	Conveyors	✗	✗
	Dock levellers and scissor lifts	✗	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	Cranes and unenclosed hoists	✗	✗
	Car lifts, car stacking systems, turntables and the like	✗	✗
	Document handling systems	✓	✗
	Other lift and conveyor installations	✓	✗
	Fire and lightning protection	✗	✗
	Fire-fighting systems	✗	✗
	Fire suppression systems	✗	✗
	Lightning protection	✗	✗
	Communication, security and control systems	✓	✗
	Communication systems	✓	✗
	Security systems	✓	✗
	Central control/building management systems	✓	✗
	Specialist installations	✓	✗
	Specialist piped supply installations	✗	✗
	Specialist refrigeration systems	✗	✗
	Specialist mechanical installations	✗	✗
	Specialist electrical/electronic installations	✗	✗
	Water features	✗	✗
	Civil Engineering Structure	✓	✗
	Builder's Work in Connection (BWIC) with Services	✗	✗
	BWIC with services	✗	✗
Prefabricated buildings and building units	Prefabricated buildings and building units	✗	✗
	Complete buildings	✗	✗
	Building units	✗	✗
	Pods	✗	✗
Work to existing building	Minor demolitions and alterations	✗	✗
	Minor Demolitions and Alterations	✗	✗
	Repairs to existing services	✗	✗
	Repairs to existing services	✗	✗
	Damp proof course/fungus and beetle eradication	✗	✗
	Damp Proof Course/Fungus and Beetle Eradication	✗	✗
	Façade Retention	✗	✗
	Façade Retention	✗	✗
	Cleaning Existing Surfaces	✗	✗
	Cleaning Existing Surfaces	✗	✗
	Renovation work	✗	✗
	Renovation Work	✗	✗
External works	Site preparation works	✓	✗
	Site clearance	✓	✗
	Preparatory groundworks	✓	✗
	Roads, paths and pavings	✓	✗
	Roads, paths and pavings	✓	✗
	Special surfacings and pavings	✓	✗
	Soft landscaping, planting and irrigation systems	✓	✗
	Seeding and turfing	✓	✗
	External planting	✓	✗
	Irrigation systems	✓	✗
	Fencing, railings and walls	✓	✗
	Fencing and railings	✓	✗
	Walls and screens	✓	✗
	Retaining walls	✓	✗
	Barriers and guardrails	✓	✗
	External fixtures	✗	✗
	Site/street furniture and equipment	✗	✗
	Ornamental features	✗	✗
	External drainage	✓	✗
	Surface water and foul water drainage	✗	✗
	Ancillary drainage systems	✗	✗
	External chemical, toxic and industrial liquid waste drainage	✗	✗
	Land drainage	✓	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	External services	✓	✗
	Water mains supply	✓	✗
	Electricity mains supply	✓	✗
	External transformation devices	✓	✗
	Electricity distribution to external plant and equipment	✓	✗
	Gas mains supply	✓	✗
	Telecommunications and other communication system connections	✓	✗
	External fuel storage and piped distribution systems	✓	✗
	External security systems	✓	✗
	External/street lighting systems	✓	✗
	Local/district heating installations	✓	✗
	BWIC with external services	✓	✗
	Minor building works and ancillary buildings	✗	✗
	Minor building works	✗	✗
	Ancillary buildings and structures	✗	✗
	Underpinning to external site boundary walls	✗	✗
Facilitating works	Toxic/hazardous/contaminated material treatment	✗	✗
	Toxic/hazardous material removal	✗	✗
	Contaminated land	✗	✗
	Eradication of plant growth	✗	✗
	Major demolition works	✓	✗
	Demolition works	✓	✗
	Soft strip works	✓	✗
	Temporary support to adjacent structures	✗	✗
	Temporary support to adjacent structures	✗	✗
	Specialist groundworks	✗	✗
	Site dewatering and pumping	✗	✗
	Soil stabilisation measures	✗	✗
	Ground gas venting measures	✗	✗
	Temporary diversion works	✗	✗
	Temporary diversion works	✗	✗
	Extraordinary site investigation	✗	✗
	Archaeological investigation	✗	✗
	Reptile/wildlife mitigation measures	✗	✗
	Other extraordinary site investigation	✗	✗
Project/design team	Consultants	✓	✗
	Planning & Approvals	✓	✗
	Main contractor's pre-construction design	✓	✗
	Project Management	✓	✗
	Main contractor's design	✓	✗
	Sales and Marketing	✓	✗
Undefined			

Life Cycle Assessment

33b Smith St, Highgate, WA

City of Vincent

Date : 25 October 2022

Authors : Robin Campbell (Lead)

Phone : 0411 141 246

Address : 99 Loftus St, Leederville

Email : info@email.com

Report Id : 30453

eToolLCD Software Disclaimer

The LCA predictions of embodied and operational impacts (including costs) conducted in eToolLCD software, by their very nature, cannot be exact. It is not possible to track all the impacts associated with a product or service back through history, let alone do this accurately. eToolLCD software has been built and tested to enable informed decisions when comparing design options. Generic cost and environmental impact coefficients do not necessarily correspond to those of individual brands of the same product or service due to differences within industries in the way these products and services are delivered.

This LCA study has not been reviewed and as such does not meet the relevant section of the ISO14044 requirements. Caution should be taken when interpreting the LCA study report.

eTool PTY LTD cannot make assurances regarding the accuracy of these reports for the above reasons.

Executive Summary

This Life Cycle Assessment has been completed for a number of design scenarios for the Low Density Dwelling, located at 33b Smith St, Highgate, WA. The Author of the study is Robin Campbell of eTool and no critical review has been conducted.

The goal of this study is to profile and improve the environmental performance of the construction works at 33b Smith St, Highgate, WA. The life cycle performance of the project is compared to other designs. The study has been conducted in accordance with ISO 14044 and EN15978.

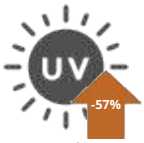
Characterised Impacts Per Occupant Per Year		Benchmark Design	Improved Design	Improved Design Savings Against Benchmark Design
Environmental Impacts				
Global Warming Potential, GWP	kg CO_2 eq	3.31e+3	1.07e+3	68%
Ozone Depletion Potential, ODP	kg CFC-11 eq	1.24e-4	1.94e-4	-57%
Acidification Potential for Soil and Water, AP	kg SO_2 eq.	8.92e+0	4.50e+0	50%
Eutrophication potential, EP	kg PO_4 eq	2.95e+0	2.06e+0	30%
Photochemical Ozone Creation Potential, POCP	kg ethylene	5.92e-1	3.35e-1	43%
Abiotic Depletion Potential - Elements, ADPE	kg antimony	1.07e-1	7.47e-2	30%
Abiotic Depletion Potential - Fossil Fuels, ADPF	MJ	44873	14169	68%

Table 1: Summary of Results

The Improved Design shows an expected performance improvement against Business as Usual for 6 of the 7 environmental indicators.

Improved Design Performance against Benchmark

Global Warming Potential, GWP



Ozone Depletion Potential, ODP

Acidification Potential for Soil and Water, AP

Eutrophication potential, EP

Photochemical Ozone Creation Potential, POCP

Abiotic Depletion Potential - Elements, ADPE

Abiotic Depletion Potential - Fossil Fuels, ADPF

Table of Contents

1 Introduction

Managing the environmental impacts that arise from the construction and operation of Building is of key importance in mitigating the damage caused directly and indirectly on the biosphere. Life Cycle Assessment (LCA) is the leading industry standard in clearly identifying optimum strategies for reducing environmental impacts. This report presents the results of the LCA completed for the Improved Design, City of Vincent Project located at 33b Smith St, Highgate, WA. eToolLCD software has been used to model the infrastructure's environmental impacts.

The study has been conducted in accordance with the following standards:

- International Standards 14040 and 14044.
- European Standard EN 15978: *Sustainability of Construction Works – Assessment of Environmental Performance of Buildings – Calculation Method*

The Author of the study is Robin Campbell of eTool and no critical review has been conducted.

2 Goal of the study

The goal of this study is to provide profile and improve the environmental performance of the construction works at 33b Smith St, Highgate, WA. The life cycle performance of the project is compared to other designs and as such this is a comparative study. The results of the study are intended to be made public.

3 Scope of the study

The LCA study has been conducted in accordance with the EN 15978 standard to assess the direct and indirect potential environmental impacts associated with the construction works at 33b Smith St, Highgate, WA as part of the City of Vincent project.

3.1 Functional Unit

The function of the Building must reflect the core purpose of the asset such that it can be compared accurately to different designs. In this case, the functional focus is the Residence and the chosen functional unit is the provision of this function for one Occupant over one year.

The estimated design life of the design is 55 years which has been adopted for the LCA study period. This takes into consideration the structural service life limit (150 years), as well as redevelopment pressure on the asset such as surrounding density, asset ownership structures, and the architectural design quality.

Note that products with expected service lives of less than the life span of the project are assumed to be replaced at increments reflecting their service life.

3.2 System Boundary

The system boundary, shown in Figure 1, follows guidance given in EN15978.

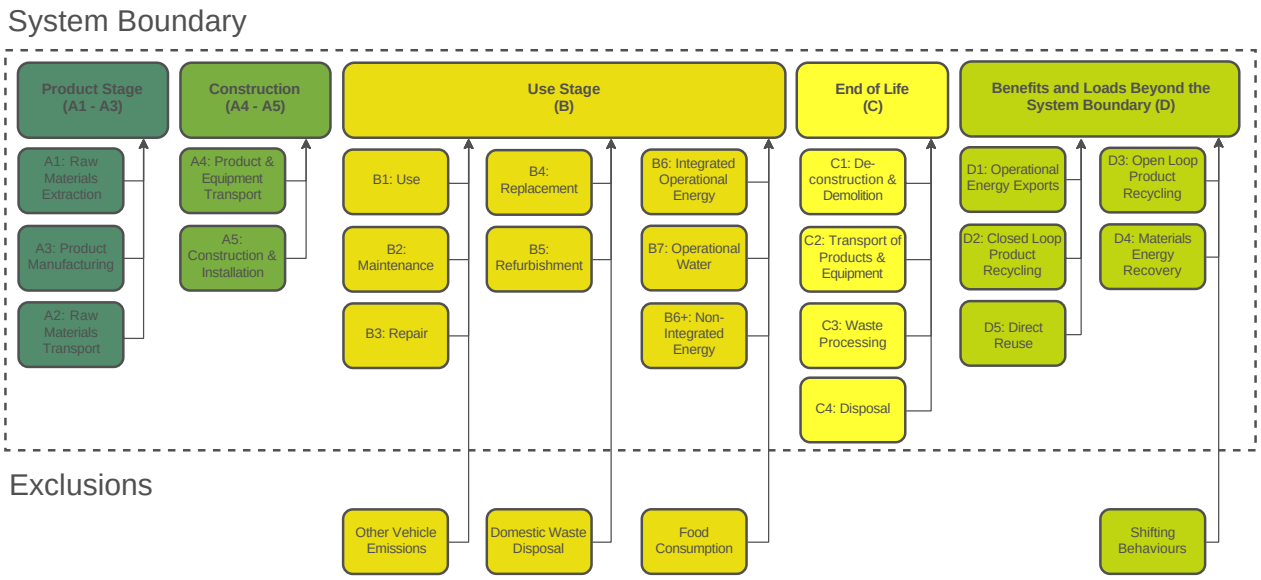


Figure 1: System Boundary Diagram

3.3 Environmental Indicators

The environmental indicators have been included in the study are detailed in Table 2. For further information regarding the environmental indicators please refer to Appendix A.

Environmental Indicator	Unit	Abbreviation	Characterisation Method
Environmental Impacts			
Global Warming Potential, GWP	kg CO_2 eq	GWP	CML-IA baseline V4.5
Ozone Depletion Potential, ODP	kg CFC-11 eq	ODP	CML-IA baseline V4.5
Acidification Potential for Soil and Water, AP	kg SO_2 eq.	AP	CML-IA baseline V4.5
Eutrophication potential, EP	kg PO_4 eq	EP	CML-IA baseline V4.5
Photochemical Ozone Creation Potential, POCP	kg ethylene	POCP	Institute of Environmental Sciences (CML)
Abiotic Depletion Potential - Elements, ADPE	kg antimony	ADPE	CML-IA baseline V4.5
Abiotic Depletion Potential - Fossil Fuels, ADPF	MJ	ADPF	CML-IA baseline V4.5

Table 2: Environmental Indicators Included in LCA study.

3.4 System Description

The object of the assessment is the Low Density Dwelling, located at 33b Smith St, Highgate, WA. The assessment includes all the upstream and downstream processes needed to provide the primary function of the structure from construction, maintenance, operation, and finally demolition and disposal associated with the low density dwelling. The inventory includes the extraction of raw materials or energy and the release of substances back to the environment or to the point where inventory items exit the system

boundary either during or at the end of the project life cycle.

The area of the project is the City of Vincent local government in Western Australia. This local government authority covers an area of approximately 10.4 square kilometres in metropolitan Perth, the capital of Western Australia, and lies about 3 km from the Perth CBD. It includes the suburbs of Highgate, Leederville, Mount Hawthorn, North Perth, as well as parts of Coolbinia, East Perth, Mount Lawley, Osborne Park, Perth and West Perth. The City of Vincent maintains 139 km of roads and 104 ha of parks and gardens.

New developments in the area must comply with the city's built form policy released in 2020.

The project location is shown in figures 2 and 3.

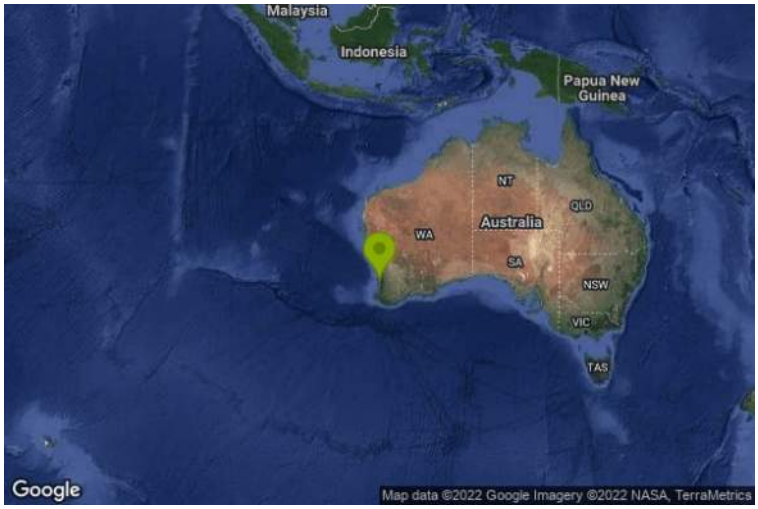


Figure 2: Location of the project - Global View.

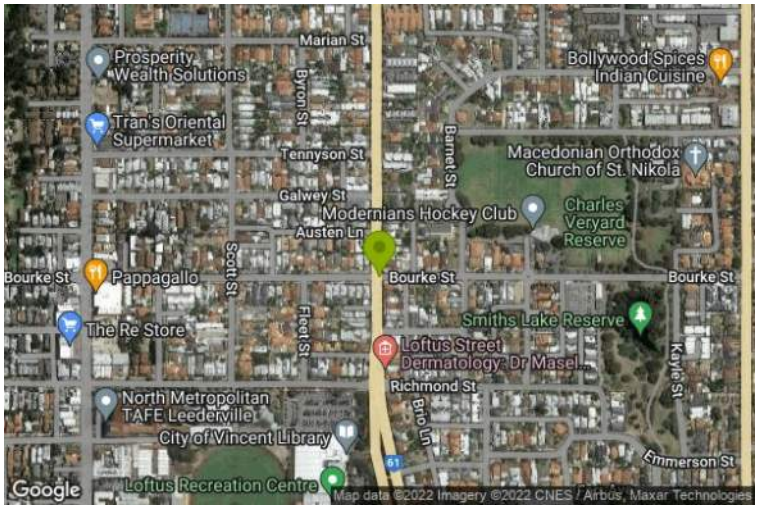


Figure 3: Location of the project - Locality View.

4 Townhouses. U3 is 3br, 2.5 bath. U4 is 3br, 2.5 bath. U5 is 3br, 3 bath. U6 is 3br, 2.5 bath. Each unit has a carport space on the ground level and there is 1 extra shared parking space for visitors.

Table 3 below shows the key characteristics of the design.

	Business as Usual	Improved Design
Design Details		
Design Name	AU WA Res Ave Code Compl CZ 5 (10 dwellings)	33b Smith St, Highgate, WA

	Business as Usual	Improved Design
Stories (#)	2	2
Functional Focus	Single Family Residence	Residence
Structural Service Life Limit	100	150
Predicted Design Life	54	55
Functional Characteristics		
Dwellings	10	4
Bedrooms	30	12
Occupants	24	10
Vehicle Spaces	0	5
Total Floor Areas		
Usable Floor Area	2,140	399
Net Lettable Area	0	0
Fully Enclosed Covered Area	3,010	399
Unenclosed Covered Area	0	90
Gross Floor Area	3,010	489
Usable and Lettable Yield	71 %	82 %

Table 3: Design Characteristics Compared

Table 4 and 5 show the scope (structural and operational) of the inventory collection for the LCA. For further details on structure scope please refer to Appendix B.

Summary Structure Scope Diagram

Key: ✓ In Scope ✓ Partial ✗ Out of Scope

Category Name	Benchmark Design	Improved Design
Substructure	✓	✗
Superstructure	✓	✗
Internal finishes	✓	✗
Fittings, furnishings and equipment	✓	✗
Services equipment	✓	✗
Prefabricated buildings and building units	✗	✗
Work to existing building	✗	✗
External works	✓	✗
Facilitating works	✓	✗
Project/design team	✓	✗
Undefined	✗	✗

Table 4: Structural scope of LCI collection

Operational Scope diagram

Key: ✓ In Scope ✗ Out of Scope

Category Name	Benchmark Design	Improved Design
Appliances | Dishwashers	✓	✗
Appliances | Entertainment	✓	✗
Appliances | Laundry Appliances	✓	✗
Appliances | Office Workstations	✓	✗
Communications	✓	✗
Cooking and Food Preparation	✓	✗
Domestic Water Heating	✓	✗
Electrical Parasitic Loads	✓	✗
Fire Protection	✗	✗
HVAC	✓	✗
Industrial & Manufacturing Equipment	✗	✗
Lifts, Elevators and Conveying	✗	✗
Lighting	✓	✗
Miscellaneous	✗	✗
Monitoring, Control and Automation	✓	✗
Power Generation and Storage	✓	✗
Refrigeration	✓	✗

Category Name	Benchmark Design	Improved Design
Safety and Security	✓	✗
Swimming Pools	✓	✗
Water Pumping	✓	✗
Water Removal and Treatment	✓	✗
Water Supply	✓	✗
Workshops, Garage & Misc	✓	✗

Table 5: Operational scope of LCI collection

3.5 Cut off Criteria

The EN15978 cut-off criteria were used to ensure that all relevant potential environmental impacts were appropriately represented:

- Mass – if a flow is less than 1% of the mass at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not of concern.
- Energy – if a flow is less than 1% of the energy at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not a concern.
- The total of neglected input flows per module, e.g. per module A1-A3, A4-A5, B1-B5, B6-B7, C1-C4 and module D shall be a maximum of 5% of energy usage and mass.
- Environmental relevance – if a flow meets the above criteria for exclusion, but is considered to potentially have a significant environmental impact, it has been included. All material flows which leave the system (emissions) and whose environmental impact is higher than 1% of an impact category, have been included.

The Operational Guidance for Life Cycle Assessment Studies (Wittstock et al. 2012) states:

The apparent paradox is that one must know the final result of the LCA (so one can show that the omission of a certain process is insignificant for the overall results) to be able to know which processes, elementary flows etc. can be left out.

The approach taken in this study is to continue modelling smaller inputs until confidence is gained that the criteria is safely met.

3.6 Allocation

Allocation rules follow those of EN15804 as given below:

- Allocation will respect the main purpose of the studied processes. If the main purpose of combined processes cannot be defined (e.g. combined mining and extraction of nickel and precious metals), economic allocation may be used to divide resources and emissions between the products.
- The principle of modularity is maintained. Where processes influence the product's environmental performance during its life cycle, they will be assigned to the module where they occur.
- The sum of the allocated inputs and outputs of a unit process are equal to the inputs and outputs of the unit process before allocation. This means no double counting of inputs or outputs is permissible.

3.7 Independent Review

No independent review has been conducted of this study.

4 Inventory Analysis

The design has been modelled using the available eToolLCD elements, templates and EPDs as shown in Table 6.

eToolLCD Item Type	Count in Design	
	Benchmark	Improved Design
Design Templates	24	129
Equipment and People Elements	495	192
Material Elements	841	341
Energy Elements	38	30
Water Elements	12	13
EPDs	0	0

Table 6: Count of elements, templates and EPDs in the design

The eToolLCD library templates are customisable and users may submit templates for validation. The template validation process is undertaken by experienced LCA practitioners and is a process of checking the user inputs and ensuring the assumptions are adequately referenced. Table 7 shows the extent to which validated templates were used in the model.

eToolLCD Item Type	Validated (%)	
	Benchmark	Improved Design
Total Design Templates	8.33	50.39
Equipment and People Elements	1.01	53.12
Material Elements	.48	37.83
Energy Elements	0	0
Water Elements	0	0

Table 7: Use of validated templates

4.1 Templates Comparison

The eToolLCD templates found in each design are provided in Table 8.

Parent Template Name	Units	Quantity
		Improved Design
Fittings, furnishings and equipment		
Appliances Residential Average (AUS)	#	4
Cooking, Res Electric Oven Induction Stove	#	4
Kitchen Medium sized (incl Equipment)	#	4
Refrigeration, Residential Well Ventilated Fridge Recess	#	4
Standard 1st Bathroom - WC/Shower-bath/Basin/WallTiles	#	10
Substructure		
Concrete Floor - 100mm slab on ground 30MPa 3.8% reo (Portland Cement)	m2	313
Staircase, Timber frame and timber treads	Other	4
Facilitating works		
Demolition - Residential (End-of-Life)	#	4
Superstructure		
Door - SolidCoreTimber/WoodenJam/Painted	#	32.5
Elevated Floor, Timber Frame 300mm Bearers and Joists, <6m Span, particle board sheeting, insulated	m2	225
Roof - TimberTruss/SteelSheeting/25degreePitch	m2	300.0833
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, coloured steel sheet cladding external	m2	178.9
Wall, External, Framed, Timber 140mm studs with battens, insulation, plasterboard and paint internal finish, fibre cement clad (9mm)	m2	396.8
Wall, Internal, Framed, Timber Stud Plasterboard and paint finish	m2	344.21
Windows Residential Aluminium Single Glaze fly screen	m2	95.7284620273972
Services equipment		
Electrical Fittings - sockets power points wiring embodied only (m2)	m2	744
LED Outdoor Lighting (Residential - Standard Efficiency), m2	m2	229.209443772257
LED Residential Lighting (Standard Efficiency)	#	4
Solar PV System Residential - Zone 3 (Perth Sydney etc)	Other	10
Split System Air Source Heat Pump for Cooling, Average Efficiency (COP/EER 3.65), R32 Refrigerant	#	7

Parent Template Name	Units	Quantity
		Improved Design
Split System Air Source Heat Pump for Heating, Average Efficiency (COP/EER 3.65), R32 Refrigerant	#	7
Standard Heat Pump (HWS_App)	#	4
Swimming Pool - Pumps and Filters Ultra Efficient	m2	0.001
Utilities Connection to Site Residential	#	4
Water tank - steel (embodied)	Other	1.6E-05
Water Use and Treatment (eTool Turbo)	#	4
Internal finishes		
Floor Covering - Carpet (glue down/Nylon)	m2	144
Floor Covering - Tiles (ceramic/5mm)	m2	33.7998675496689
Floor Covering - Vinyl (PVC) or Synthetic Linoleum	m2	273.74
External works		
Pool Structure - Concrete	m2	0.001
Swimming Pool Seasonal Temperature Control - No Pool Cover - Gas	m2	0.001

Table 8: Templates Comparison (showing master templates only)

4.2 eToolLCD software

eToolLCD software was used to model life cycle impacts of the project. eToolLCD uses third party background processes aggregated as mid-point indicators and stored in a number of libraries within the software which are coupled with algorithms and user inputs to output the environmental impact assessment. A map of user inputs, data sources and algorithms (outputs) is given in Figure 4.

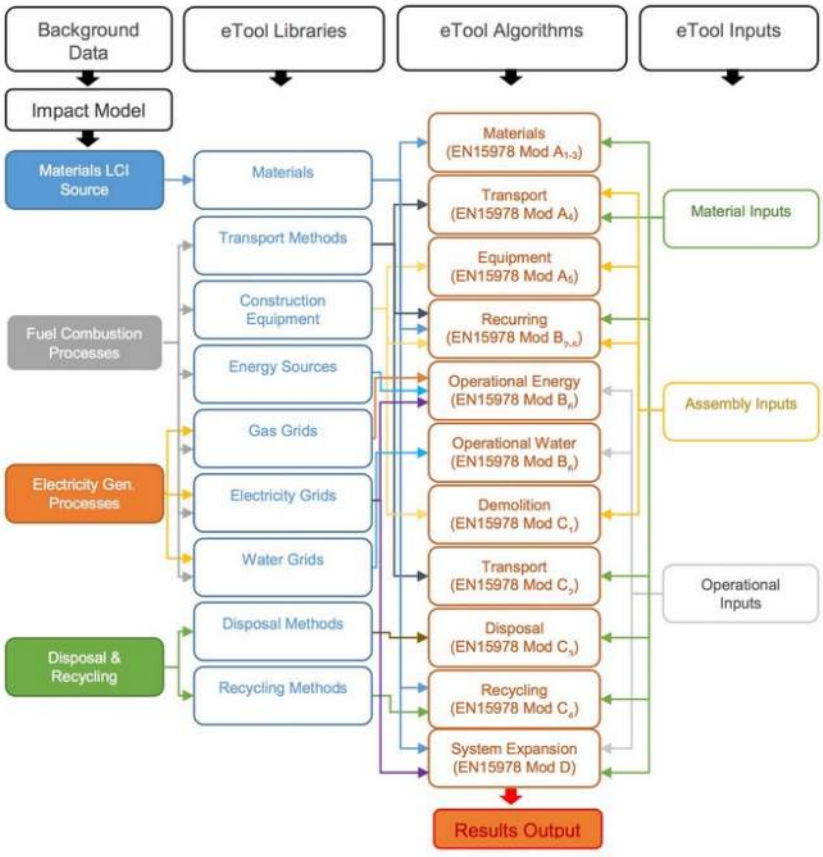


Figure 4: Relationship between LCI background data, eToolLCD software library, inputs and algorithms.

4.3 Data Quality

The data quality requirements for the background data are detailed in Table 9. Each of the criteria has been assessed for compliance and

results presented below.

Criteria	Background Data Requirement	Compliance	
		Benchmark	Improved Design
Temporal Relevancy	For annually fluctuating processes like Grid electricity fuel mixes the datasets must have been updated within the last 2 years. More static processes like materials production must have been updated within the last 10 years. Product specific EPDs must have been updated in the last 5 years.	Failed Grid Passed Materials	Failed Grid Passed Materials
Geographical Relevancy	The background data should be specifically compiled for the same country (preferable) or continent as the project location.	Passed (Same Continent)	Passed (Same Country)
Precision	No requirement specified however a qualitative review undertaken to ensure no erroneous values	Passed	Passed
Completeness	Qualitative assessment of the process to ensure no obvious exclusions	Passed	Passed
Technological Relevancy	Ensure that technology assumptions are representative for the product or product group.	Passed	Passed
Consistency	The study methodology holds for the background data.	Passed	Passed
Reproducibility	The information available about the methodology and the data values reported should allow an independent practitioner to reproduce the results reported in the study.	Passed	Passed

Table 9: Summary of data quality requirements for the study.

Criteria	Inventory Collection Requirement (eToolLCD User Inputs)	Compliance	
		Benchmark	Improved Design
Temporal Relevancy	All inputs into eToolLCD to be reflective of the project being assessed and if assumptions are made these are to be based on industry practices that are consistent with the project commissioning date.	Passed 0/5 Checks	Passed 0/1 Checks
Geographical Relevancy	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these are based on the current practices employed in the project country.	Passed 0/5 Checks	Passed 0/2 Checks
Precision	To avoid aggregated errors a high level of precision is expected inputs into eToolLCD software, being either to 3 significant figures or: • Two significant figures or nearest 10 hours for equipment run time • Two significant figures or nearest 10kg for material quantities • Two significant figures or nearest 100MJ / annum for operational energy • Two significant figures or nearest 100kL / annum for operational water use	Passed 0/4 Checks	Passed 0/1 Checks
Completeness	Inputs to cover all life cycle phases and elements identified in the system boundary. The link between background data, eToolLCD algorithms and subsequent LCA results is not to introduce significant gaps in the data.	Passed 0/9 Checks	Passed 0/2 Checks
Technological Relevancy	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these must be drawn from appropriate examples of like technology.	Passed 0/5 Checks	Passed 0/1 Checks
Consistency	All inputs into eToolLCD must be reflective of the project being assessed and if assumptions are made these are drawn from the same reference library.	Passed 0/9 Checks	Passed 0/0 Checks
Reproducibility	The information available about the methodology and the data values reported should allow an independent practitioner to reproduce the results reported in the study.	Passed 0/9 Checks	Passed 0/1 Checks

Table 10: Summary of data quality requirements for the study.

4.4 Completeness

The study aims to follow EN15804 procedures for exclusion of inputs and outputs:

- All inputs and outputs to a (unit) process shall be included in the calculation, for which data are available.
- Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be documented.
- In case of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1 % renewable and non-renewable primary energy usage and 1 % of the total mass input of that unit process.
- The total of neglected input flows per module, e.g. per module shall be a maximum of 5 % of energy usage and mass.
- Conservative assumptions in combination with plausibility considerations and expert judgement can be used to demonstrate compliance with these criteria.
- Particular care should be taken to include material and energy flows known to have the potential to cause significant emissions into air and water or soil related to the environmental indicators.

Two major tests were run to determine the compliance with the above cut-off rules.

4.3.1 Inventory Mass Quantities

The cumulative mass of inventory entries is shown in Figure 5. Given that 184 material elements within the LCA base design make up the last 1% of mass inventory entries a high level of confidence exists that the cut off rules have been upheld.

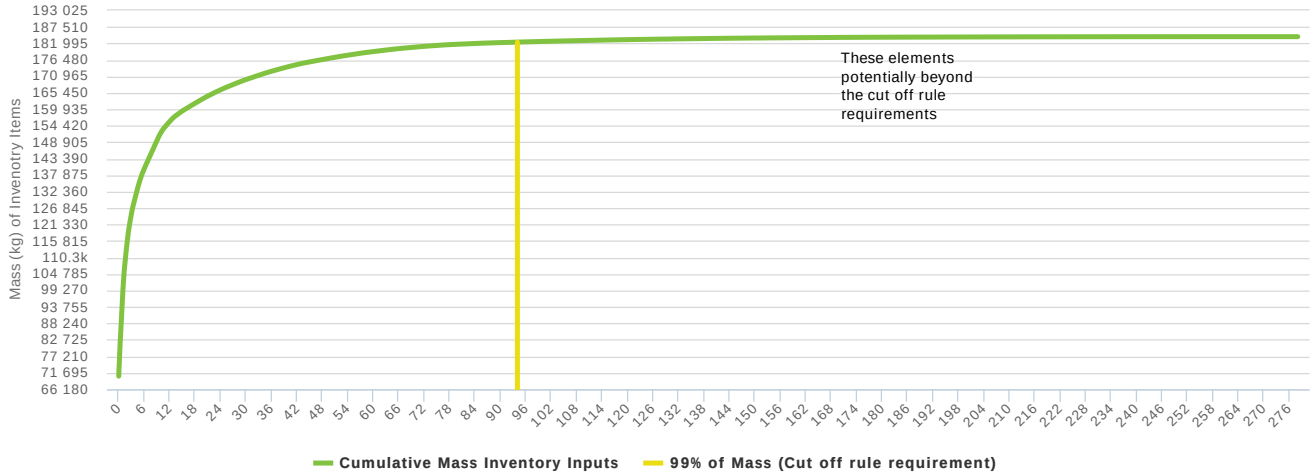


Figure 5: Cumulative Mass Inventory Entries. In this case 65.95% make up the last 5% of mass inventory entries.

4.3.2 Inventory Energy Analysis

The cumulative embodied energy of inventory entries is shown in Figure 6. Given that 337 elements within the LCA base design make up the last 1% of embodied energy inventory entries a high level of confidence exists that the cut off rules have been upheld.

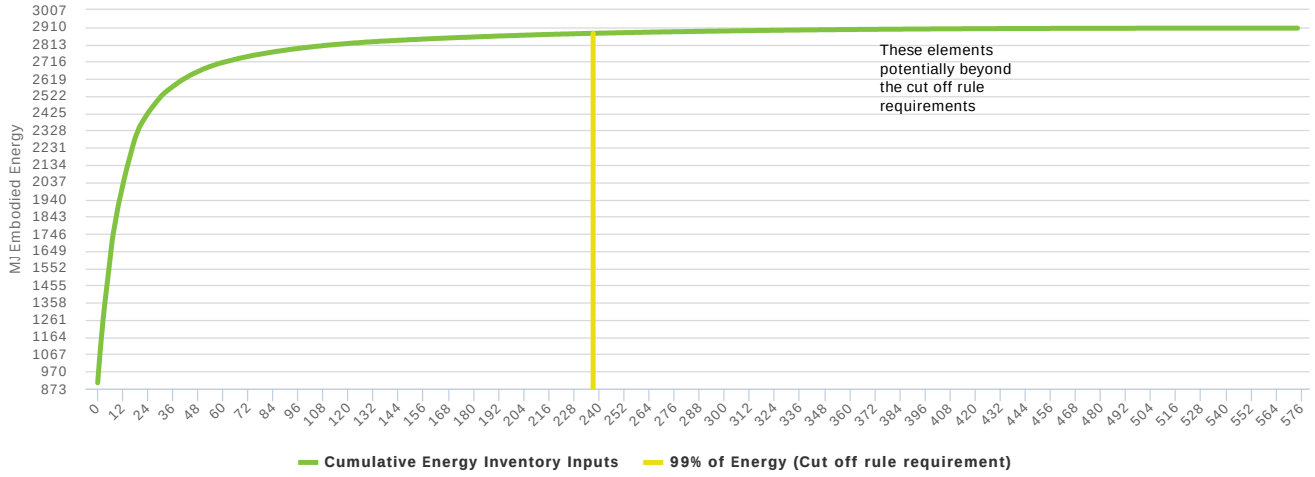


Figure 6: Cumulative Energy Inventory Entries. In this case 58.61% make up the last 5% of energy inventory entries.

5 Life Cycle Impact Assessment

The Life Cycle Impact Assessment (LCIA) results are provided in Table 11 and subsequent tables in the EN15978 reporting format. The heat map highlights the highest impacts for each indicators assessed and conversely in the comparison tables the highest savings observed. For further details on the LCIA please refer to interpretation.

5.1 Improved Design Environmental Impacts Indicators

Characterised Impacts Per Occupant Per Year		Materials and Construction			Use Stage								End of Life Stage				Benefits and Loads Beyond the System Boundary	Total
		A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B6+	B7	C1	C2	C3	C4	D	
Benchmark																		
GWP	kg CO_2 eq	6.18e+2	1.24e+2	95.742	0	0	MNA	5.06e+2	0	9.40e+2	8.22e+2	1.66e+2	0	50.083	0	69.335	-75.873	3.31e+3
ODP	kg CFC-11 eq	3.00e-5	1.91e-5	1.47e-5	0	0	MNA	3.44e-5	0	4.88e-6	6.59e-6	3.61e-6	0	7.97e-6	0	4.61e-6	-2.26e-6	1.24e-4
AP	kg SO_2 eq.	3.5093	0.3927	0.2682	0	0	MNA	2.4678	0	1.1599	1.5239	0.3678	0	0.1555	0	0.0906	-1.0128	8.9228
EP	kg PO_4 eq	1.28e+0	9.64e-2	4.67e-2	0	0	MNA	8.26e-1	0	3.81e-1	5.09e-1	2.43e-1	0	3.47e-2	0	1.94e-2	-4.85e-1	2.95e+0
POCP	kg ethylene	2.24e-1	2.51e-2	3.61e-2	0	0	MNA	1.67e-1	0	8.29e-2	4.24e-2	2.40e-2	0	1.03e-2	0	1.40e-2	-3.41e-2	5.92e-1
ADPE	kg antimony	5.86e-2	3.61e-3	2.61e-4	0	0	MNA	4.79e-2	0	4.21e-3	6.09e-3	2.88e-3	0	2.02e-3	0	1.11e-4	-1.88e-2	1.07e-1
ADPF	MJ	7674.4	1899.3	1298.7	0	0	MNA	7168.8	0	1.38e+4	1.06e+4	2002.3	0	779.5	0	464	-826.2	44873
Improved Design																		
GWP	kg CO_2 eq	161.66	37.76	24.868	-0.435	2.064	MNA	3.41e+2	0	29.053	751.82	1.02e+2	9.684	10.448	1.832	71.327	-477.83	1.07e+3
ODP	kg CFC-11 eq	3.98e-5	5.80e-6	2.54e-6	0	2.61e-7	MNA	1.35e-4	0	2.33e-7	6.03e-6	2.36e-6	1.67e-6	1.66e-6	3.68e-7	7.98e-7	-2.38e-6	1.94e-4
AP	kg SO_2 eq.	2.11e+0	1.23e-1	5.49e-2	0	7.52e-3	MNA	1.80e+0	0	5.39e-2	1.39e+0	2.32e-1	2.82e-2	3.21e-2	4.43e-3	1.67e-2	-1.36e+0	4.50e+0
EP	kg PO_4 eq	1.11e+0	0.0333	8.27e-3	0	2.18e-3	MNA	7.77e-1	0	1.80e-2	4.65e-1	1.71e-1	5.73e-3	7.13e-3	9.63e-4	3.61e-3	-5.42e-1	2.06e+0
POCP	kg ethylene	1.50e-1	7.87e-3	1.20e-2	0	5.78e-4	MNA	1.37e-1	0	1.50e-3	3.88e-2	1.51e-2	2.18e-3	2.13e-3	1.67e-4	1.05e-2	-4.30e-2	3.35e-1
ADPE	kg antimony	3.23e-2	9.85e-4	5.14e-5	0	1.02e-4	MNA	4.23e-2	0	2.15e-4	5.57e-3	1.97e-3	7.46e-5	3.78e-4	1.58e-5	1.86e-5	-9.17e-3	7.47e-2
ADPF	MJ	3231.7	573	236.8	0	29.5	MNA	4371.9	0	375.4	9715.4	1222.8	145.5	161.5	23.4	79.1	-5997	14169
Savings (Improved Design Compared to Benchmark)																		
GWP	kg CO_2 eq	4.56e+2	86.251	70.874	0.435	-2.064	MNA	1.64e+2	0	9.11e+2	70.229	63.105	-9.684	39.635	-1.832	-1.991	4.02e+2	67.83%
ODP	kg CFC-11 eq	-9.77e-6	1.33e-5	1.22e-5	0	-2.61e-7	MNA	-1.01e-4	0	4.64e-6	5.63e-7	1.25e-6	-1.67e-6	6.31e-6	-3.68e-7	3.82e-6	1.17e-7	-57.12%
AP	kg SO_2 eq.	1.40e+0	2.69e-1	2.13e-1	0	-7.52e-3	MNA	6.70e-1	0	1.11e+0	1.30e-1	1.36e-1	-2.82e-2	1.23e-1	-4.43e-3	7.39e-2	3.44e-1	49.56%
EP	kg PO_4 eq	1.70e-1	6.31e-2	3.84e-2	0	-2.18e-3	MNA	4.87e-2	0	3.63e-1	4.35e-2	7.21e-2	-5.73e-3	2.75e-2	-9.63e-4	1.58e-2	5.62e-2	30.11%
POCP	kg ethylene	7.42e-2	1.73e-2	2.41e-2	0	-5.78e-4	MNA	3.03e-2	0	8.14e-2	3.62e-3	8.94e-3	-2.18e-3	8.16e-3	-1.67e-4	3.47e-3	8.91e-3	43.45%
ADPE	kg antimony	2.63e-2	2.62e-3	2.10e-4	0	-1.02e-4	MNA	5.58e-3	0	3.99e-3	5.20e-4	9.08e-4	-7.46e-5	1.64e-3	-1.58e-5	9.24e-5	-9.61e-3	30.04%
ADPF	MJ	4442.8	1326.3	1061.9	0	-29.5	MNA	2796.9	0	1.34e+4	907.5	779.5	-145.5	617.9	-23.4	384.9	5170.8	68.42%

Table 11: Environmental Impacts Impact of Each Life Cycle Phase.
INA: Indicator Not Assessed. MNA: Module Not Assessed.
Impact Key: Top 10% Top 20% Top 30%
Savings Key: Top 10% Top 20% Top 30%

6 Life Cycle Interpretation

The following sections provide more detailed results of the life cycle impact assessment for each environmental indicator with the aim of identifying the largest areas of impact. A one page profile for each indicator is provided on the subsequent pages giving detailed information about the indicator. Each chart provided is explained below.

Impact Time Series Chart:

A chart displaying when impacts occur during the life of a design. This enables users to gain insights such the “environmental payback period” of a design compared to alternatives, or when there are jumps in an impact value during the life of the project (for example, relating to a large replacement item).

Top Five Charts

Each top 5 chart categorises the buildings and expresses the environmental impacts by these categories. This enables a detailed understanding of what is responsible for the greatest environmental burdens and also compares these burdens between designs. The pie chart associated with each bar chart shows the proportion of the building that is represented in the bar chart. A brief description of the categories is provided below:

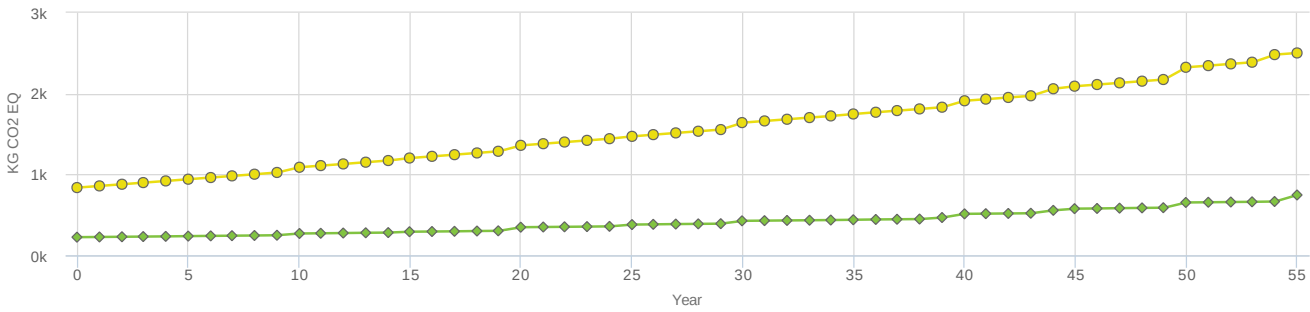
- **LC Module Impacts:** The EN15978 Life Cycle Modules. Generally 100% building impacts will be included in the bar chart.
- **Construction Category:** The breakdown of the impacts by construction category. The bar chart will generally only part of the total building impacts.
- **Operational Demand:** The building end use demands that are driving environmental impacts.
- **Energy Supply:** The supply of fuels to the building, in effect the upstream fuel sources supplying energy for on site use during construction, operational and demolition.
- **Materials:** The materials (grouped into common categories) that are driving the environmental impacts.
- **Equipment and People:** The equipment and people required during construction, maintenance and demolition and all associated transport trips that are driving the environmental impacts

All impact figures are quoted per the functional unit selected for the study.

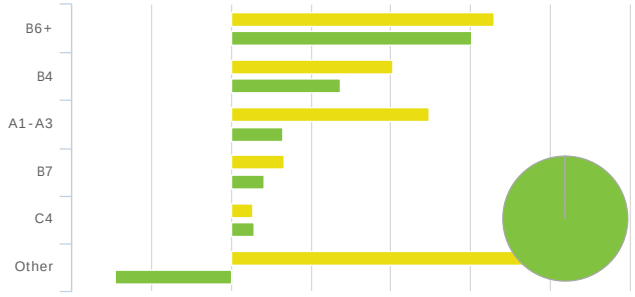
6.1 Global Warming Potential, GWP Profile

Business as Usual Improved Design

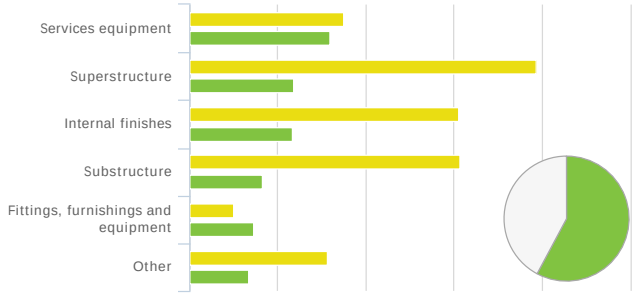
TIME SERIES CHART



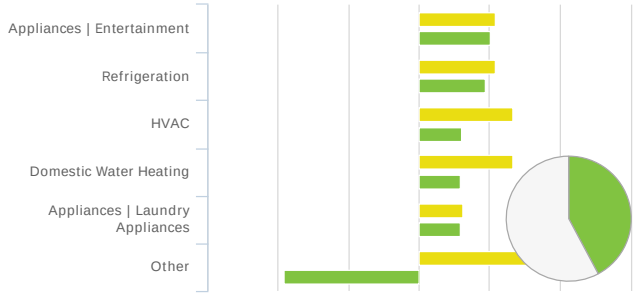
Top 5 Life Cycle Modules



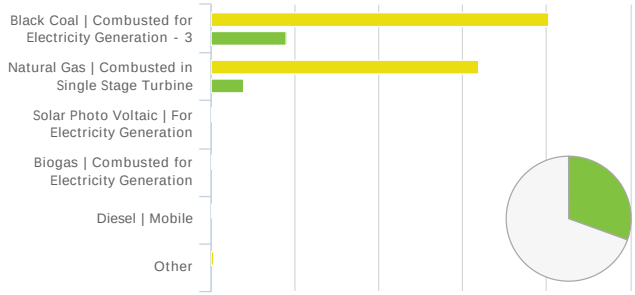
Top 5 Construction Categories



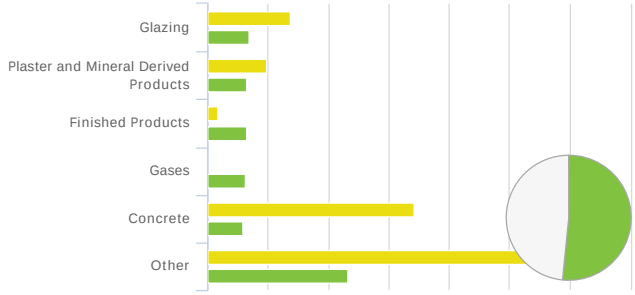
Top 5 Operational Demands



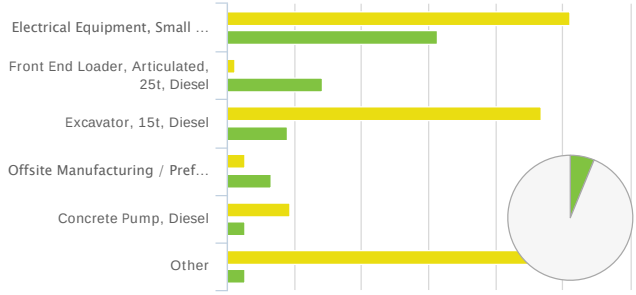
Top 5 Operational Supply Sources



Top 5 Materials

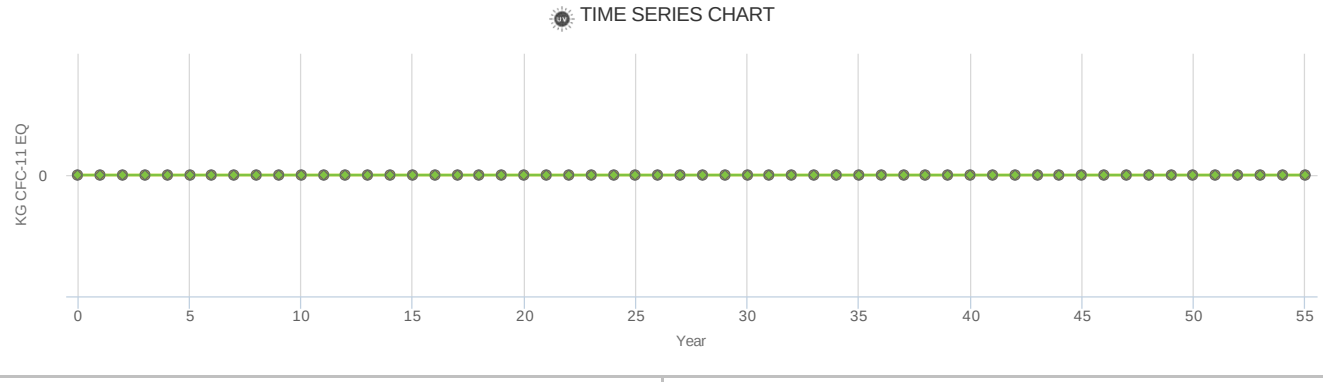


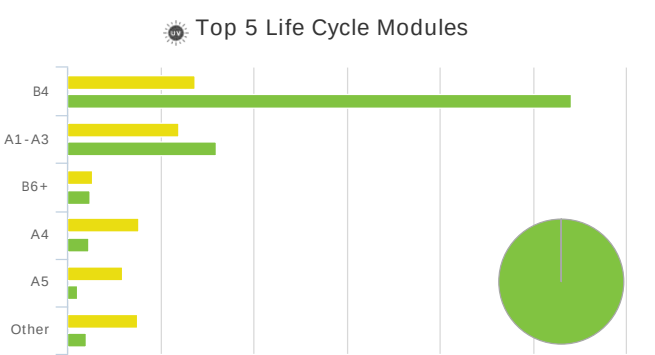
Top 5 Equipment & People

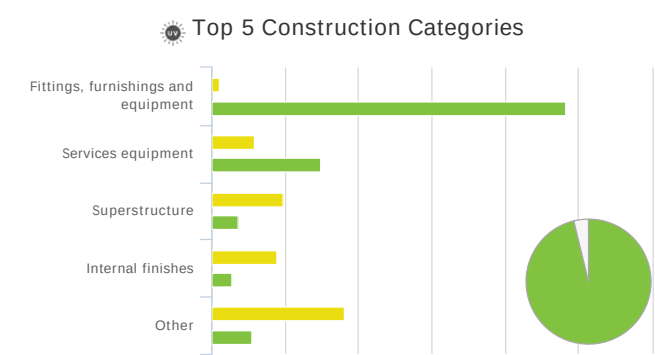


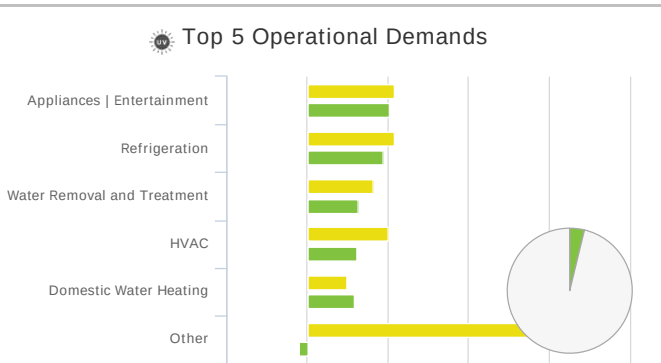
6.2 Ozone Depletion Potential, ODP Profile

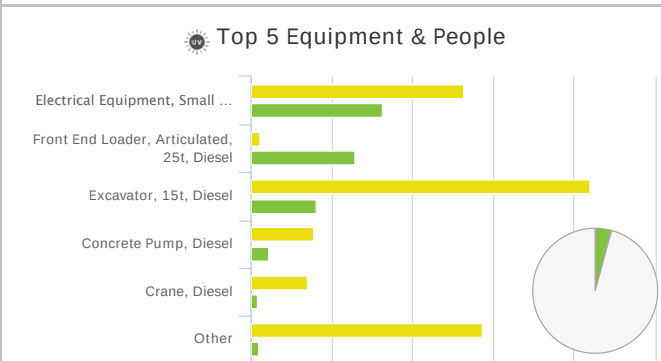
Business as Usual Improved Design





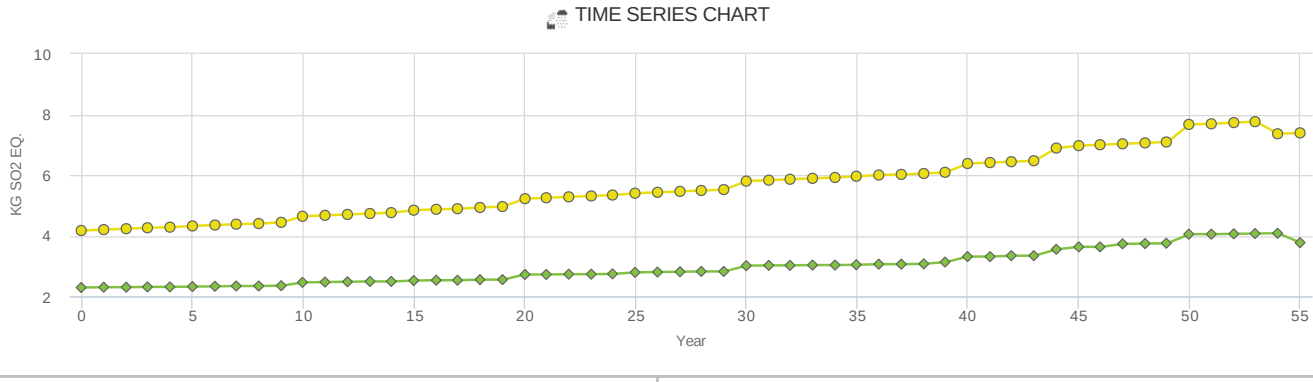


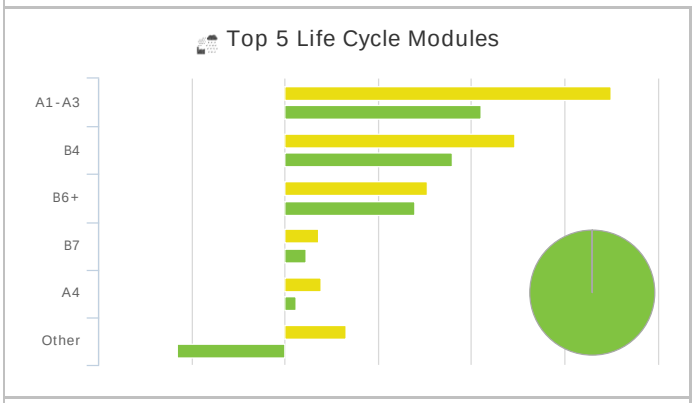


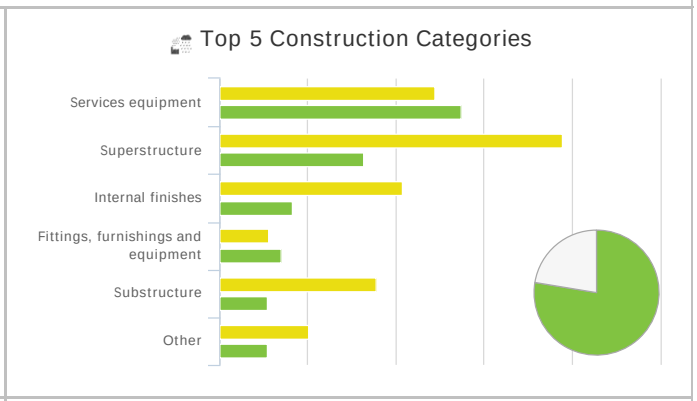


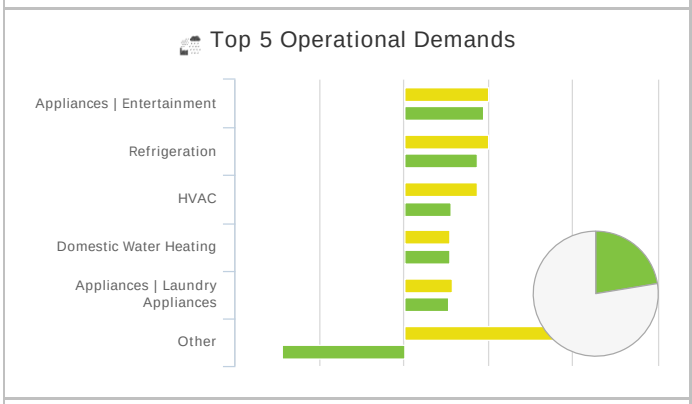
6.3 Acidification Potential for Soil and Water, AP Profile

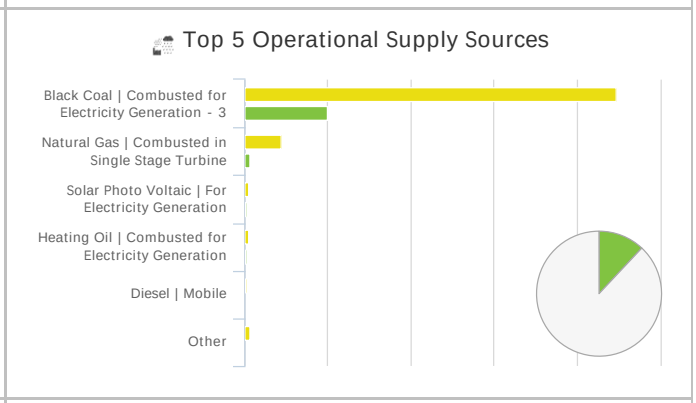
Business as Usual Improved Design

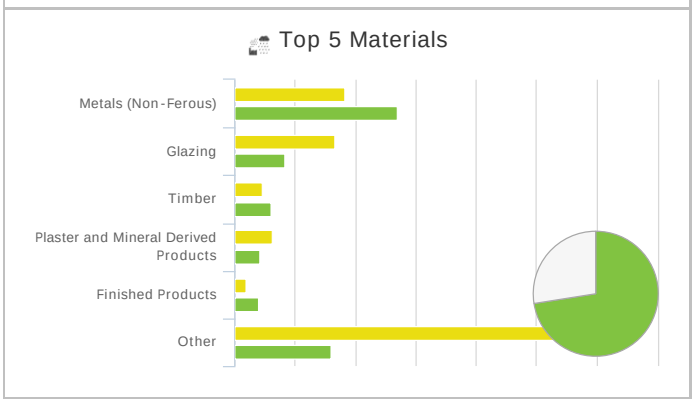


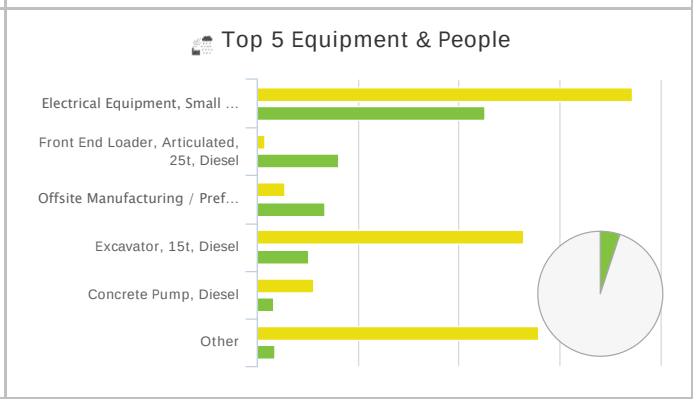






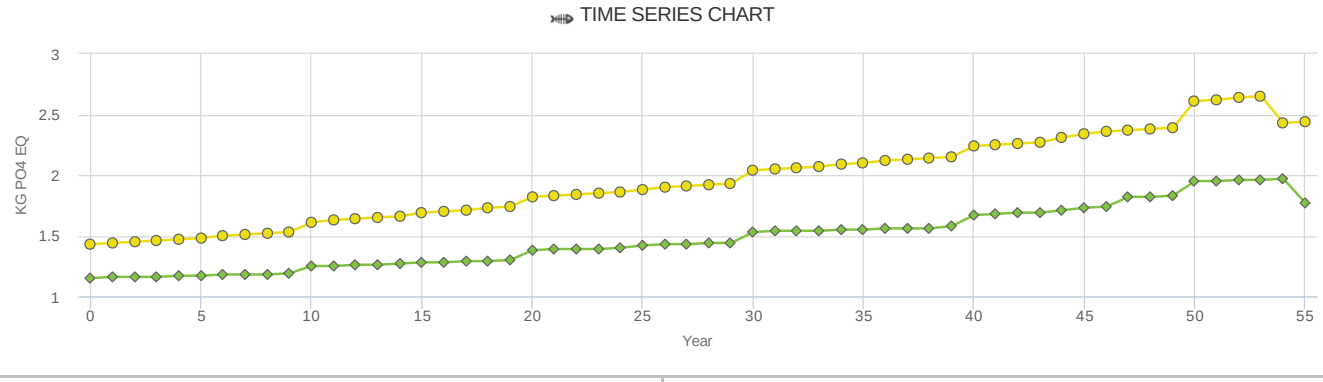


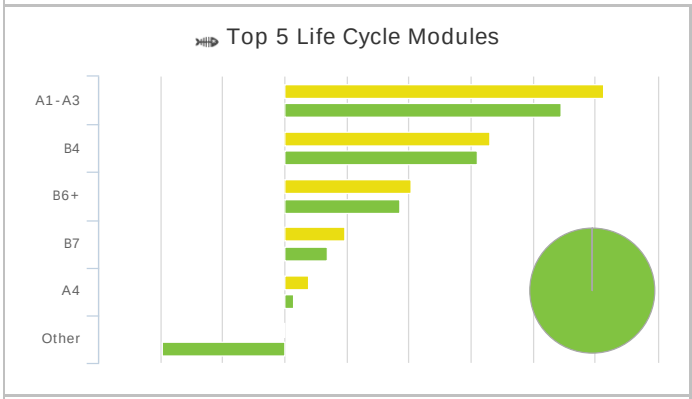


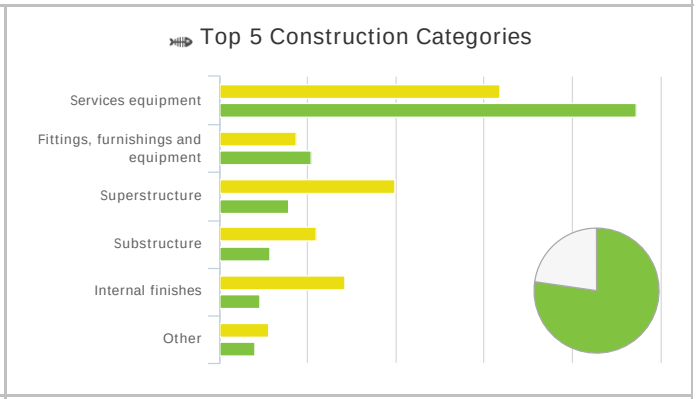


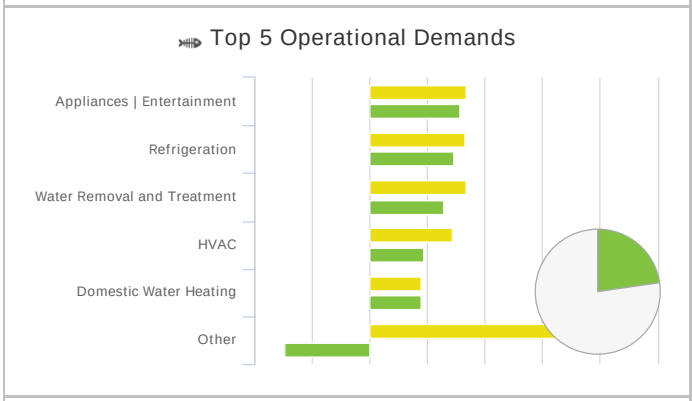
6.4 Eutrophication potential, EP Profile

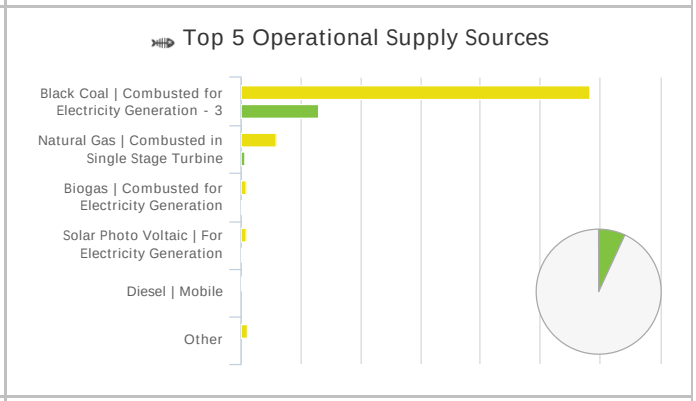
Business as Usual Improved Design

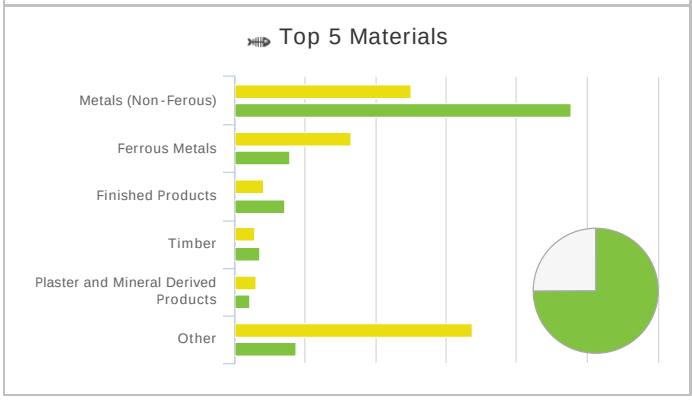


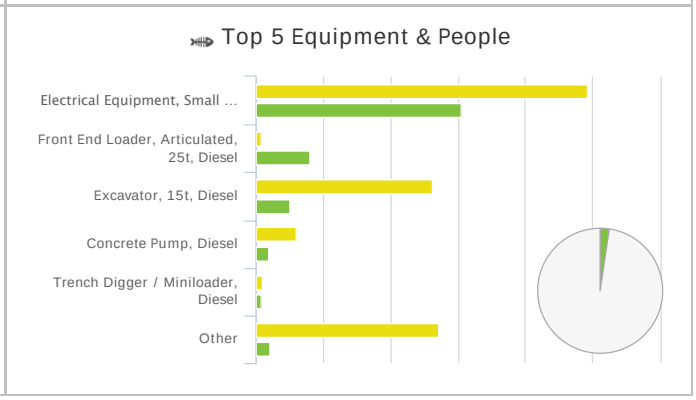






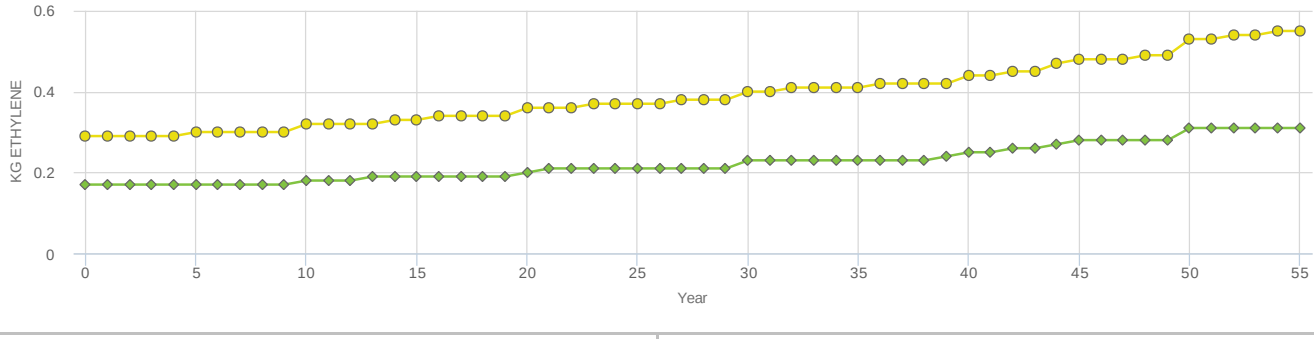


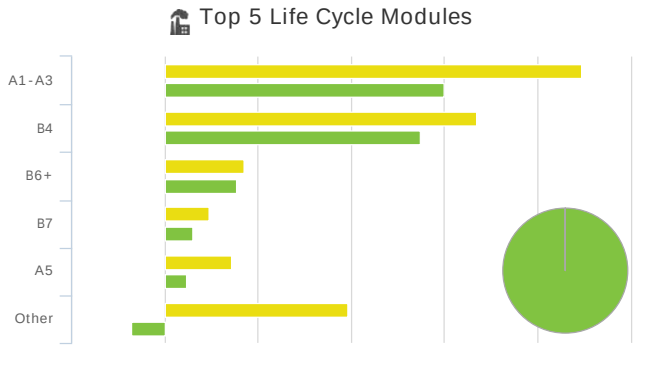


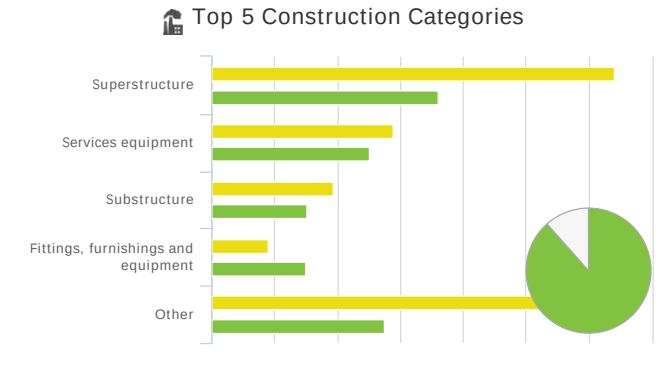


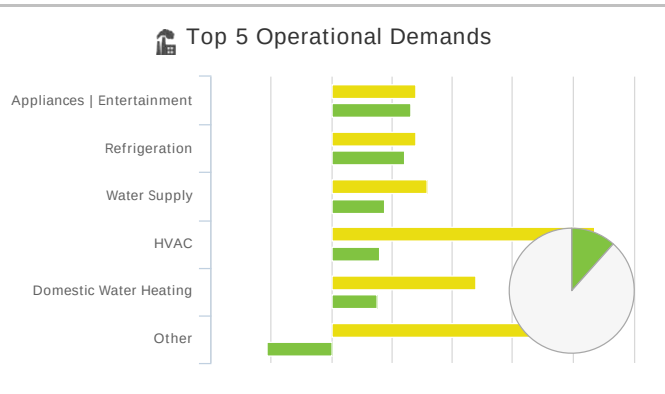
6.5 Photochemical Ozone Creation Potential, POCP Profile

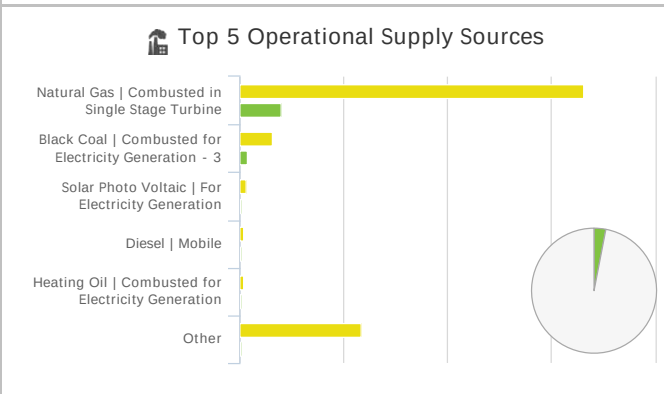
Business as Usual Improved Design

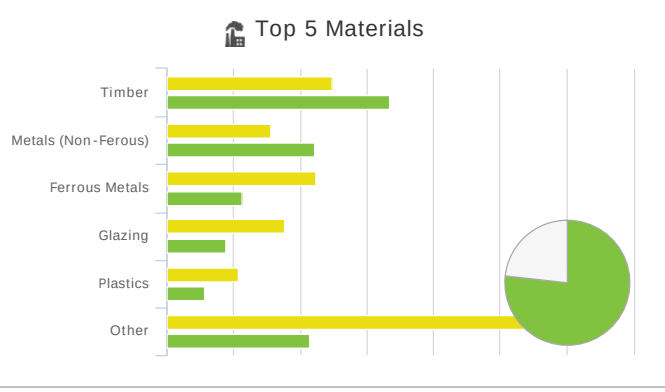


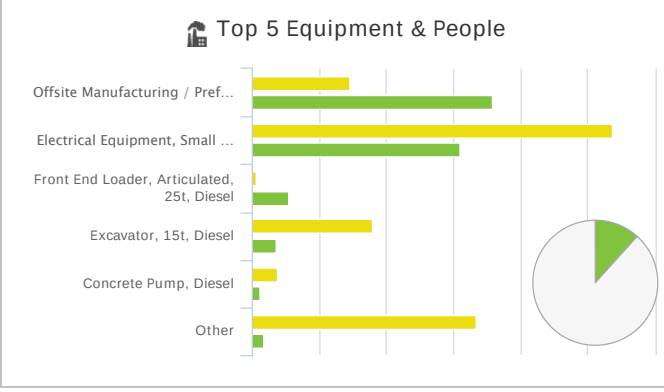






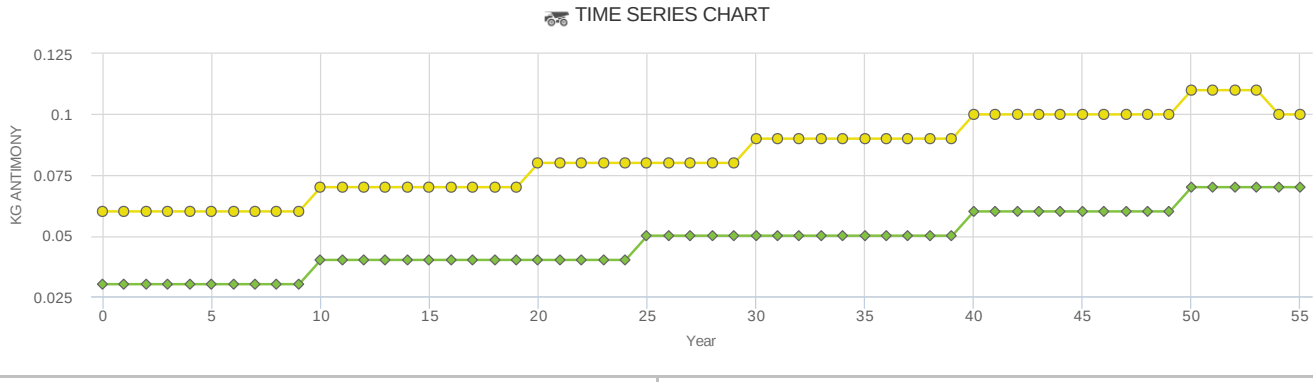


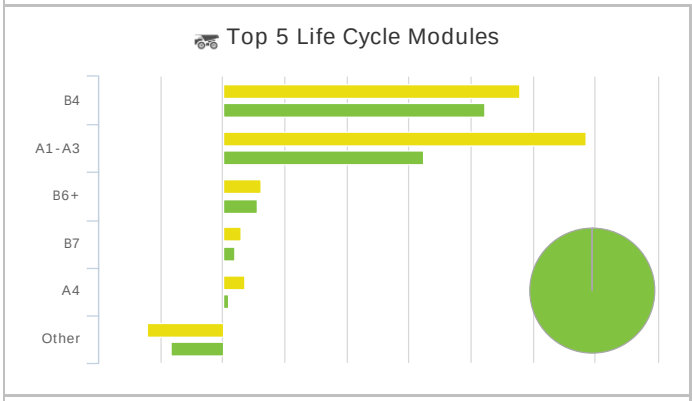


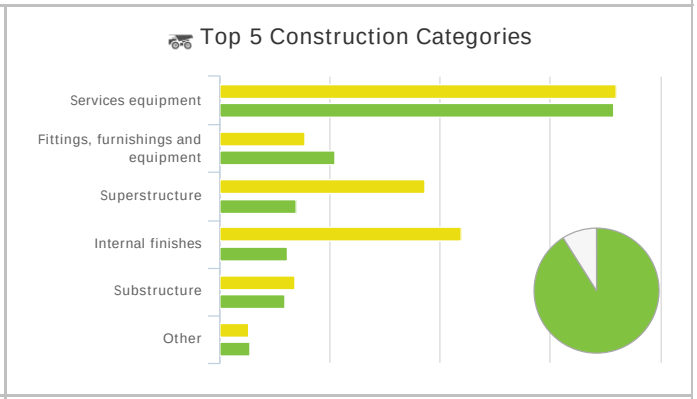


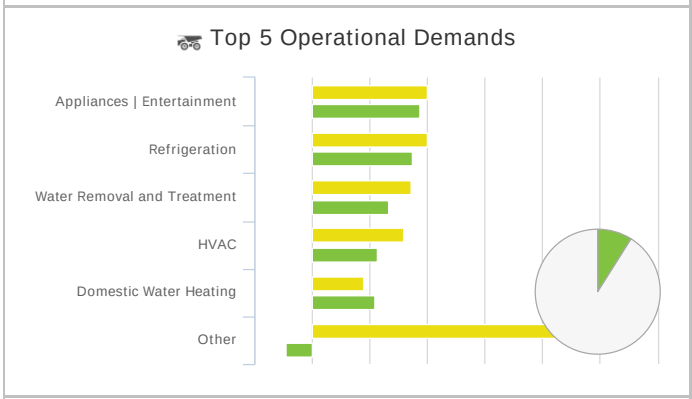
6.6 Abiotic Depletion Potential - Elements, ADPE Profile

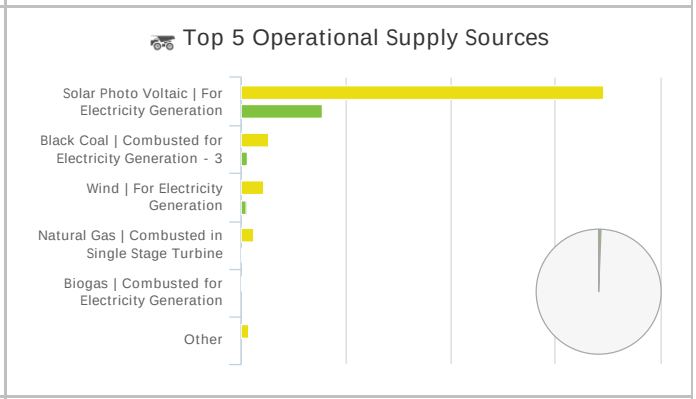
Business as Usual Improved Design

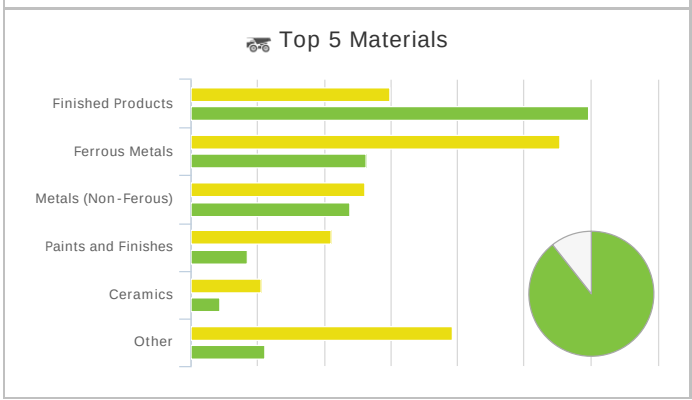


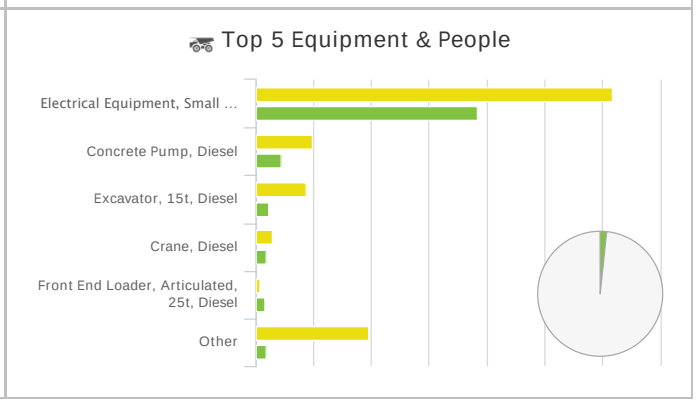








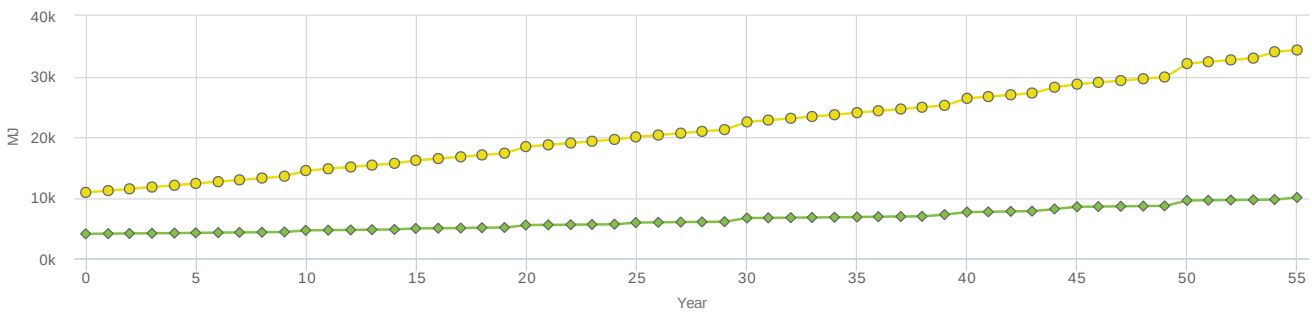




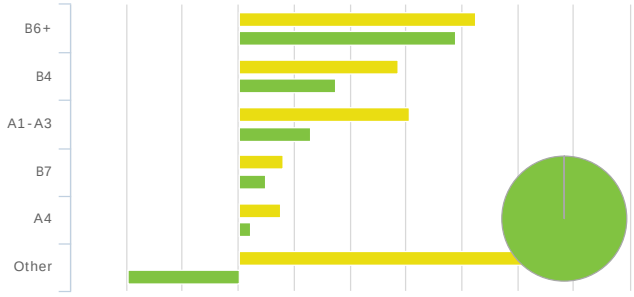
6.7 Abiotic Depletion Potential - Fossil Fuels, ADPF Profile

Business as Usual Improved Design

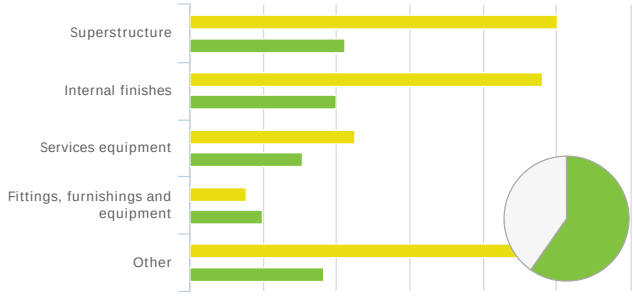
TIME SERIES CHART



Top 5 Life Cycle Modules

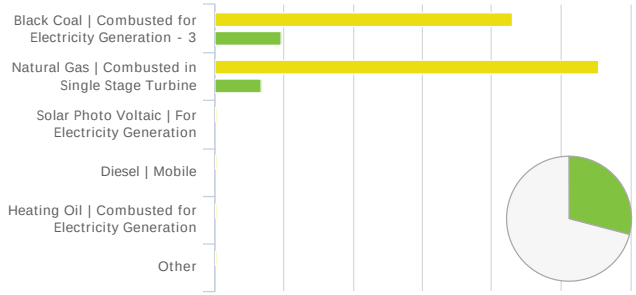


Top 5 Construction Categories

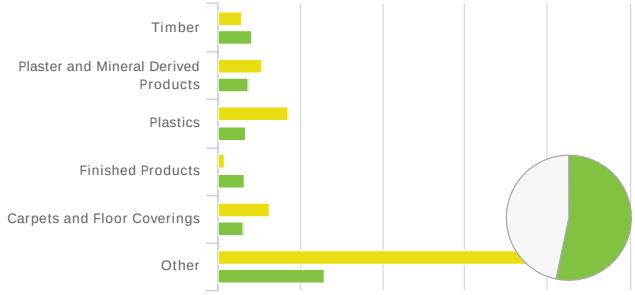


Top 5 Operational Demands

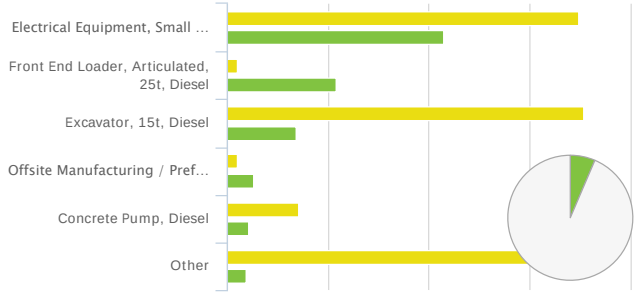
Top 5 Operational Supply Sources



Top 5 Materials



Top 5 Equipment & People



7 Low Impact Strategies

The following potential low impact design strategies were modelled in the LCA study to determine the relative benefits and aid the design decision making process.

For each design strategy, the relative savings for all indicators is provided and given in context to the other strategies. A basic description of the strategy is also provided.

8 Conclusions

The Improved Design shows an expected performance improvement against Business as Usual for 6 of the 7 environmental indicators.

9 References

9.1 Background LCI Data

Life Cycle Strategies, 2015, Australasian LCI - V15 - Life Cycle Strategies (BETA)

9.2 Inventory - Design Documentation

No design documents were recorded.

9.3 Inventory - Assumptions

, 2008, Energy Use in the Australian Residential Sector 1986 To 2020 (Report),
Super Efficient Equipment and Appliance Deployment, Clean Energy Ministerial, 2013, Heat Pump Water Heaters: Summary and Comparison of International Test Standards, Web Link.
2006, Life Expectancy of Building Components, https://costmodelling.com/lifespans, Web Link.
2007, Study of Life Expectancy of Home Components, Web Link.
2013, Truck-mounted concrete pump 47 M5 XXT with optimised boom and innovative support, Web Link.
2018, Rawlinsons Construction Cost Guide 2019, Perth, WA, Web Link.
Australian Government, Equipment Energy Efficiency, 2018, Decision Regulation Impact Statement: Swimming pool pumps, Web Link.
Bauer Marc, Bödeker Jan Maurice, International Aluminium Institute, Pehnt Dr. Martin, 2010, Aluminium and Renewable Energy Systems – Prospects for the Sustainable Generation of Electricity and Heat, Heidelberg, Web Link.
BlueScope Steel, 2013, Lysaght Products, Web Link.
BlueScope Steel, Colorbond Steel Warranty, Port Kembla, NSW, Web Link.
Commonwealth of Australia , 2012, Air-Source Heat Pump Water Heaters in Australia and New Zealand, Canberra, Web Link.
Cost Modelling, 2012, Typical Life Expectancy of Building Components - Floor & Ceiling Finishes, Web Link.
Cost Modelling, 2012, Typical Life Expectancy of Building Components - Wall Finishes, Web Link.
Daisy Pool Covers, 2020, The Facts about Pool Blankets, Web Link.
DEFRA, Energy Saving Trust, 2008, Measurement of Domestic Hot Water Consumption in Dwellings, Web Link.
Estimating Demolition Costs for Single Residential Buildings, Deakin University, Web Link.
Field F, Gregory J, Kirchain R, Nicholson A, Olivetti E, 2009, End of Life Allocation Methods: Open Loop Recycling Impacts on Robustness of Material Selection Decisions,
General Information (Door hinge loads), Web Link.
Graedel Thomas E, 2011, Recycling Rates of Metals, Web Link.
Grant Tim, Pears Alan, 2006, Allocation Issues in Life Cycle Assessment - Benefits of Recycling and the Role of Environmental Rating Schemes,
Home Interiors, Tile Adhesive and Grout Calculator, Web Link.
Malabago Nolasco K. , 2016, Refrigerant Recovery and Recycling Machine: An Innovation, Cebu, Web Link.
PACIA, 2007, Plastic Recycling Rates,
Rawlinsons, 2011, Rawlinsons Australian Construction Handbook, Perth,
Reinforcing Steel Bars Weights and Dimensions, Web Link.
Reinforcing Steel Bars Weights and Dimensions, Web Link.
The Roofing Professionals, THE DIFFERENCE BETWEEN COLORBOND AND ZINCALUME, Web Link.
Tiles LTP, Tile Coverage Calculator, Web Link.
Villaume Gayle, 2011, 2010 Recycling Data - Australian Packaging Covenant,

9.4 Environmental Product Declarations

No EPD references were recorded.

Appendix A: Environmental Indicators Description

Global Warming Potential, GWP

Anthropogenic global warming is caused by an increase of greenhouse gasses (GHG) in the earth's atmosphere. These gasses reflect some of the heat radiated from the earth's surface that would normally escape into space back to the surface of the earth. Overtime this warms the earth. Common GHGs include CO2, N2O, CH4 and volatile organic compounds (VOCs). Global Warming Potential (GWP) is expressed in equivalent GHGs released, usually in kgCO2e.

Ozone Depletion Potential, ODP

Ozone is formed and depleted naturally in the earth's stratosphere (between 15-40 km above the earth's surface). Halocarbon compounds are persistent synthetic halogen containing organic molecules that can reach the stratosphere leading to more rapid depletion of the ozone. As the ozone in the stratosphere is reduced more of the ultraviolet rays in sunlight can reach the earth's surface where they can cause skin cancer and reduced crop yields. Ozone Depletion Potential (ODP) is expressed in equivalent ozone depleting gasses (normally kgCFC11e).

Acidification Potential for Soil and Water, AP

Acidification is a consequence of acids (and other compounds which can be transformed into acids) being emitted to the atmosphere and subsequently deposited in surface soils and water. Increased acidity can result in negative consequences for flora and fauna in addition to increased corrosion of manmade structures (buildings vehicles etc.). Acidification Potential (AP) is an indicator of such damage and is usually measured in kgSO_2e

Eutrophication potential, EP

Over enrichment of aquatic ecosystems with nutrients leading to increased production of plankton, algae and higher aquatic plants leading to a deterioration of the water quality and a reduction in the value and/or the utilisation of the aquatic ecosystem. Eutrophication is primarily caused by surplus nitrogen and phosphorus. Sources of nutrients include agriculture (fertilisers and manure), aquaculture, municipal wastewater, and nitrogen oxide emissions from fossil fuel combustion.

Photochemical Ozone Creation Potential, POCP

Photochemical Ozone Creation Potential (POCP), commonly known as smog, is toxic to humans in high concentration. Although ozone is protective in the stratosphere at low levels it is problematic from both a health and nuisance perspective. Plant growth is also effected through damaged leaf surfaces and reduced photosynthesis. POCP is formed when sunlight and heat react with Volatile Organic Compounds (VOCs).

Abiotic Depletion Potential - Elements, ADPE

Abiotic Resource Depletion of energy (ADPM) is a measure of the extraction and consumption of primary resources from the earth. Such exploitation reduces resources available to future generations and as such must be managed.

Abiotic Depletion Potential - Fossil Fuels, ADPF

Abiotic Resource Depletion of energy (ARDE) is a measure of the extraction and consumption of non-renewable energy sources (primarily fossil fuels, but also inclusive of other energy sources such as uranium). Primary energy content of non-renewable energy sources including the embodied energy to extract, process and deliver the non renewable fuels, or manufacture, transport and install the renewable generator. Hence there is usually and non-renewable energy content associated with renewable fuels also.

Appendix B: Detailed Structure Scope Diagram

Key: ✓ In Scope, In Design ✓ In Scope, Not In Design ✓ Partial ✗ Out of Scope

Parent Name	Sub Category Name	Benchmark Design	Improved Design
Substructure	Substructure	✓	✗
	Standard foundations	✓	✗
	Specialist foundations	✓	✗
	Lowest floor construction	✓	✗
	Insulation	✓	✗
	Basement excavation	✓	✗
	Basement retaining walls	✓	✗
Superstructure	Frame	✓	✗
	Frame	✓	✗
	Upper floors	✓	✗
	Floors	✓	✗
	Insulation	✓	✗
	Balconies	✓	✗
	Drainage to balconies	✓	✗
	Roof	✓	✗
	Insulation	✓	✗
	Roof structure	✓	✗
	Roof coverings	✓	✗
	Specialist roof systems	✓	✗
	Roof drainage	✓	✗
	Rooflights, skylights and openings	✓	✗
	Roof features	✗	✗
	Stairs and ramps	✓	✗
	Stair/ramp structures	✓	✗
	Stair/ramp finishes	✓	✗
	Stair/ramp balustrades and handrails	✓	✗
	Ladders/chutes/slides	✓	✗
	External walls	✓	✗
	External Paint, Textures and Renders	✓	✗
	External enclosing walls above ground level	✓	✗
	Insulation	✓	✗
	External enclosing walls below ground level	✓	✗
	Solar/rain screening	✓	✗
	External soffits	✓	✗
	Subsidiary walls, balustrades and proprietary balconies	✓	✗
	Façade access/cleaning systems	✓	✗
	Windows and external doors	✓	✗
	External windows	✓	✗
	Security and Fly Screens	✓	✗
	External doors	✓	✗
	Internal walls and partitions	✓	✗
	Walls and partitions	✓	✗
	Insulation	✓	✗
	Balustrades and handrails	✓	✗
	Moveable room dividers	✓	✗
	Cubicles	✓	✗
	Internal doors	✓	✗
	Internal doors	✓	✗
Internal finishes	Wall finishes	✓	✗
	Wall finishes	✓	✗
	Cornices & Shadowlines	✓	✗
	Paint - Walls	✓	✗
	Wet Area Walls	✓	✗
	Floor finishes	✓	✗
	Finishes to floors	✓	✗
	Wet Area Floors	✓	✗
	Raised access floors	✓	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	Ceiling finishes	✓	✗
	Finishes to ceilings	✓	✗
	False ceilings	✓	✗
	Demountable suspended ceilings	✓	✗
Fittings, furnishings and equipment	Fittings, furnishings and equipment	✓	✗
	General fittings, furnishings and equipment	✓	✗
	Domestic kitchen fittings and equipment	✓	✗
	Special purpose fittings, furnishings and equipment	✗	✗
	Signs/notices	✗	✗
	Works of art	✗	✗
	Non-mechanical and non-electrical equipment	✗	✗
	Internal planting	✗	✗
	Bird and vermin control	✗	✗
Services equipment	Sanitary installations	✓	✗
	Sanitary appliances	✓	✗
	Sanitary ancillaries	✓	✗
	Services equipment	✓	✗
	Services equipment	✓	✗
	Disposal installations	✓	✗
	Foul drainage above ground	✓	✗
	Chemical, toxic and industrial liquid waste disposal	✗	✗
	Refuse disposal	✓	✗
	Water installations	✓	✗
	Mains water supply	✓	✗
	Cold water distribution	✓	✗
	Hot water distribution	✓	✗
	Local hot water distribution	✓	✗
	Steam and condensate distribution	✗	✗
	Heat source	✓	✗
	Heat source	✓	✗
	Space heating and air conditioning	✓	✗
	Central heating	✓	✗
	Local heating	✓	✗
	Central cooling	✓	✗
	Local cooling	✓	✗
	Central heating and cooling	✓	✗
	Local heating and cooling	✓	✗
	Central air conditioning	✓	✗
	Local air conditioning	✓	✗
	Ventilation systems	✓	✗
	Central ventilation	✓	✗
	Local and special ventilation	✓	✗
	Smoke extract/control	✓	✗
	Electrical installations	✓	✗
	Electric mains and sub-mains distribution	✓	✗
	Power installations	✓	✗
	Lighting installations	✓	✗
	Specialist lighting installations	✓	✗
	Local electricity generation systems	✓	✗
	Earthing and bonding systems	✓	✗
	Fuel installations	✗	✗
	Fuel storage	✗	✗
	Fuel distribution systems	✗	✗
	Lift and conveyor installations	✓	✗
	Lifts and enclosed hoists	✓	✗
	Escalators	✓	✗
	Moving pavements	✓	✗
	Powered stairlifts	✗	✗
	Conveyors	✗	✗
	Dock levellers and scissor lifts	✗	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	Cranes and unenclosed hoists	✗	✗
	Car lifts, car stacking systems, turntables and the like	✗	✗
	Document handling systems	✓	✗
	Other lift and conveyor installations	✓	✗
	Fire and lightning protection	✗	✗
	Fire-fighting systems	✗	✗
	Fire suppression systems	✗	✗
	Lightning protection	✗	✗
	Communication, security and control systems	✓	✗
	Communication systems	✓	✗
	Security systems	✓	✗
	Central control/building management systems	✓	✗
	Specialist installations	✓	✗
	Specialist piped supply installations	✗	✗
	Specialist refrigeration systems	✗	✗
	Specialist mechanical installations	✗	✗
	Specialist electrical/electronic installations	✗	✗
	Water features	✗	✗
	Civil Engineering Structure	✓	✗
	Builder's Work in Connection (BWIC) with Services	✗	✗
	BWIC with services	✗	✗
Prefabricated buildings and building units	Prefabricated buildings and building units	✗	✗
	Complete buildings	✗	✗
	Building units	✗	✗
	Pods	✗	✗
Work to existing building	Minor demolitions and alterations	✗	✗
	Minor Demolitions and Alterations	✗	✗
	Repairs to existing services	✗	✗
	Repairs to existing services	✗	✗
	Damp proof course/fungus and beetle eradication	✗	✗
	Damp Proof Course/Fungus and Beetle Eradication	✗	✗
	Façade Retention	✗	✗
	Façade Retention	✗	✗
	Cleaning Existing Surfaces	✗	✗
	Cleaning Existing Surfaces	✗	✗
	Renovation work	✗	✗
	Renovation Work	✗	✗
External works	Site preparation works	✓	✗
	Site clearance	✓	✗
	Preparatory groundworks	✓	✗
	Roads, paths and pavings	✓	✗
	Roads, paths and pavings	✓	✗
	Special surfacings and pavings	✓	✗
	Soft landscaping, planting and irrigation systems	✓	✗
	Seeding and turfing	✓	✗
	External planting	✓	✗
	Irrigation systems	✓	✗
	Fencing, railings and walls	✓	✗
	Fencing and railings	✓	✗
	Walls and screens	✓	✗
	Retaining walls	✓	✗
	Barriers and guardrails	✓	✗
	External fixtures	✗	✗
	Site/street furniture and equipment	✗	✗
	Ornamental features	✗	✗
	External drainage	✓	✗
	Surface water and foul water drainage	✗	✗
	Ancillary drainage systems	✗	✗
	External chemical, toxic and industrial liquid waste drainage	✗	✗
	Land drainage	✓	✗

Parent Name	Sub Category Name	Benchmark Design	Improved Design
	External services	✓	✗
	Water mains supply	✓	✗
	Electricity mains supply	✓	✗
	External transformation devices	✓	✗
	Electricity distribution to external plant and equipment	✓	✗
	Gas mains supply	✓	✗
	Telecommunications and other communication system connections	✓	✗
	External fuel storage and piped distribution systems	✓	✗
	External security systems	✓	✗
	External/street lighting systems	✓	✗
	Local/district heating installations	✓	✗
	BWIC with external services	✓	✗
	Minor building works and ancillary buildings	✗	✗
	Minor building works	✗	✗
	Ancillary buildings and structures	✗	✗
	Underpinning to external site boundary walls	✗	✗
Facilitating works	Toxic/hazardous/contaminated material treatment	✗	✗
	Toxic/hazardous material removal	✗	✗
	Contaminated land	✗	✗
	Eradication of plant growth	✗	✗
	Major demolition works	✓	✗
	Demolition works	✓	✗
	Soft strip works	✓	✗
	Temporary support to adjacent structures	✗	✗
	Temporary support to adjacent structures	✗	✗
	Specialist groundworks	✗	✗
	Site dewatering and pumping	✗	✗
	Soil stabilisation measures	✗	✗
	Ground gas venting measures	✗	✗
	Temporary diversion works	✗	✗
	Temporary diversion works	✗	✗
	Extraordinary site investigation	✗	✗
	Archaeological investigation	✗	✗
	Reptile/wildlife mitigation measures	✗	✗
	Other extraordinary site investigation	✗	✗
Project/design team	Consultants	✓	✗
	Planning & Approvals	✓	✗
	Main contractor's pre-construction design	✓	✗
	Project Management	✓	✗
	Main contractor's design	✓	✗
	Sales and Marketing	✓	✗
Undefined