APPLICATION FOR PLANNING APPROVAL

LOT 6 (12) FLORENCE STREET, WEST PERTH
SUPPLEMENTARY URBAN DESIGN ANALYSIS

XSCOPE PTY LTD
TOWN OF VINCENT

13 October 2020

fpdc
Ferraro planning and development consultancy

Office: Unit 217/396 Scarborough Beach Road Osborne Park WA 6017 ~ Mail: PO Box 1563 Melville South WA 6156 ~ Nikagem Pty Ltd as Trustee for The Ferraro Family Trust ABN 62 060 106 272

REVIEW OF THE BUILT AND NATURAL ENVIRONMENT

Florence Street is located only 2km north west of the centre of the Perth CBD. The area was developed early in the colonisation of the State and is evidenced through a wide range of character homes that remain in the area, ranging from modest 19th and 20th century weatherboard homes, federation bungalows through to new contemporary dwellings.

The area has been the subject to extensive rebuilding over the years and now accommodates a wide range of housing types from large free standing homes through to large multiple housing complexes.

There is no apparent consistent building style or material use evident throughout the suburb, with buildings largely reflecting the trends of the era in which they were built.

While metal roofs can be found on the older dwellings, clays tiles are now prevalent throughout.

The natural environment is largely confined to historical open space areas, such as Hyde Park and Smiths Lake, while active playing areas make up the balance of the green space.

The medium density grouped housing development proposed for 12 Florence Street is consistent with the more recent form and type of development that has been approved and developed in the area. The presentation of major openings to the public realm, together with interesting and varied architectural features add interest and creates a visual separation from the character buildings that remain in the area. The use of light colours and metal roofing aims to complement the original dwellings and create and interesting and harmonic streetscape.

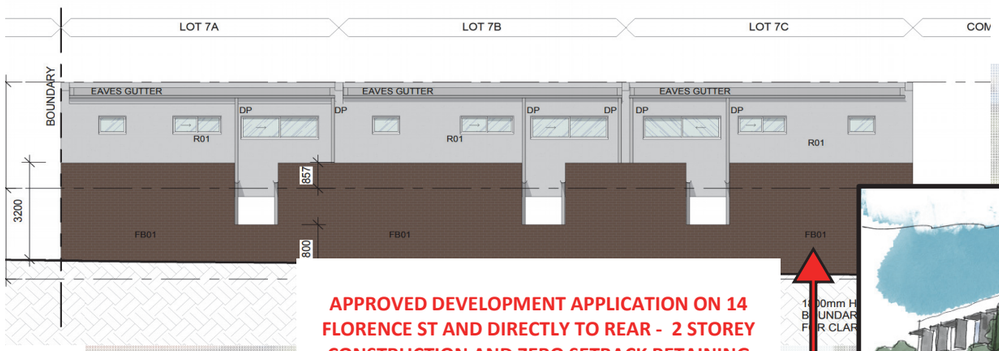
URBAN DESIGN ANALYSIS

Lot 6 (12) FLORENCE STREET, WEST PERTH

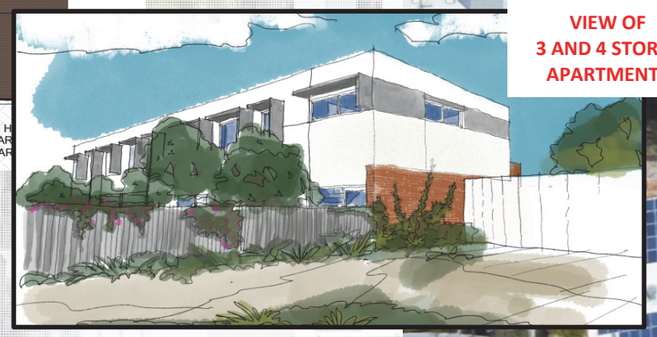
EXISTING STREET VIEW - 10 - 14 FLORENCE STREET

PROPOSED STREET VIEW - 10 - 14 FLORENCE STREET

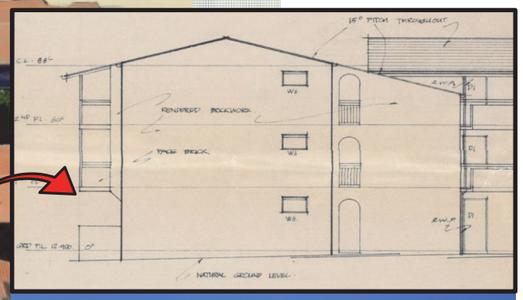
12 FLORENCE ST WEST PERTH - SUPPLEMENTARY NEIGHBOURING DWELLING HEIGHT STUDY



APPROVED DEVELOPMENT APPLICATION ON 14 FLORENCE ST AND DIRECTLY TO REAR - 2 STOREY CONSTRUCTION AND ZERO SETBACK RETAINING APPROVED



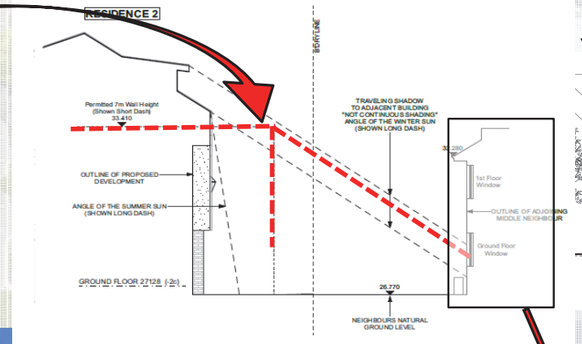
VIEW OF 3 AND 4 STOREY APARTMENTS



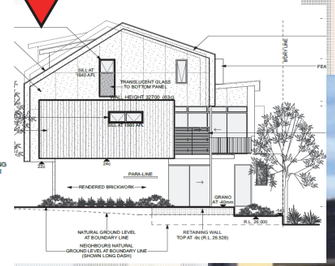
FRONT ELEVATION

12 FLORENCE ST / LOT 6

REAR ASPECT OF 12 FLORENCE ST SHOWN



REAR ELEVATION



Permitted 7m Wall Height
(Shown Short Dash)
33.410

EXAMPLES OF EXISTING FLORENCE ST ELEVATIONS

PROJECT: Proposed Group Dwellings	DRAWN: D.L.	REVISION: 27 - 10 - 2020 18 - 09 - 2020
CLIENT: XScope Pty Ltd (van Dommelen)	DATE: JUNE 2020	
ADDRESS: Lot 6 (# 12) Florence Street West Perth	SCALE: 1 : 100	© Copyright
	JOB NO: 110-18 (A1)	SHEET 4B OF 6
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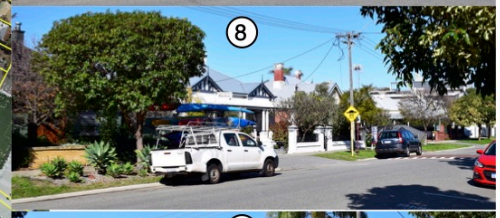
DANIEL LOMMA DESIGN

URBAN DESIGN ANALYSIS

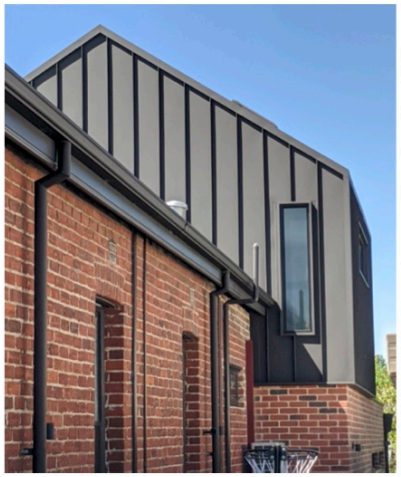
Lot 6 (12) FLORENCE STREET, WEST PERTH



Florence Street Character Analysis - Eclectic mix of housing types and styles

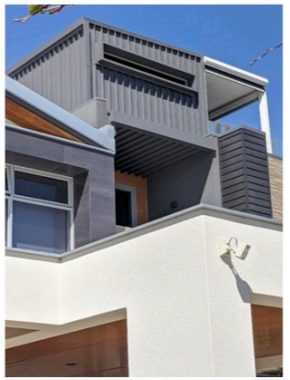
URBAN DESIGN ANALYSIS

Lot 6 (12) FLORENCE STREET, WEST PERTH



FLORENCE STREET, NORTH

4 FLORENCE STREET



7 CARR STREET

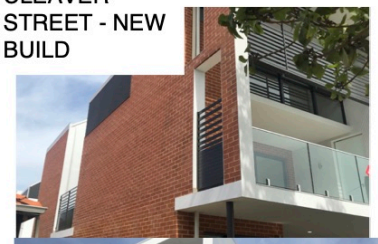
DESIGN INFLUENCES

Florence Street and its surrounds are characterised by a range of housing types, styles and ages. The streetscape provides evidence of intergenerations changes in housing styles ranging from Federation bungalows through to contemporary dwellings.

The use of solid masory on ground floor levels is a consistent theme throughout the area regardless of the age of the building.

The front facades of many new dwellings include a variety of geometric shapes and features which provides a clear distinction between the housing styles of the heritage buildings, while reflecting the aspirations of the new residents to the area. The design features proposed for Lot 6, have been drawn from many of the design elements that have been applied in the area. The design includes bold geometric shapes, partly concealed roofing and the use of distinct masonary features, reflect elements that are now common in the area.

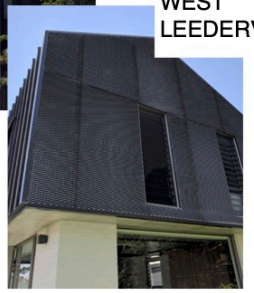
CLEAVER STREET - NEW BUILD



CARR STREET, SOUTH

CLEAVER STREET, NEW AGED CAR UNDER CONSTRUCTION

CLEAVER STREET



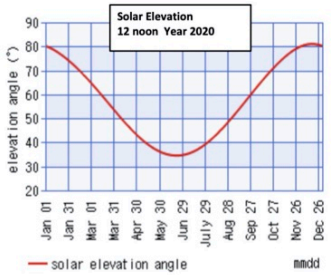
WEST LEEDERVILLE

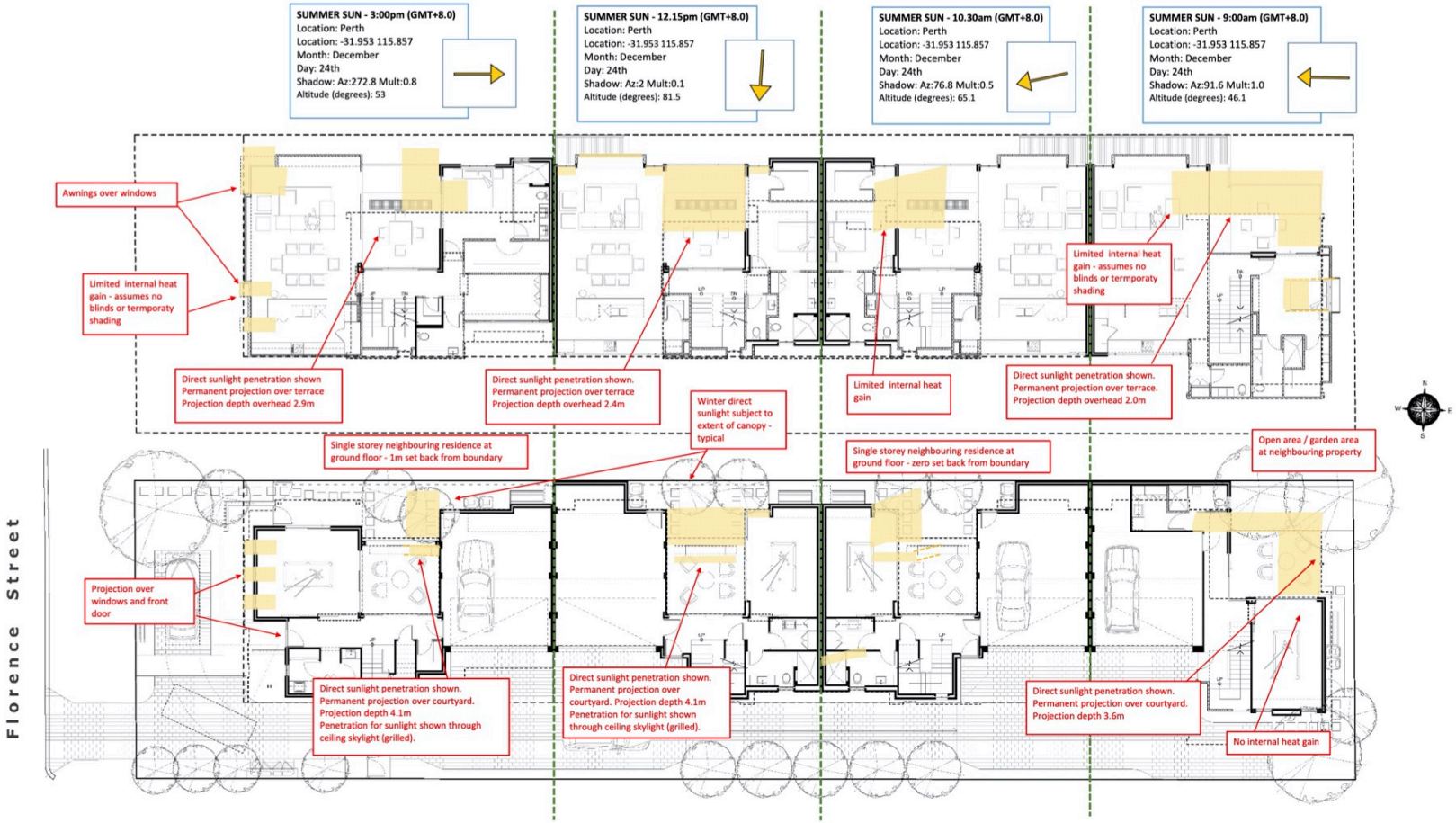
SUNLIGHT PENETRATION ANALYSIS -SUMMER

PASSIVE SOLAR DESIGN STUDY
SUMMER - 24th December

NORTH ORIENTATED TERRACE
UNWANTED NORTHERN SUMMER SUN

Position :
-31.95285360,115.85733890



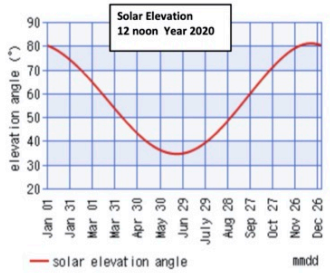


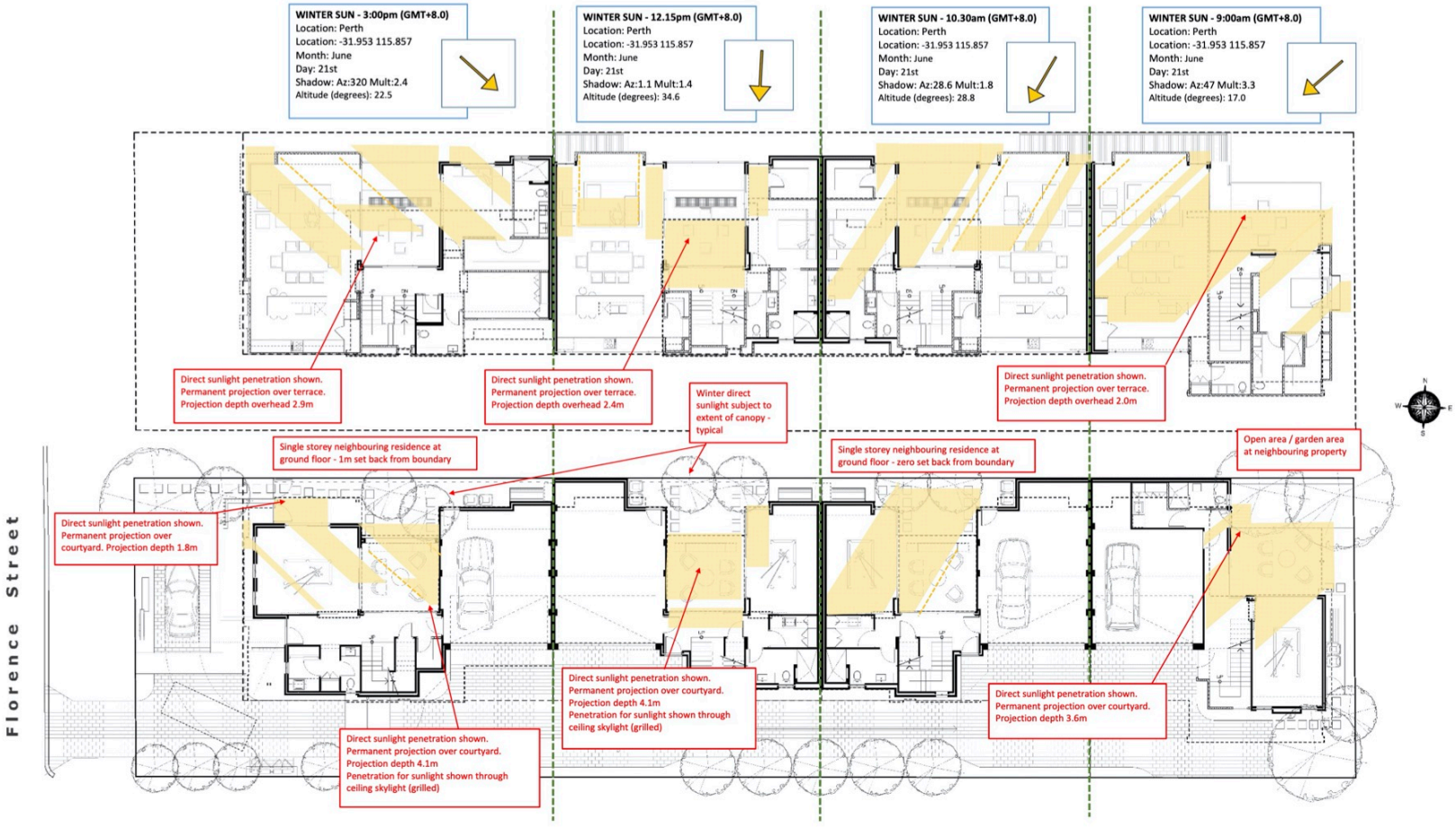
SUNLIGHT PENETRATION ANALYSIS - WINTER

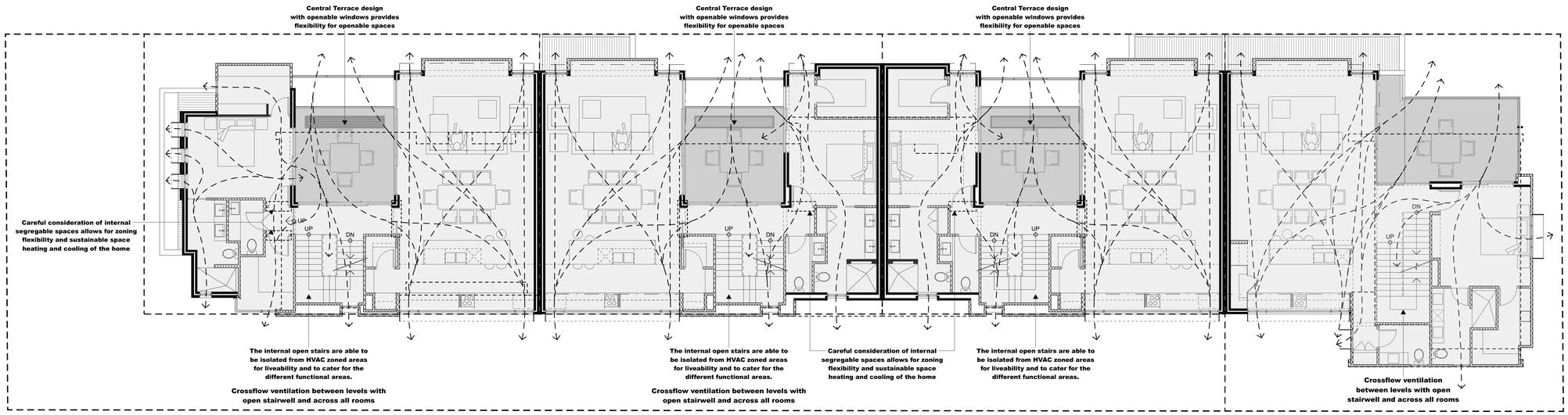
PASSIVE SOLAR DESIGN STUDY
WINTER - 21st June

NORTH ORIENTATED TERRACE
BENEFICIAL NORTHERN WINTER SUN

Position :
-31.95285360,115.85733890

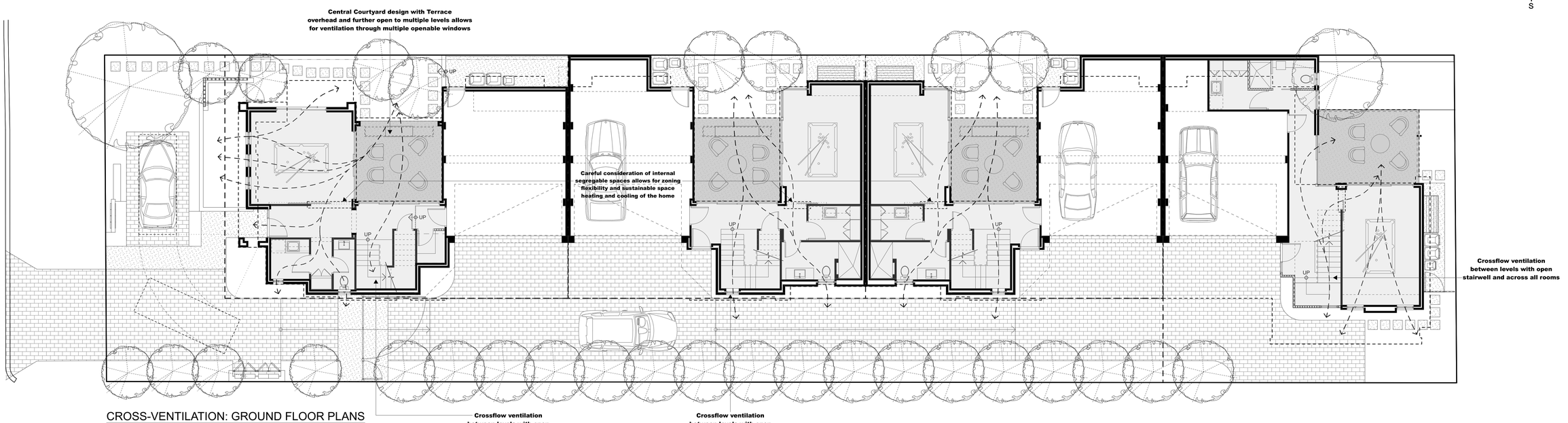






CROSS-VENTILATION: FIRST FLOOR PLANS

SCALE 1:100



CROSS-VENTILATION: GROUND FLOOR PLANS

SCALE 1:100

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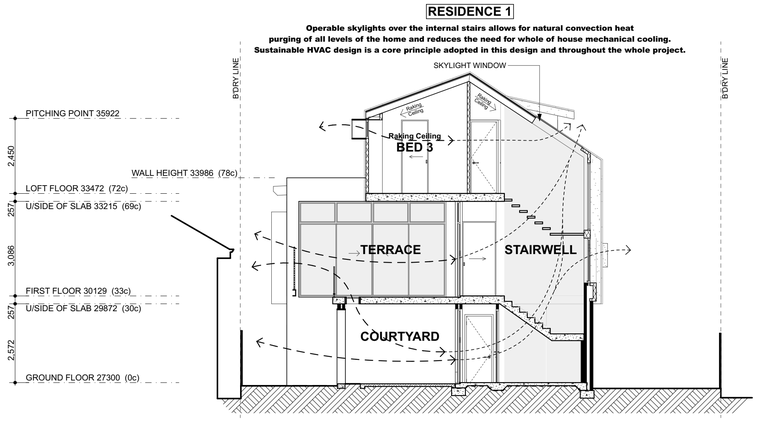
DANIEL LOMMA DESIGN

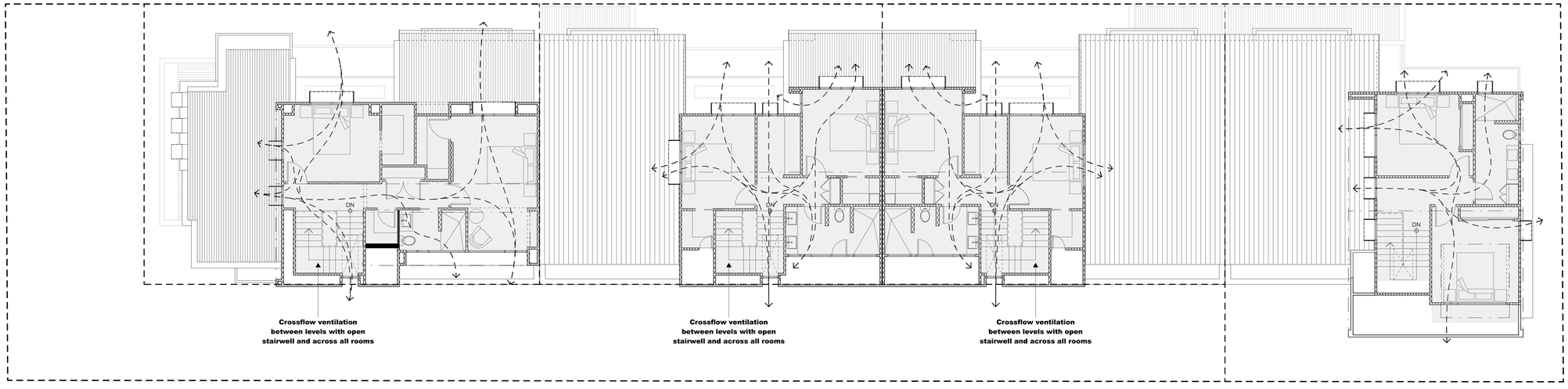
RESIDENCE 1

Operable skylights over the internal stairs allows for natural convection heat purging of all levels of the home and reduces the need for whole of house mechanical cooling. Sustainable HVAC design is a core principle adopted in this design and throughout the whole project.



CROSS-VENTILATION: SECTION

SCALE 1:100



CROSS-VENTILATION: LOFT FLOOR PLANS

SCALE 1:100

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W
E
S

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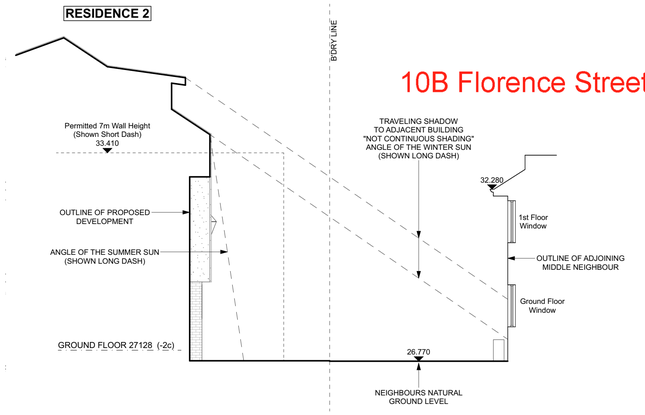
DANIEL LOMMA DESIGN

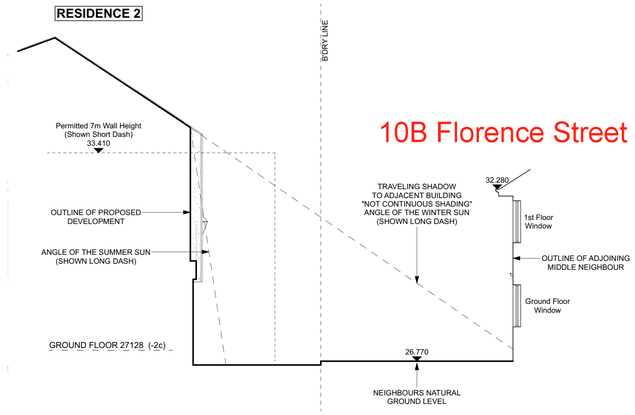
10C Florence Street

10B Florence Street

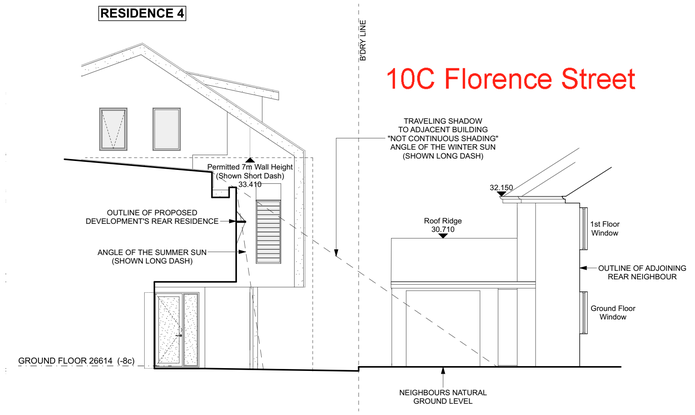
OVERSHADOWING STUDY TO ESTABLISHED DWELLING TO THE SOUTH



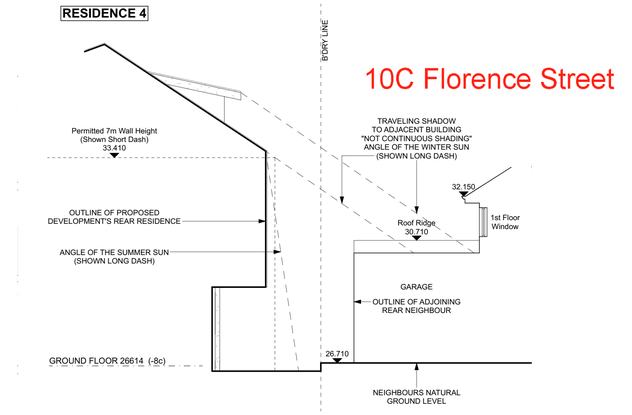
OVERSHADOWING SECTION 1
SCALE 1:100



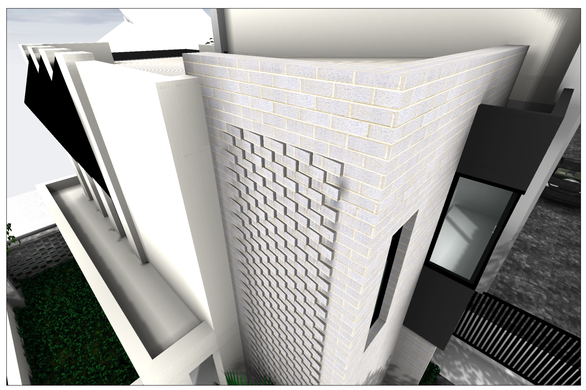
OVERSHADOWING SECTION 2
SCALE 1:100



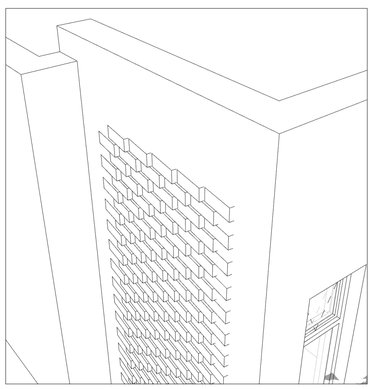
OVERSHADOWING SECTION 3
SCALE 1:100



OVERSHADOWING SECTION 4
SCALE 1:100

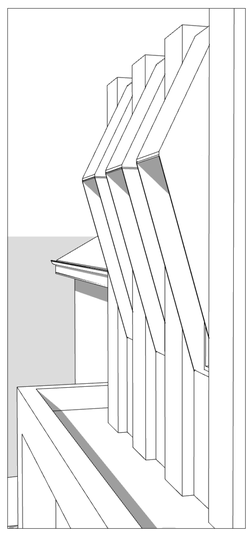


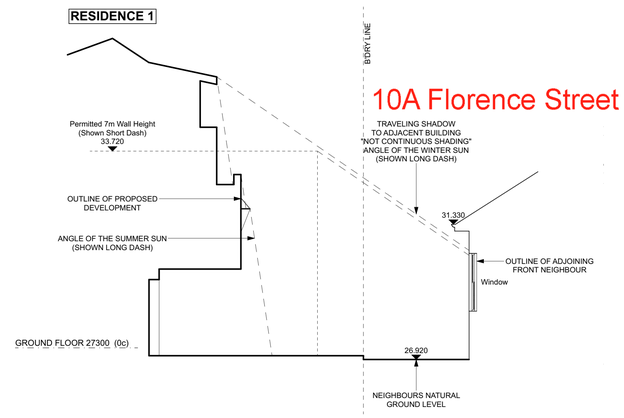
FEATURE BRICK PROJECTIONS



FEATURE BRICK PROJECTIONS

MODERN TAKE ON TRADITIONAL AWNING / WINDOW CANOPY





OVERSHADOWING SECTION 5
SCALE 1:100

PROJECT: Proposed Group Dwellings	DRAWN: D.L.	REVISION: 27 - 10 - 2020 26 - 10 - 2020
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DA N IEL LOM MA DE SIGN

12 Florence St Leederville

4 Grouped Housing Development

Revised 10 Oct 2020 Including CoV Requirements

Revised 28 Oct 2020 Including Environmental Performance Study Agreement

The City's Built Form Policy includes Local Housing Objectives related to achieving a development which incorporates Environmentally Sustainable Design (ESD) principles.

These principles seek to achieve new developments which have a reduced environmental impact, improved energy and water efficiency, and reduced reliance on non-renewable energy sources. The development of energy efficient buildings also delivers medium to long-term savings for owners and occupants.

By considering these principles of ESD through the development application process, a more holistic approach can be taken towards incorporating ESD principles into the building design, rather than retrospectively once the building design has been completed.

The Local Housing Objectives in the Built Form Policy are performance-based, which requires consideration as to how each of these have been achieved.

To assist landowners and applicants in preparing a development application, the below table outlines the Local Housing Objectives applicable to Single Houses and Grouped Dwellings, and information on how these can be addressed through principles of ESD.

For further information and further examples of what you could provide, please refer to the City's Environmentally Sustainable Design Information Sheet HERE. Alternatively, feel free to contact the City's Development and Design team on 9273 6000.

Please outline how each of the following elements have been addressed and attach any relevant or supporting photos, images, diagrams or drawings where applicable.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
Environmental Impact *Development that considers the whole of life environmental impact of the building and incorporates measures to reduce this impact.*	
The environmental impact of developments can be impact by considerations such as building orientation, design and construction materials. Construction	The grouped dwelling footprint extends in an overall east-west orientation to achieve an advantageous north facing aspect for

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
materials which are durable and are low maintenance generally have a low environmental impact. Some examples of building materials and design choices with reduced environmental impacts include: • Incorporating an east-west orientation (where possible); • Minimising the extent of the building footprint; • Incorporating good solar-passive design; • Reverse brick veneer (internal thermal mass, external insulation); • Low emission concrete; • Lightweight, recycled, non-toxic, minimally processed and recyclable materials; • Gabion walls filled with demolition waste; • High quality (durable), energy and water saving fixtures and fittings (such as reversible ceiling fans, water efficient taps and toilets); and • Installation of appropriate and effective insulation.	courtyards and terrace windows. The built form has been designed within the R50 requirements and seeks a balance between access to external space, landscaping and internal liveability whilst maintaining the deep soil and permeability requirements. The building materials include a mixture of rendered brickwork, face brickwork, cladding (Innova Durascape, Axon cladding or similar) and Colorbond cladding as required. Demolition of an existing brick house allows for salvage of reclaimed red face bricks to be used in select feature panels and internal walls. The first level and under roof loft space is designed to utilise timber framed walls and lightweight building materials where possible. The use of external Colorbond cladding that accentuates the roof shape and further used to define the articulated building elements on the south face provides further opportunity to maintain a lightweight structure. LED lighting, ceiling fans in all living and bedrooms areas, energy efficient appliances and rainwater tanks for garden use will achieved a high quality and energy sensitive project.
Thermal Performance *Development that optimises thermal performance of the building throughout the year through design elements and material selection.*	
Thermal performance relates to the efficiency of buildings and materials to retain or transmit heat. In summer, a development with poor thermal performance will often absorb and retain more heat, resulting in the inside of the building feeling hotter. Design elements which can assist with achieving a high level of thermal performance relate to solar-passive design and includes the orientation and layout of the building, the placement of thermal mass, and the use of insulation. Material selection which can assist with achieving a high level of thermal performance can include those which have thermal mass (such as concrete, brick, tile, rammed earth) and insulation properties (such lightweight	12 Florence St has sought to maximise the north facing aspect for the first floor terraces and the ground floor courtyards to promote passive solar design elements. The internal courtyard layout has been used to introduce direct sunlight in winter and to provide protection from direct sunlight in summer through the use of building projections over the majority of the terrace glazed elements. The direct winter sunlight on the concrete internal floors, as well as the first floor terrace slab that runs through to the internal spaces will further provide passive thermal performance in winter through the use of retained daytime heat and built up thermal inertia to reduce the heating requirements in winter. These floor slabs are substantially protected from direct sunlight and are shaded during the summer months.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
cladding, wood, recycled plastic composite, range of insulation materials, strategic use of air gaps).	Cavity insulation (Aircell) is employed where double brick walls are nominated, with rockwool or batts and vapour seals used for light weight walls. Roofs are installed with both Anticon under the Colorbond metal roof and R4 insulation batts installed above the internal ceilings under each of the roofs. Operable skylights mounted over the stair wells in each of the dwellings, with skylights provided with both rain sensors and sun blinds, allows for evening purging of summer heat as well as ventilation of each floor via the central open stairs. The living space and functional spaces can be isolated to limit the volume that requires space heating or cooling and provide the occupant operating flexibility of the reverse cycle air-conditioning provided by ducted and zone-controlled home air conditioning systems. The floor layout seeks to recognise that both passive and active solar and HVAC design should have configurable controls and work together to reduce the need for whole of house space heating /cooling when only some areas are in use. Review of the winter and summer solar angles are provided in document Urban Design Supplementary Analysis 20200724.
Solar Passive Design *Development shall incorporate site planning principles that maximise solar passive design opportunities for both summer and winter*	
• Where the long axis of building runs east-west, the majority of glazing being provided to the north, with limited glazing provided to the east and west; and/or • The inclusion of a central light well or courtyard can help to maximise access to northern light.	The solar passive design has been addressed under the Thermal Performance section above. Central light wells and courtyards have been fundamental to the design of the dwellings, and this detail has previously been presented to the DRP as being the preferred solution for this project. The design allows for wrap around glazing where blinds or curtains are not required to be employed year-round to achieve internal comfort or privacy, and achieves viewing angles across the house at each floor. Windows facing east and west are screened with window surrounds or structural elements that project over the windows.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
	Units 1 through to 3 also include a grilled penetration in the terrace concrete floor to throw additional direct and indirect natural light into the ground floor courtyard. The floor penetrations on the northern edge of the first floor terraces have been located so that it not directly shaded during summer and winter. Furthermore, the angle of solar elevation will allow winter sun to reach further into the ground floor courtyard during winter noon hours and prevent direct summer solar light during summer noon hours. A grilled penetration in the unit 4 terrace has not been required to introduce additional natural light at the ground floor level due to the set back of the building at the rear/east end of this development.
Sunlight and Ventilation *The provision of natural ventilation and daylight penetration to reduce energy consumption*	
• Rooms provided with ventilation openings on both sides to allow cross-flow of air; • Maximum glazing provided to north-facing living areas; • Bedrooms being located on the south; and/or • Utility rooms and garages being located on east and west sides of a dwelling.	The cross flow or air has been detailed for each room in the provided document titled Urban Design Supplementary Analysis 20200724. The north facing glazing has been addressed in the Thermal Performance and Solar Passive Design discussion points provided above. Glazing that faces directly east or west has been reduced and internal lightwell / courtyard glazing has been maximised.
Solar Heating *The provision of daytime areas with north-facing glazing to allow passive solar heating during winter*	
• Up to 80% of the glazing provided to north facing living areas being unshaded in winter, and fully shaded by external structures in summer.	Please refer to the provided document Urban Design Supplementary Analysis 20200724 which identifies the consideration given to solar elevations for different times of year. The projections over north facing and courtyard facing glazing achieves significant summer shading.
Cross Ventilation *The provision of openable windows and/or ceiling fans to habitable rooms or occupied spaces that allow natural and cross ventilation*	
• Windows located on north and south side of the dwelling being openable to utilise cooling breezes in summer; and/or • Reversible ceiling fans facilitate cooling in summer and improve air dispersion for more efficient heating in winter.	Openable widows are generously provided for to achieve indoor/outdoor access to the courtyard as well as cross flow within each floor and up the central open stairs.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
	Ceiling fans are allowed as addressed under the above Environmental Impact discussion points.
Water Re-use *The provision of recovery and re-use of rainwater, storm water, grey water and/or black water for non-potable water applications*	
• Rainwater captured in tank/s above or below ground and plumbed into toilet and laundry; • Greywater used for garden irrigation, or hand basin draining into toilet cistern for flushing; and/or • Soft landscaping is maximised to increase on-site stormwater infiltration.	Rainwater tanks are proposed to capture and use for garden water. Greywater systems will require further consideration as the project will already include many energy efficiency design, study and submission components at considerable cost. This consideration will become budget driven. Soft landscaping is as detailed in the landscaping plan provided.
Solar Gain *Incorporation of shading devices to reduce unwanted solar gain in summer and increase passive solar gain in winter*	
• Eaves, pergolas and other external shade structures designed to the correct depth to provide 0% shading in mid-winter and 100% shading in mid-summer. • Such structures may also be movable, (e.g. mobile screens and adjustable pergolas) to allow increased control over light and heat gain.	These details are discussed in the sections above.
Energy Consumption *Integration of renewable energy and energy storage systems to optimise energy consumption.*	
• Solar photovoltaic system (with or without battery storage) for electricity generation; • Solar or heat pump hot water system; and/or • Smart-wired home to enable automated diversion of excess solar energy to power air conditioners and other appliances and reduce energy use at other times.	Rooftop PV is able to be installed on the flat roof sections above each living room. Conduit pre-lay and panel roof space is provided such that Solar PV can be either installed during construction or readily fitted after completion. The owners will decide the extent of PV rooftop solar that will be installed to suit their use case, as the solar design will take into consideration lifestyle and daytime use, as well as the integration and need for storage and EV facilities. We see this evolve rapidly over the next few years and will progress the design and integration to suit during the build phase.
Solar Absorptance ***Flat roof*** *structures that are not visible from the street or adjacent properties shall have a maximum solar absorptance rating of 0.4*	

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
or ***Pitched roof*** *structures or roof structures that are visible from the street or adjacent properties shall have a maximum solar absorptance rating of 0.5, unless a suitable alternative is identified in the Urban Design Study*	
Solar absorptance rating is a measure of how much solar energy a material absorbs and therefore how hot it gets when exposed to the sun. A rating of zero means no absorption and the material remains cool. A rating of 1 is 100% absorption and the material becomes very hot. As a general rule, light roof colours have lower absorptance values than dark roof colours. Roofing material suppliers can provide the absorptance values of their colour range. Roofs that are visible from the street or adjacent properties are permitted a higher absorptance value because lighter colours (which have lower absorptance values) may be visually less comfortable for some neighbours.	The flat roofs (not forming part of the loft roof elements) are proposed to be Colorbond colour Shale Grey or Surfmist with Solar Absorptance values of 0.43 and 0.32 respectively. Surfmist is classified as a light colour under NCC Volume Two 2019 and we would seek to understand if a more reflective roof is accepted by CoV before adopting this option, as other councils have preferred Shale Grey or similar. Loft roofs and pitched roofs were originally proposed to be colorbond Monument as they provide a dramatic design feature. Following DRP input and consultation Basalt was proposed as a lighter material (albeit other similar details in the precinct that rely on Colorbond Monument or black coloured cladding for dramatic shape language). Whilst there are multiple dwellings in the area with dark roofs under construction, we have been advised by CoV that for this and DA submissions going forward that these colours would be rejected. The design has now been resubmitted with roof colours and cladding selected as Shale Grey with a Solar Absorptance value of 0.43 to satisfy CoV requirements. Selection of Colorbond colours that achieve a Solar Absorptance value of 0.5 or less for roof and wall cladding for the loft pitched roof and wall cladding restrict selection to 6 of the available standard colours.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective

Colour	Solar Absorptance
Surfmist®	0.32
Classic Cream™	0.32
Paperbark®	0.42
Evening Haze®	0.43
Shale Grey™	0.43
Dune®	0.47
Cove™	0.54
Windspray®	0.58
Pale Eucalypt®	0.60
Gully™	0.63
Mangrove®	0.64
Wallaby®	0.64
Jasper®	0.68
Basalt®	0.69
Manor Red®	0.69
Terrain®	0.69
Woodland Grey®	0.71
Monument®	0.73
Ironstone®	0.74
Cottage Green®	0.75
Deep Ocean®	0.75
Nightsky®	0.96

Allowed colours for wall and roof cladding – understood to be applied to all CoV developments. Council has confirmed that darker roof colours and alternatives can not be proposed for all future developments.

What Does This Mean and How Can I Achieve This?	Applicant Comment – How I have achieved this objective
Environmental Performance Demonstrate that the development is capable of achieving the following performance standards when compared against the Perth statistical average for residences: • 50% reduction in global warming potential (greenhouse gas emissions); and • 50% reduction in net fresh water use. The acceptable method for demonstrating this is an independently reviewed EN15978 compliant Target Setting life cycle assessment (LCA) with a 20% factor of safety applied to improvement strategies	
Applications for new Single Houses and Grouped Dwellings should be accompanied by a target setting LCA which measures the environmental performance of the building over its lifetime, to understand how the design contribute towards reduced environmental impacts. You can find an LCA assessor by contacting the Australian Life Cycle Assessment Society (ALCAS) or by doing a general internet search. Please ensure that you or the assessor you engage use methodologies compliant with: • Environmental standard EN15978 – Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method; and • That the system boundary includes all Life Cycle Modules (A1-2, B1-7, C1-4 and D) in addition to non-integrated energy (plug loads). As an alternative to the LCA for Single and Grouped Dwellings, the City may accept an 8 star NatHERS rating, in conjunction with the development meeting the other local housing objectives listed above. The City can also consider other environmental sustainable design reports, however it is recommended these be discussed with the City prior to engaging someone, to ensure that the report will be accepted by the City.	Unit 2 Environmental Performance study is under development as a representative study for all 4 units, these being closely aligned in construction methodology, floor area, window set out and energy efficient appliances, HVAC and fixtures.

Please complete all sections of this template and send to **mail@vincent.wa.gov.au** along with all relevant attachments. Alternatively, you can submit your application in person at our **Administration Centre (244 Vincent Street, Leederville)** or post to **PO Box 82, Leederville, 6902**.

Life Cycle Assessment

12 Florence Street, West Perth, WA 6005

City of Vincent

Date : 13 November 2020

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Version : 1

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.
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 options for Lot 2 - 12 Florence Street, City of Vincent located at 12 Florence Street, West Perth, WA 6005. The Author of the study is Michelle Jessup of ETool and the critical review has been conducted by Fei Ngeow of eTool PTY LTD.

The goal of this study is to profile and improve the environmental performance of the construction works at 12 Florence Street, West Perth, WA 6005. 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	Scenario Design	Scenario Design Savings Against Benchmark Design
Environmental Impacts				
Global Warming Potential, GWP	kg CO2 eq	3.66e+3	1.31e+3	64%
Ozone Depletion Potential, ODP	kg CFC-11 eq	1.69e-4	3.21e-4	-90%
Acidification Potential for Soil and Water, AP	kg SO2 eq.	1.01e+1	7.2722	28%
Eutrophication potential, EP	kg PO4--- eq	3.29e+0	2.99e+0	9%
Photochemical Ozone Creation Potential, POCP	kg ethylene	6.57e-1	6.66e-1	-1%
Abiotic Depletion Potential - Elements, ADPE	kg antimony	1.15e-1	1.45e-1	-26%
Abiotic Depletion Potential - Fossil Fuels, ADPF	MJ	4.99e+4	1.67e+4	67%
Resource Use				
Net use of fresh water, FW	m3	9.26e+4	4.66e+4	50%

Table 1: Summary of Results

The Scenario Design shows an expected performance improvement against Business as Usual for 5 of the 8 environmental indicators.

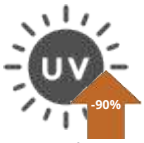
The following low impact strategies are included in the Scenario Design:

Design Strategy Performance	GWP	ODP	AP	EP	POCP	ADPE	ADPF	FW
HVAC: Residential Ceiling Fans Assisted Cooling	0.61%	-0.19%	-0.11%	-0.82%	-0.30%	-0.46%	0.54%	0.05%
Replacement: Recycled Bricks	0.26%	0.15%	0.17%	0.11%	0.26%	0.07%	0.18%	0.01%
Finishes: Reduce Floor Coverings (Tile to Polished concrete/Timber)	4.88%	7.76%	6.62%	5.30%	8.33%	26.89%	5.03%	0.40%
Finishes: Reduce Floor Coverings (Carpet to Polished concrete)	0.13%	0.06%	0.14%	0.08%	0.31%	0.11%	0.13%	0.00%
Open Exposed Ceiling (no plasterboard)	2.41%	5.06%	3.59%	2.76%	4.26%	3.10%	3.02%	0.25%
6.6kW PV system with 5kW Inverter Single Phase Connection (Connected)	60.94%	-4.22%	36.81%	33.93%	13.67%	-24.55%	57.96%	5.23%
Water-wise gardens (minimise lawn/native plants)	0.30%	0.11%	0.23%	0.22%	0.23%	0.10%	0.28%	8.60%
Dripper Irrigation System (in place of sprays)	0.14%	0.05%	0.10%	0.10%	0.10%	0.04%	0.13%	3.87%
2kL Rainwater Tank for Garden Irrigation Water	-0.39%	-0.81%	-0.53%	-0.69%	-0.48%	-0.57%	-0.59%	7.09%
Low Flow Shower Heads (7.5L/min)	0.64%	0.14%	0.26%	0.57%	0.39%	0.17%	0.70%	4.55%
Water efficient fixtures and fittings (Mixers and Toilets only)	0.45%	0.23%	0.37%	0.88%	0.37%	0.28%	0.39%	7.47%
Proposed Design	0%	0%	0%	0%	0%	0%	0%	0%

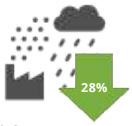
Table 2: Design Strategies in Scenario Design

Scenario 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

Net use of fresh water, FW

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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 Scenario Design, City of Vincent Project located at 12 Florence Street, West Perth, WA 6005. 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 Michelle Jessup (Lead) of ETool and the critical review has been conducted by Fei Ngeow of eTool PTY LTD.

2 Goal of the study

The goal of this study is to provide profile and improve the environmental performance of the construction works at 12 Florence Street, West Perth, WA 6005. 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 12 Florence Street, West Perth, WA 6005 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 Residential 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 (120 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.

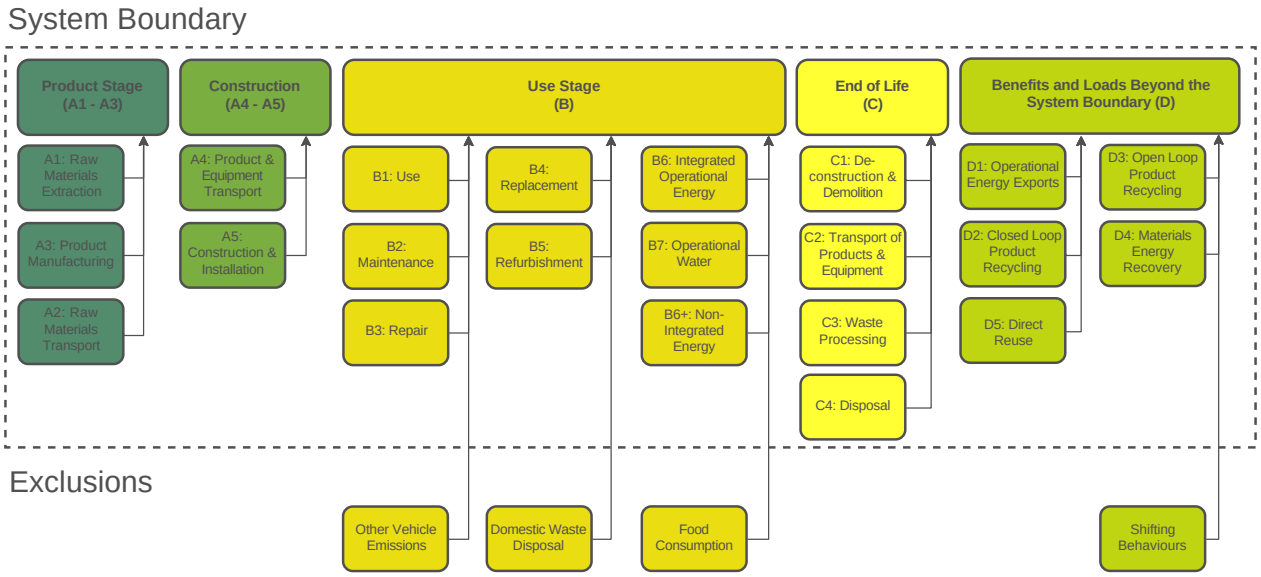


Figure 1: System Boundary Diagram

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 CO2 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 SO2 eq.	AP	CML-IA baseline V4.5
Eutrophication potential, EP	kg PO4--- 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
Resource Use			
Net use of fresh water, FW	m3	FW	Not Applicable - 1:1 factor on H20 Consumed

Table 2: Environmental Indicators Included in LCA study.

3.4 System Description

The object of the assessment is the structure itself. 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. 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.

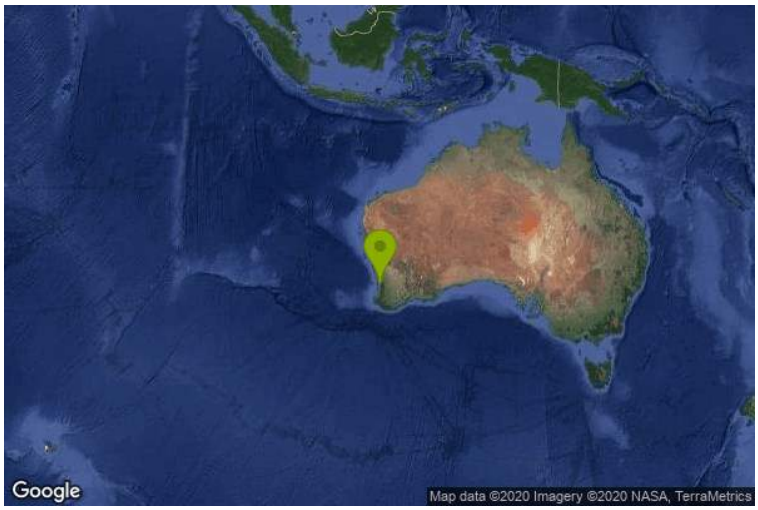


Figure 2: Location of the project - Global View.

Figure 3: Location of the project - Locality View.

Lot 2 is one of a 4 dwelling development. This lot comprises a single residential building on an 235sqm lot in West Perth. The building is a three storey, double brick construction to ground floor and framed construction above where structurally possible, concrete slabs and metal roof, with facebrick, render and cladding finishes. Each residence has 3 bedrooms, 3.5 bathrooms, games room, study nook and double garage.

Energy and water assumptions for the business as usual model have been made based on a code compliant Nathers 6 star dwelling.

The Proposed Design has been orientated to promote passive solar design and cross ventilation elements with a sensor operated skylight over the stairwell that will open to purge excess heat reducing the energy demand for mechanical cooling. Sustainability features such as Solar PV, Ceiling Fans, Rainwater tanks, Waterwise landscaping and water saving fixtures have also been specified.

The motivation of this life cycle assessment is for the development to demonstrate how it achieves a 50% reduction in CO2 emissions and 50% reduction in fresh water use per occupant / per year as required by the City of Vincent Policy No 7.1.1 - Built Form; Clause 1.8 - Environmentally Sustainable Design.

The designs being assessed in the LCA include:

- Residential Benchmark building for City of Vincent representing a statistical average dwelling
- Business As Usual baseline design which represents a code compliant / standard practice version of the same design
- Proposed Design representing the design options selected by the client during the life cycle design feedback workshop

Table 3 below shows the key characteristics of the design.

	Business as Usual	Scenario Design
Design Details		
Design Name	AU WA Res Ave Code Compl CZ 5 (10 dwellings)	Proposed Design
Stories (#)	2	3
Primary Function	Single Family Residence	Residential
Structural Service Life Limit	100	120
Predicted Design Life	54	55
Functional Characteristics		
Dwellings	10	1
Bedrooms	30	3
Occupants	24	3
Total Floor Areas		
Usable Floor Area	2,140	281
Net Lettable Area	0	0
Fully Enclosed Covered Area	3,010	281
Unenclosed Covered Area	0	32
Gross Floor Area	3,010	313
Usable and Lettable Yield	71 %	90 %

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	Scenario 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	Scenario 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	✓	✓
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

The critical review has been undertaken in accordance with ISO14044.

4 Inventory Analysis

The inventory analysis was aided by the following design documents:

- Other Design Documentation: Take-off from LCD Lite Helper Spreadsheet, November 2020 by
- Other Design Documentation: ABCB_Nathers Heating and Cooling Load Limits_extract, November 2020 by
- Other Design Documentation: Lot2 - Florence St_LCD Lite Spreadsheet, November 2020 by
- Other Design Documentation: Lot2 - Florence St_Occupancy Calculator, November 2020 by
- Architectural Documentation: van Dommelen (Florence Street) Amended TP (22-09-2020), November 2020 by
- Other Design Documentation: Lot2 - Florence St_Rain Water Calculator, November 2020 by

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	Scenario Design
Design Templates	24	179
Equipment and People Elements	495	241
Material Elements	841	363
Energy Elements	38	22
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 extend to which validated templates were used in the model.

eToolLCD Item Type	Validated (%)	
	Benchmark	Scenario Design
Total Design Templates	8.33	55.31
Equipment and People Elements	1.01	62.24
Material Elements	.48	49.31
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
		Scenario Design
Fittings, furnishings and equipment		
Appliances, Residential Average (AUS) Op&Em (2020 Update)	#	1
Cooking Res Gas Stove Electric Oven Op&Em	#	1
Kitchen Fittings, Furnishings & Equipment - medium sized	#	1
Refrigeration Residential Detailed (AUS) Op&Em	#	1
Standard 1st Bathroom - WC/Shower-bath/Basin/WallTiles	#	3
Standard Laundry sink (steel) + services	#	1
Standard Powder Room - WC/Basin	#	1
Services equipment		
Business as Usual Plumbing Fittings Mains Water and Offsite Treatment (Average Water Use & Treatment WA/AUS (no pool))	#	1
Electrical Fittings - sockets power points wiring embodied only (m2)	m2	312.7
HVAC Residential Ceiling Fans	#	5
HVAC Residential Split System Air Source Heat Pump (MEPs Average)	#	1
HWS - Gas Instantaneous	#	1
LED Outdoor Lighting (Residential - Standard Efficiency), m2	m2	80
Lighting Residential LED Med Natural Light	#	1
Rainwater tank and Pump for Residence (Above Ground)	m3	17

Parent Template Name	Units	Quantity
		Scenario Design
Solar PV System Commercial - Zone 3 (Perth)	Other	6.6
Utilities Connection to Site Residential	#	1
Superstructure		
Concrete Floor - 172mm elevated slab 40MPa 3.8% reo (First flr)	m2	140
Concrete Floor - 172mm elevated slab 40MPa 3.8% reo (Loft Flr)	m2	64.5
Door - HollowCoreTimber/WoodenJam/painted	#	17
Door - SolidCoreTimber/WoodenJam/Painted	#	3
External Finish - 13mm Render (Cement)	m2	102
Garage Door (number of car bays)	#	2
Louvre aluminium screen (by area)	m2	6.5
Roof - TimberTruss/SteelSheeting/foil ins.	m2	148
Skylight, residential	m2	1
Staircase Concrete (40Mpa 2% reo by volume)	lm	2
Wall External Masonry double brick 110-50-110 insulated with finishes	m2	20
Wall External Masonry double brick 90-50-90 insulated with int. finishes (Boundary Wall)	m2	135
Wall External Masonry double brick 90-50-90 insulated with int. finishes (Render separate template)	m2	102
Wall Internal Framed Timber Stud Plasterboard and paint finish	m2	153.255
Wall Internal Masonry Single Brick Wall (90mm) with finishes	lm	50
Wall, External, Timber Stud with CFC Cladding, PB Lining, Insulation, Painted, m2	m2	20
Wall, External, Timber Stud with Sheet metal Cladding, PB Lining, Insulation and Footings, Painted, m2	m2	65
Windows Residential Aluminium Single Glaze fly screen	m2	61.2892
Facilitating works		
Demolition - Residential (End-of-Life)	#	1
External works		
External Works - Concrete Paving, poured in-situ, 125mm thick	m2	22
External Works - Paving (limestone pavers)	m2	20
Substructure		
Floor Covering - 13mm Hardwood, Timber Floating Floor with Acoustic Underlay	m2	20
Floor, 100mm slab on ground, strip foundation	m2	108.2
Internal finishes		
Floor Covering - Carpet (glue down/Nylon)	m2	47
Floor Covering - Tiles (ceramic/5mm) (Bathrooms)	m2	26.5
Floor Finish - Grind+Polished Concrete	m2	126.76

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.

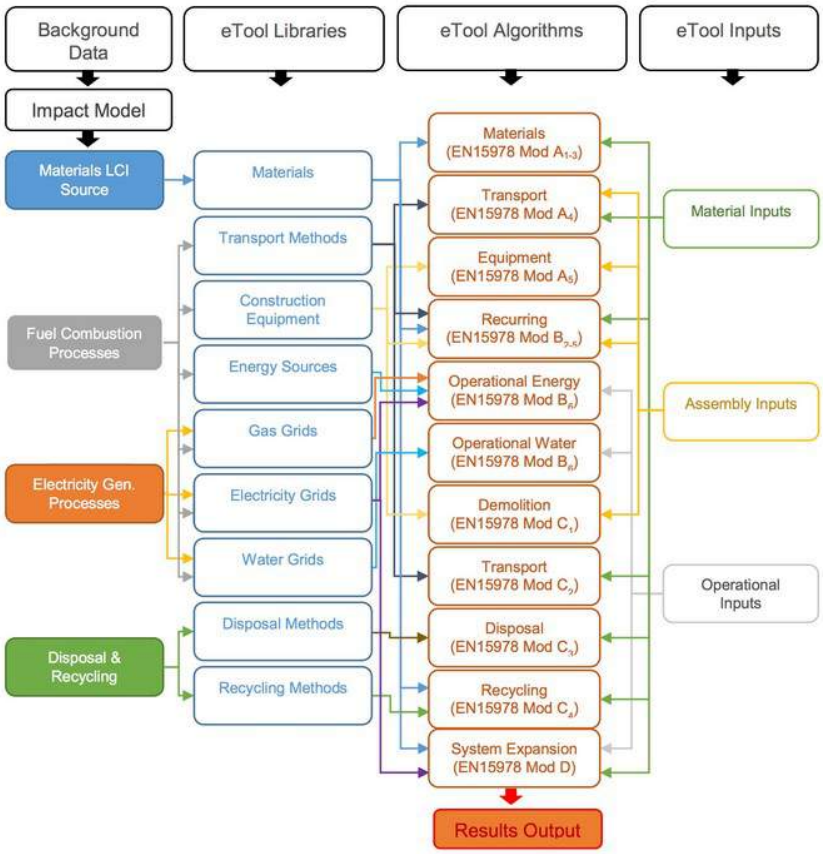


Figure 4: Relationship between LCI background data, eToolLCD software library, inputs and algorithms.

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	Scenario 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.	Passed Grid Passed Materials	Passed 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	Scenario 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 1/1 Checks

Criteria	Inventory Collection Requirement (eToolLCD User Inputs)	Compliance	
		Benchmark	Scenario Design
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 3/3 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 0/3 Checks	Passed 1/2 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 5/5 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 1/1 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 3/3 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 0/10 Checks	Passed 2/2 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 227 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.

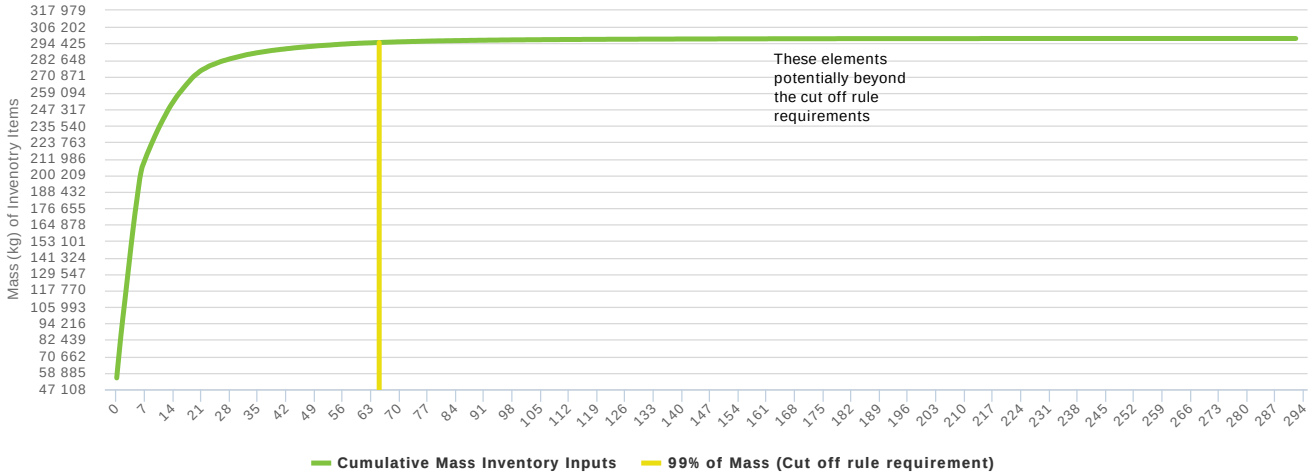


Figure 5: Cumulative Mass Inventory Entries. In this case 77.47% make up the last 5% of mass inventory entries.

4.3.2 Inventory Energy Analysis

The cumulative embodied energy of inventory entries is shown in Figure 6. Given that 278 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.

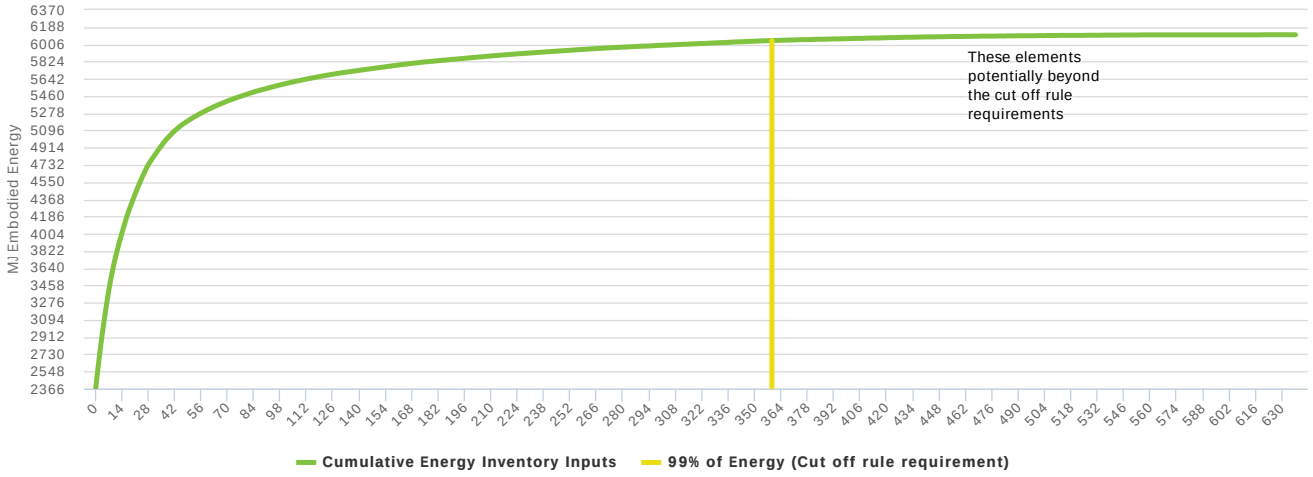


Figure 6: Cumulative Energy Inventory Entries. In this case 43.57% make up the last 5% of energy inventory entries.

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 Scenario 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 CO2 eq	6.18e+2	267.66	96.551	0	0	MNA	6.95e+2	0	9.40e+2	8.22e+2	1.66e+2	0	65.904	0	69.335	-76.099	3.66e+3
ODP	kg CFC-11 eq	3.00e-5	3.76e-5	1.49e-5	0	0	MNA	5.86e-5	0	4.88e-6	6.59e-6	3.61e-6	0	1.06e-5	0	4.61e-6	-2.27e-6	1.69e-4
AP	kg SO2 eq.	3.5093	0.8573	0.2703	0	0	MNA	3.088	0	1.1599	1.5239	0.3678	0	0.1978	0	0.0906	-0.9942	1.01e+1
EP	kg PO4--- eq	1.28e+0	2.36e-1	4.71e-2	0	0	MNA	1.01e+0	0	3.81e-1	5.09e-1	2.43e-1	0	0.0432	0	1.94e-2	-4.81e-1	3.29e+0
POCP	kg ethylene	2.24e-1	5.13e-2	3.62e-2	0	0	MNA	2.03e-1	0	8.29e-2	4.24e-2	2.40e-2	0	1.31e-2	0	1.40e-2	-3.36e-2	6.57e-1
ADPE	kg antimony	5.86e-2	6.78e-3	2.61e-4	0	0	MNA	5.31e-2	0	4.21e-3	6.09e-3	2.88e-3	0	2.03e-3	0	1.11e-4	-1.88e-2	1.15e-1
ADPF	MJ	7674.4	3980.6	1310.7	0	0	MNA	9926.2	0	1.38e+4	1.06e+4	2002.3	0	1013.1	0	464	-864.5	4.99e+4
Scenario Design																		
GWP	kg CO2 eq	7.22e+2	3.06e+2	47.547	0	41.762	MNA	7.90e+2	0	-444.03	7.84e+2	95.286	16.178	55.496	4.759	1.01e+2	-1.21e+3	1.31e+3
ODP	kg CFC-11 eq	6.41e-5	4.09e-5	5.51e-6	0	9.96e-6	MNA	1.86e-4	0	-5.43e-6	6.29e-6	2.23e-6	2.48e-6	8.83e-6	1.34e-6	4.79e-6	-5.31e-6	3.21e-4
AP	kg SO2 eq.	4.6846	1.0164	0.1303	0	0.1133	MNA	3.468	0	-1.202	1.4537	0.2174	0.0501	0.1718	0.0139	0.0941	-2.9393	7.2722
EP	kg PO4--- eq	2.09e+0	2.96e-1	1.90e-2	0	4.19e-2	MNA	1.21e+0	0	-4.06e-1	4.86e-1	1.66e-1	1.24e-2	3.83e-2	0.0028	0.0202	-9.92e-1	2.99e+0
POCP	kg ethylene	3.52e-1	5.99e-2	2.92e-2	0	6.52e-3	MNA	2.30e-1	0	-1.54e-2	4.05e-2	1.41e-2	3.42e-3	1.14e-2	5.91e-4	1.56e-2	-8.14e-2	6.66e-1
ADPE	kg antimony	7.22e-2	1.00e-2	2.31e-4	0	1.43e-3	MNA	7.22e-2	0	-5.05e-3	5.81e-3	1.89e-3	3.11e-4	2.16e-3	5.55e-5	1.15e-4	-1.60e-2	1.45e-1
ADPF	MJ	8588.4	4540.3	539	0	444.7	MNA	9805.1	0	-4672.8	1.01e+4	1131.3	241.1	861.4	63.2	481.1	-1.55e+4	1.67e+4
Savings (Scenario Design Compared to Benchmark)																		
GWP	kg CO2 eq	-1.04e+2	-38.286	49.004	0	-41.762	MNA	-95.864	0	1.38e+3	37.83	70.312	-16.178	10.408	-4.759	-31.297	1.14e+3	64.3%
ODP	kg CFC-11 eq	-3.41e-5	-3.28e-6	9.36e-6	0	-9.96e-6	MNA	-1.27e-4	0	1.03e-5	3.03e-7	1.38e-6	-2.48e-6	1.79e-6	-1.34e-6	-1.71e-7	3.05e-6	-89.95%
AP	kg SO2 eq.	-1.1753	-0.1591	0.1401	0	-0.1133	MNA	-0.38	0	2.3619	0.0701	0.1504	-0.0501	0.026	-0.0139	-0.0035	1.9451	27.79%
EP	kg PO4--- eq	-8.12e-1	-5.95e-2	2.81e-2	0	-4.19e-2	MNA	-1.99e-1	0	7.87e-1	2.34e-2	7.72e-2	-1.24e-2	4.93e-3	-0.0028	-7.60e-4	5.12e-1	9.24%
POCP	kg ethylene	-1.28e-1	-8.61e-3	7.06e-3	0	-6.52e-3	MNA	-2.77e-2	0	9.83e-2	1.95e-3	9.94e-3	-3.42e-3	1.69e-3	-5.91e-4	-1.65e-3	4.78e-2	-1.41%
ADPE	kg antimony	-1.36e-2	-3.22e-3	3.08e-5	0	-1.43e-3	MNA	-1.91e-2	0	9.26e-3	2.80e-4	9.84e-4	-3.11e-4	-1.31e-4	-5.55e-5	-4.06e-6	-2.84e-3	-26.18%
ADPF	MJ	-913.9	-559.7	771.7	0	-444.7	MNA	121.1	0	1.85e+4	488.9	871.1	-241.1	151.7	-63.2	-17	1.46e+4	66.53%

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%

5.2 Scenario Design Resource Use 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																		
FW	m3	3.29e+3	554.93	173.5	0	0	MNA	2.15e+3	0	1.20e+3	1.76e+3	8.32e+4	0	121.48	0	494.8	-291.68	9.26e+4
PERE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PERM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PERT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
SM	KG	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
RSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
NRSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
Scenario Design																		
FW	m3	3.62e+3	669.35	95.01	0	71.65	MNA	3.29e+3	0	-1.46e+3	1.68e+3	4.11e+4	29.83	108.48	78.63	512	-3.25e+3	4.66e+4
PERE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PERM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PERT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
PENRT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
SM	KG	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
RSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
NRSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0
Savings (Scenario Design Compared to Benchmark)																		
FW	m3	-327.26	-114.42	78.5	0	-71.65	MNA	-1.14e+3	0	2.66e+3	80.89	4.21e+4	-29.83	12.99	-78.63	-17.2	2.95e+3	49.74%
PERE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
PERM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
PERT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
PENRE	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
PENRM	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
PENRT	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
SM	KG	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
RSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%
NRSF	MJ	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	0%

Table 12: Resource Use 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

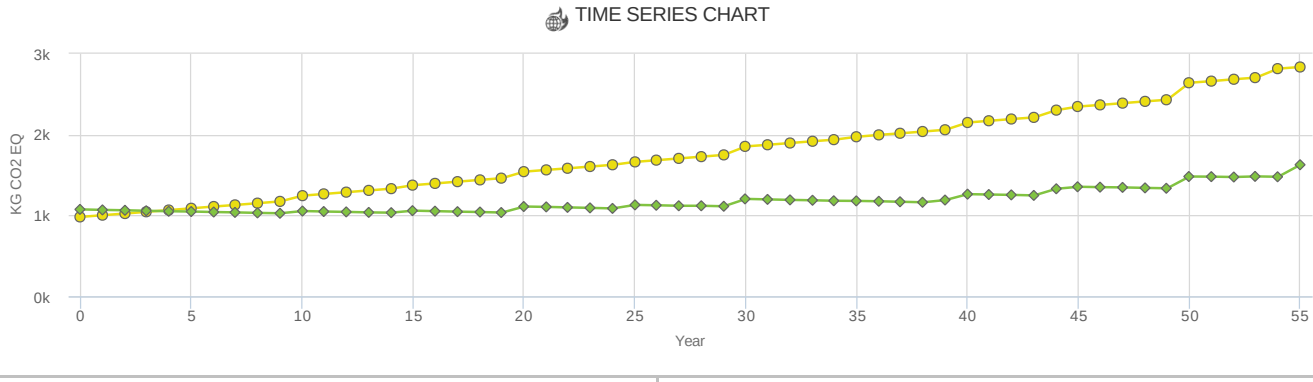
Each top 5 chart categorises the buildings and expresses the environmental impacts by these categories. This enables a detailed understanding of what is responsible for the greatest environmental burdens and also compares these burdens between designs. The pie chart associated with each bar chart shows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

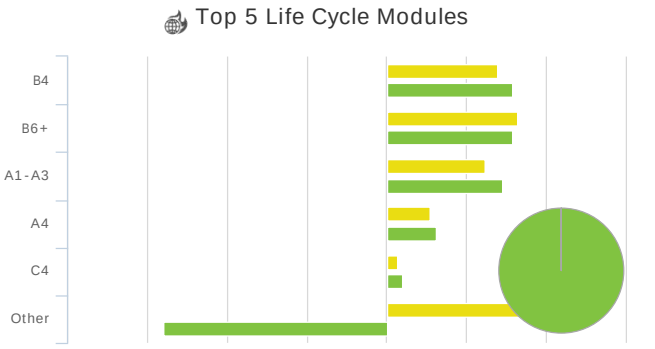
- **LC Module Impacts:** The EN15978 Life Cycle Modules. Generally 100% building impacts will be included in the bar chart.
- **Construction Category:** The breakdown of the impacts by construction category. The bar chart will generally only part of the total building impacts.
- **Operational Demand:** 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

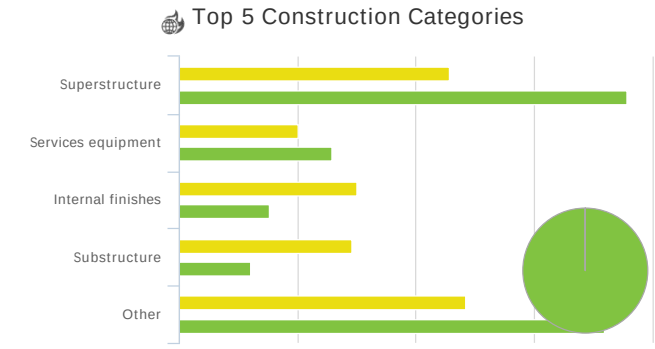
All impact figures are quoted per the functional unit selected for the study.

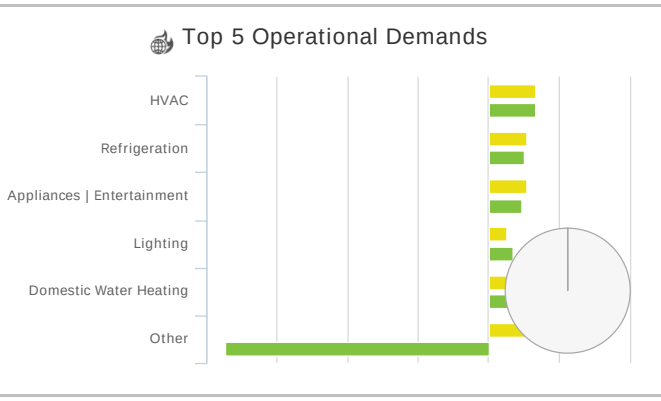
6.1 Global Warming Potential, GWP Profile

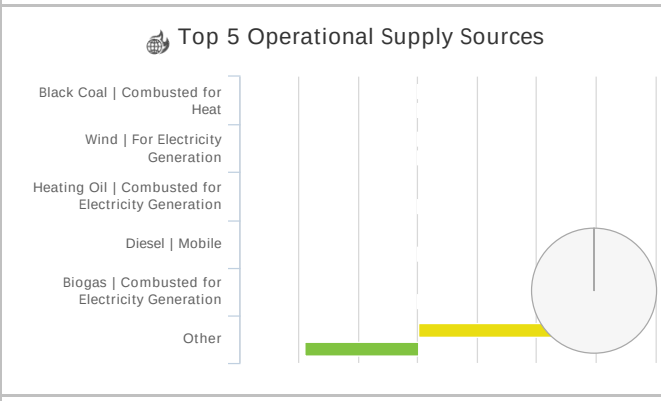
Business as Usual Scenario Design

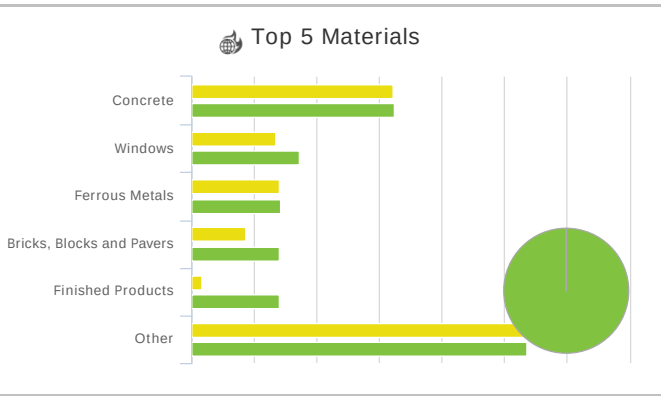


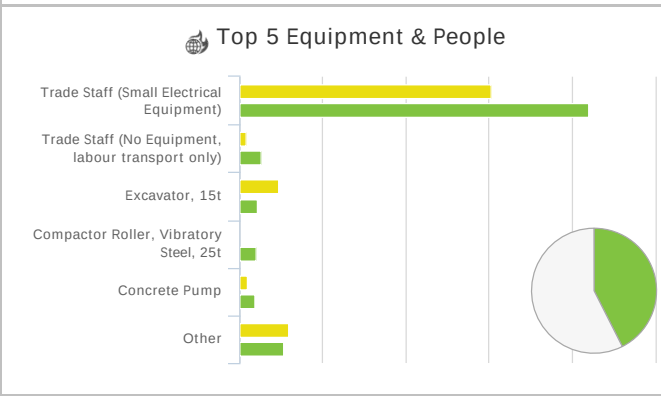






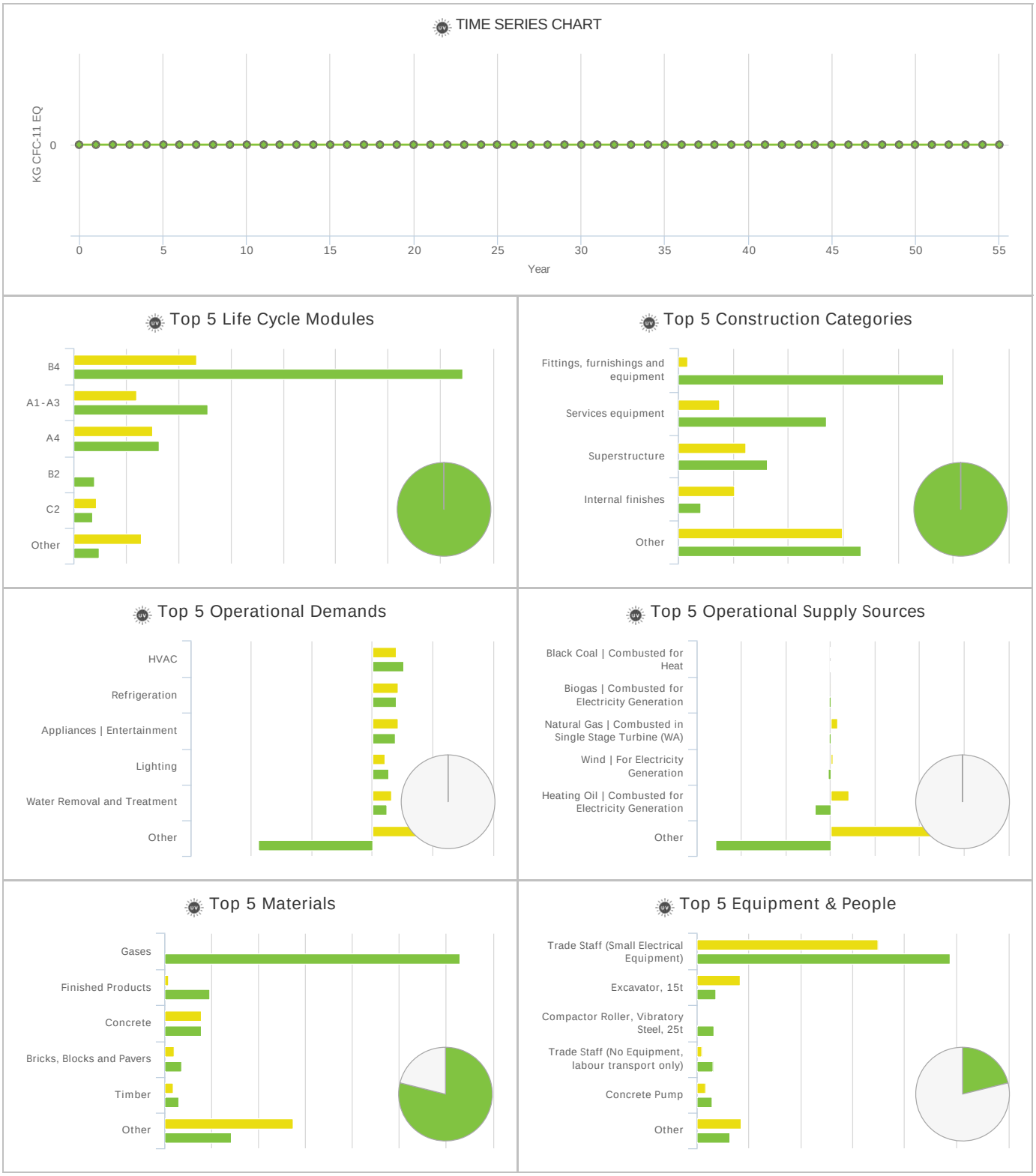






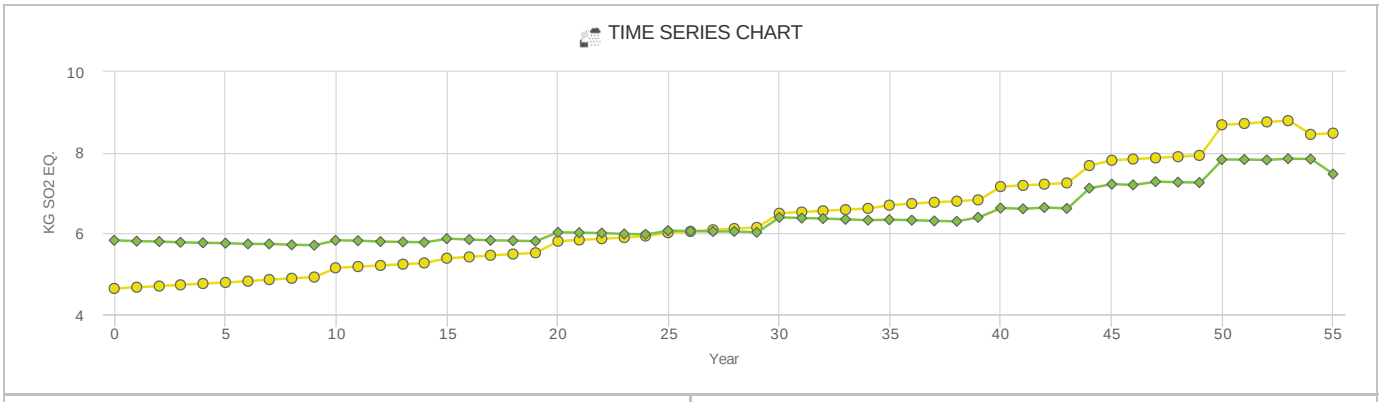
6.2 Ozone Depletion Potential, ODP Profile

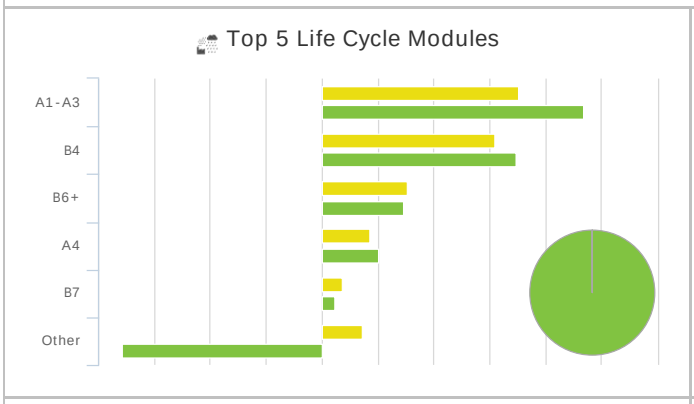
Business as Usual Scenario Design

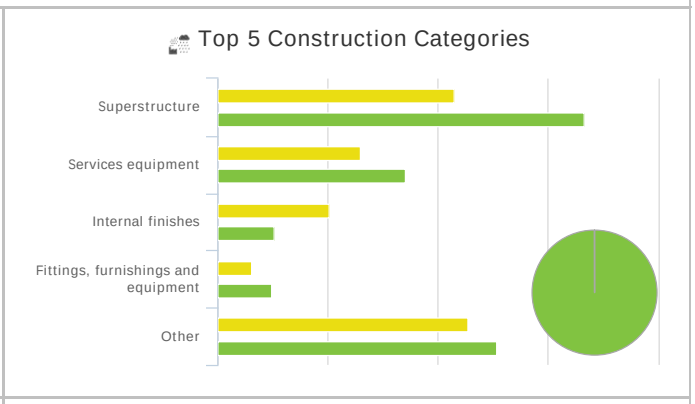


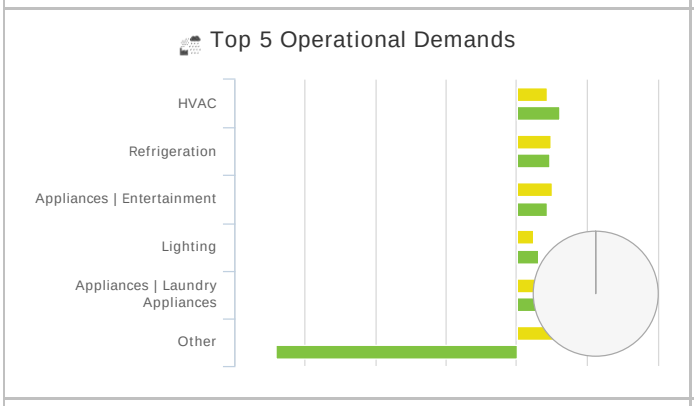
6.3 Acidification Potential for Soil and Water, AP Profile

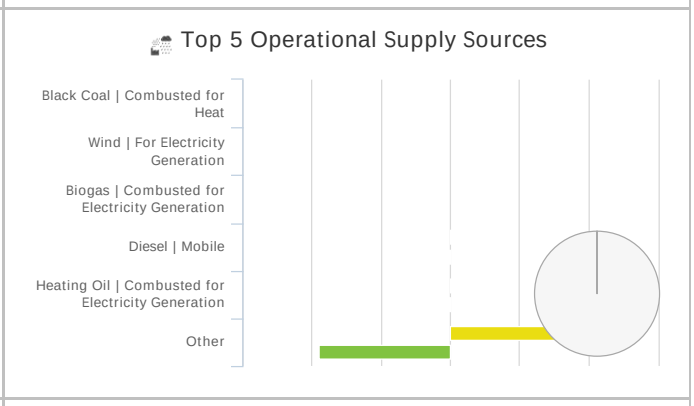
Business as Usual Scenario Design

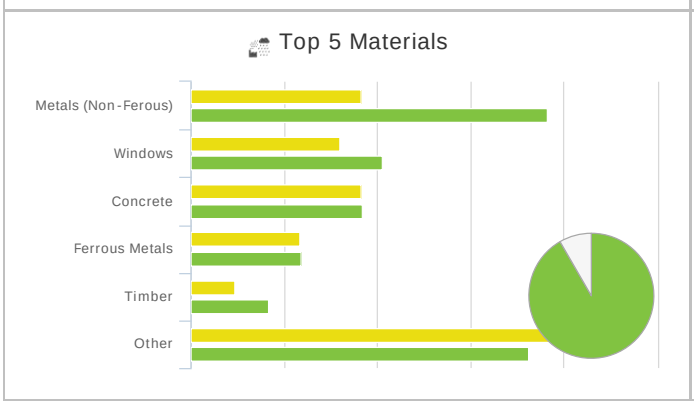


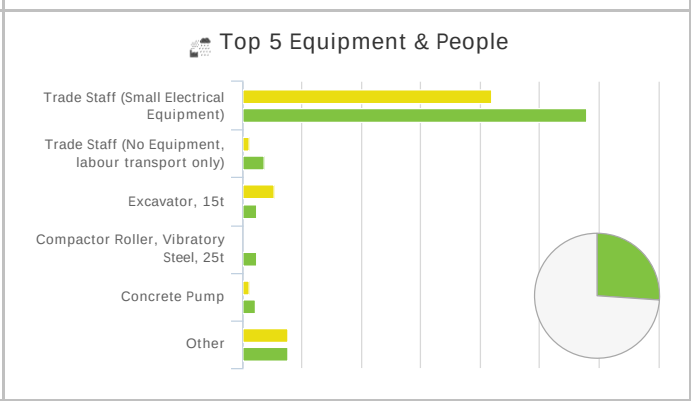








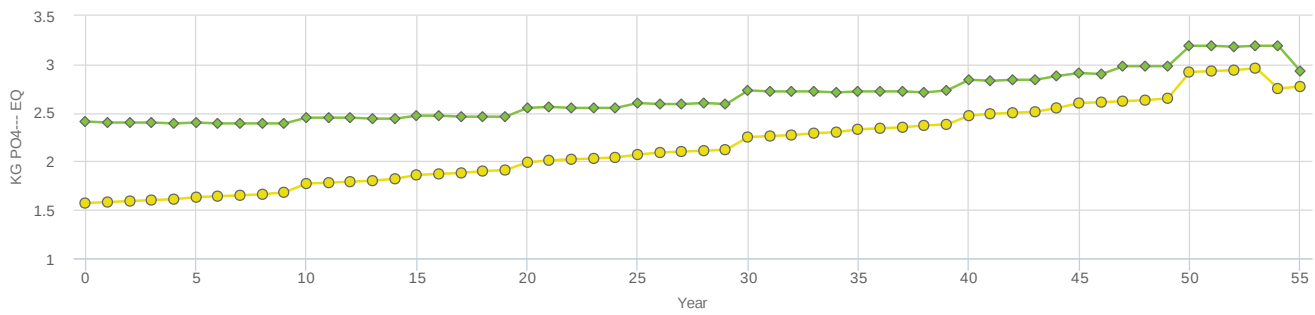




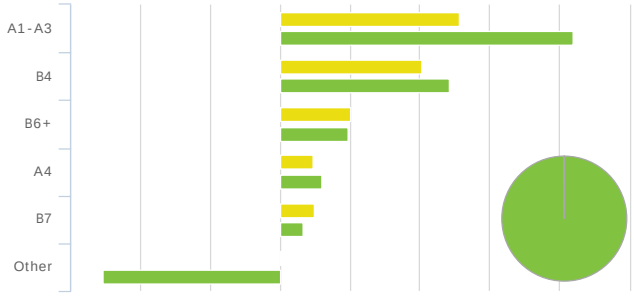
6.4 Eutrophication potential, EP Profile

Business as Usual Scenario Design

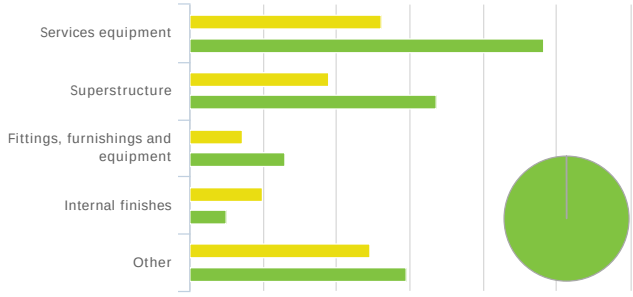
TIME SERIES CHART



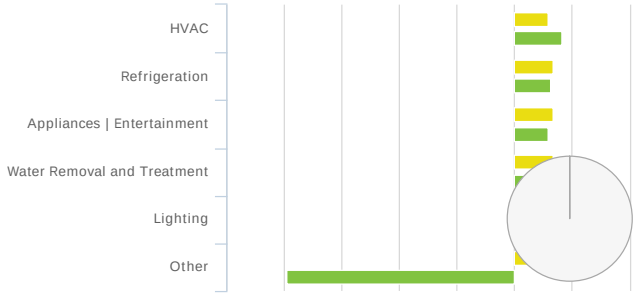
Top 5 Life Cycle Modules



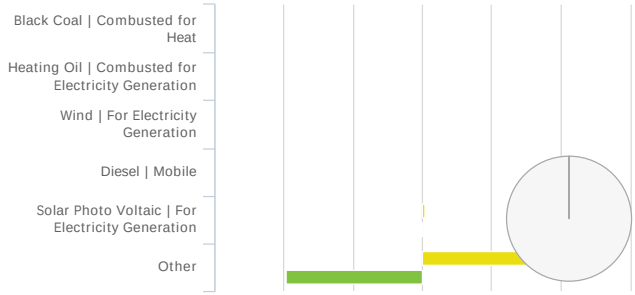
Top 5 Construction Categories



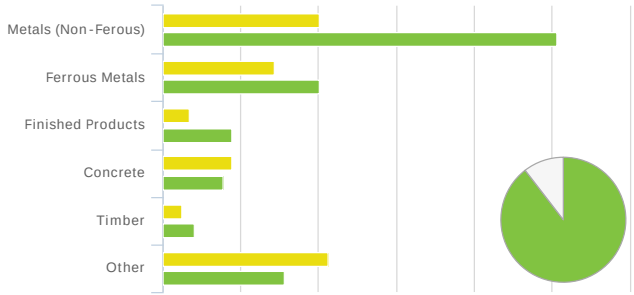
Top 5 Operational Demands



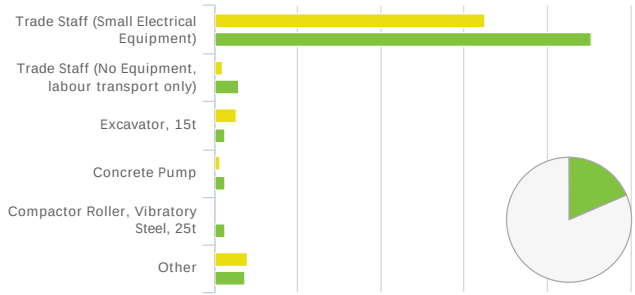
Top 5 Operational Supply Sources



Top 5 Materials



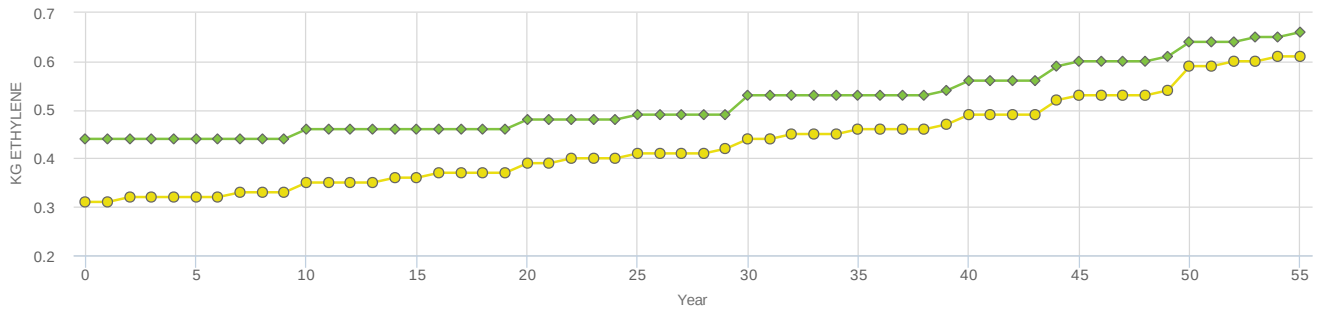
Top 5 Equipment & People



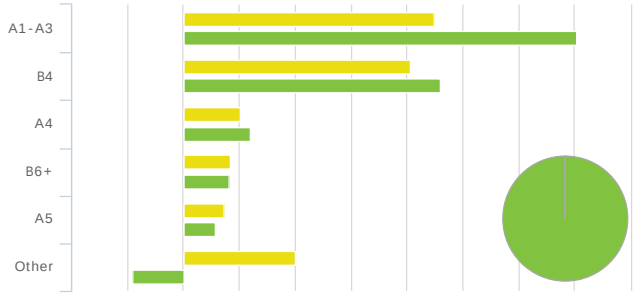
6.5 Photochemical Ozone Creation Potential, POCP Profile

Business as Usual Scenario Design

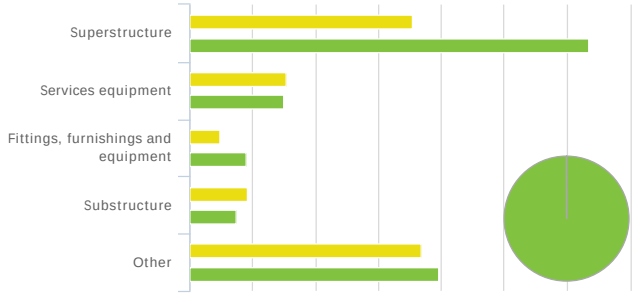
TIME SERIES CHART



Top 5 Life Cycle Modules

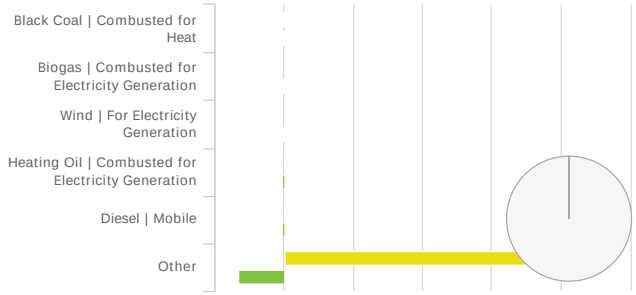


Top 5 Construction Categories

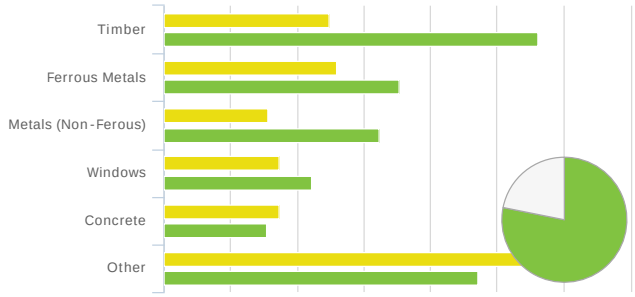


Top 5 Operational Demands

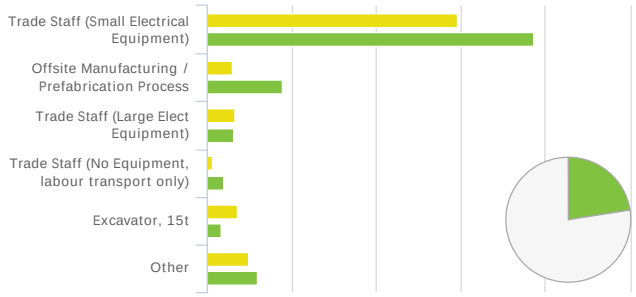
Top 5 Operational Supply Sources



Top 5 Materials

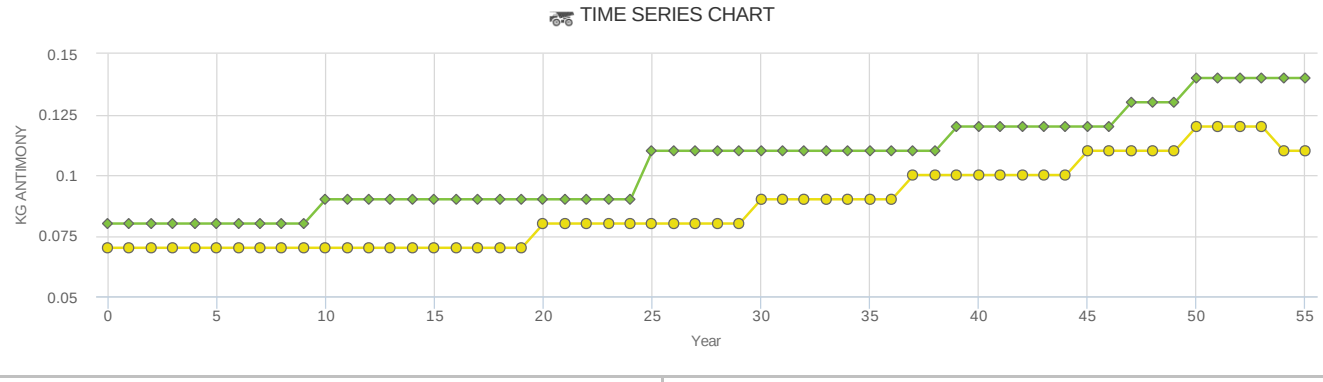


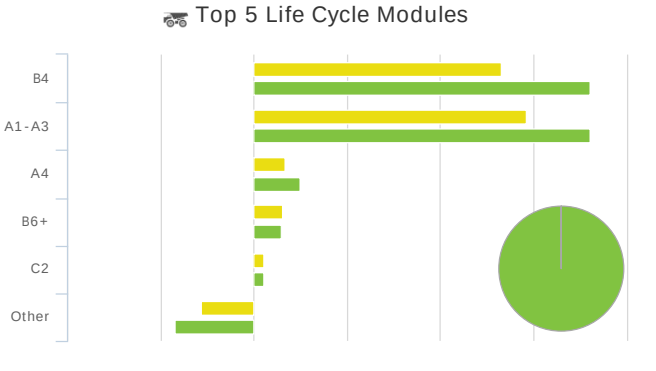
Top 5 Equipment & People

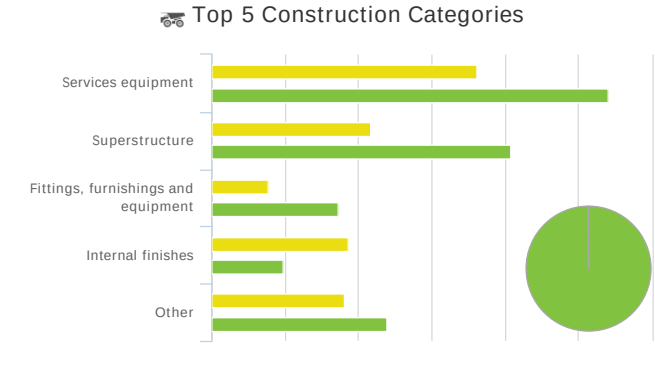


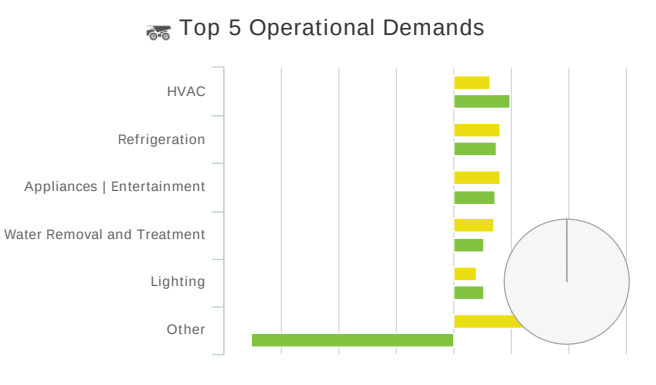
6.6 Abiotic Depletion Potential - Elements, ADPE Profile

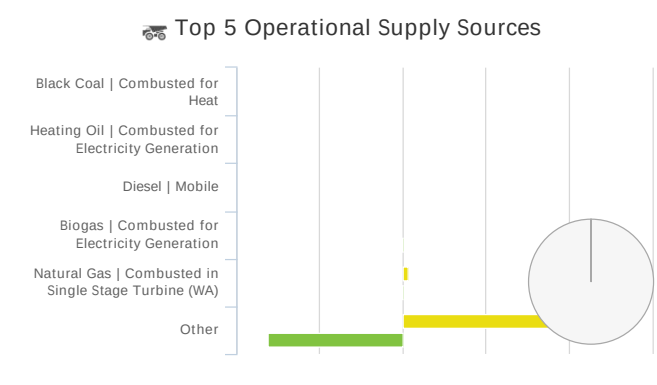
Business as Usual Scenario Design

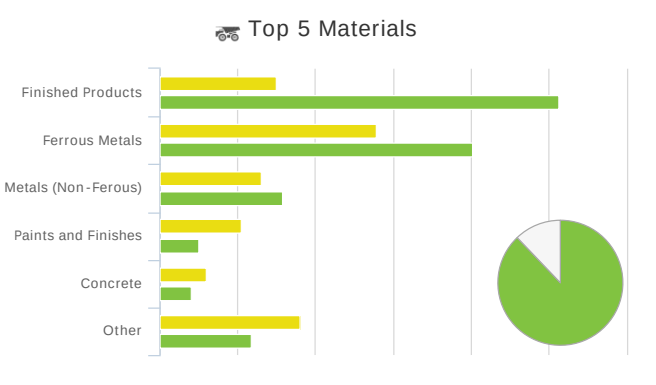


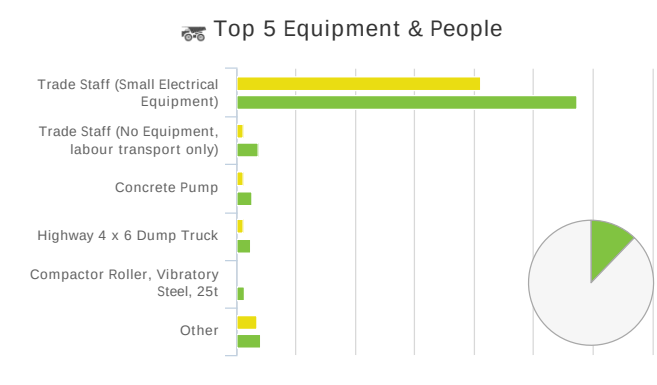






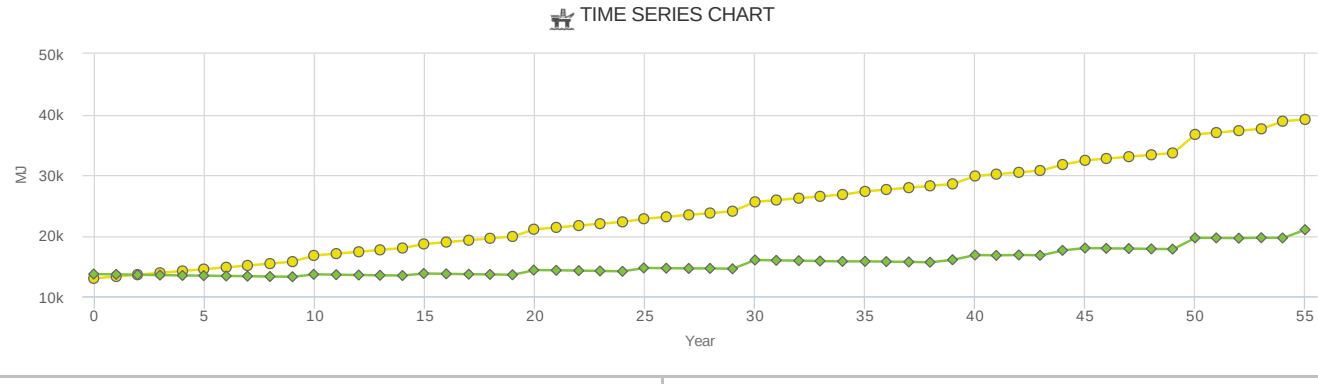


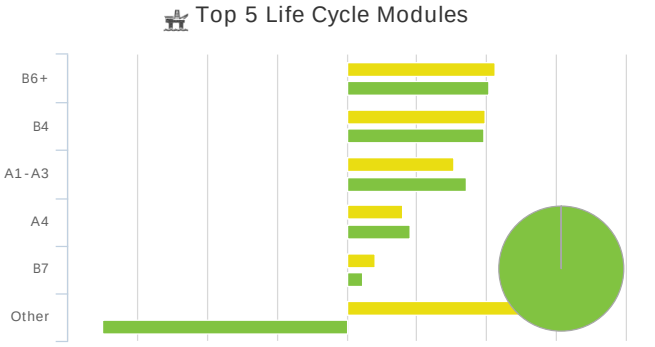


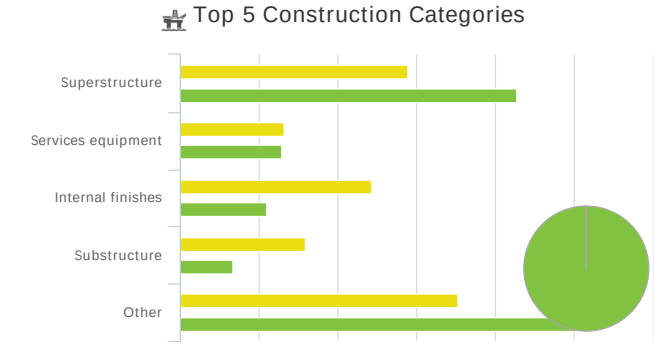


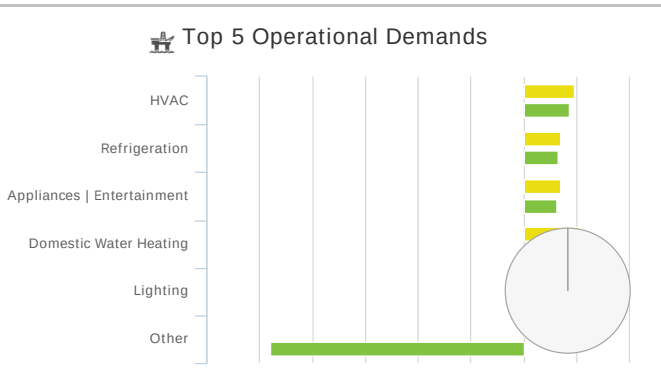
6.7 Abiotic Depletion Potential - Fossil Fuels, ADPF Profile

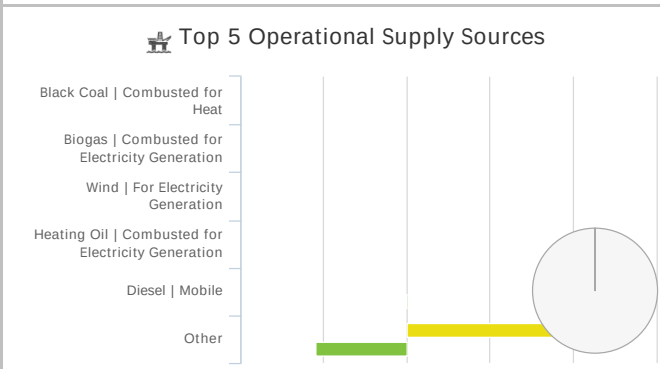
Business as Usual Scenario Design

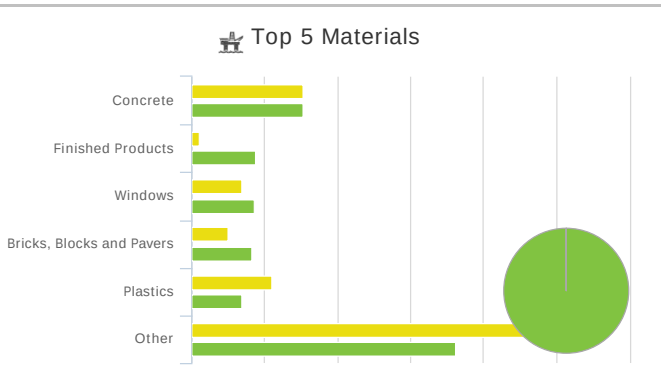


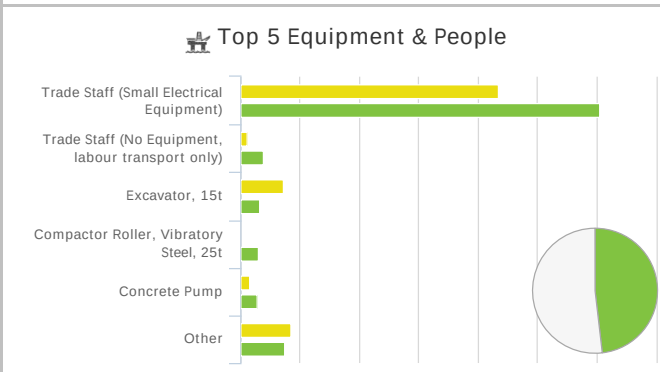






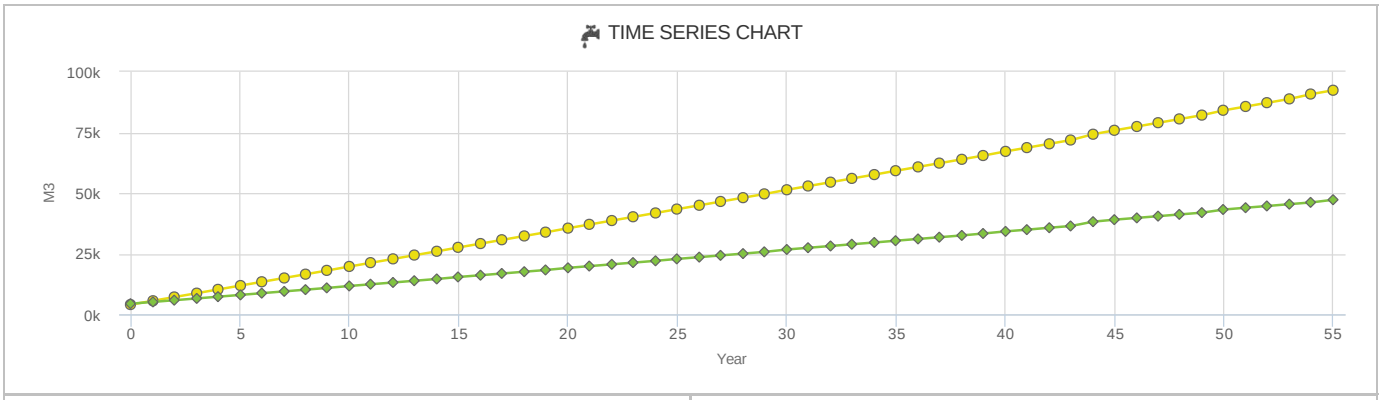


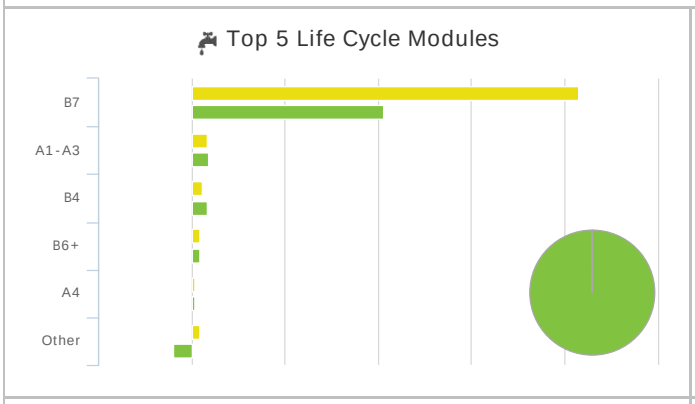


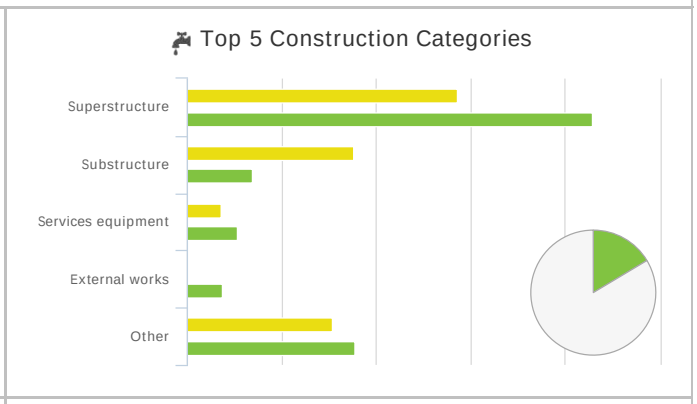


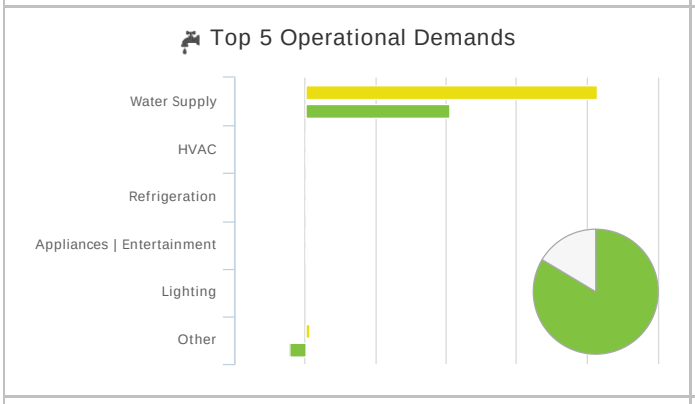
6.8 Net use of fresh water, FW Profile

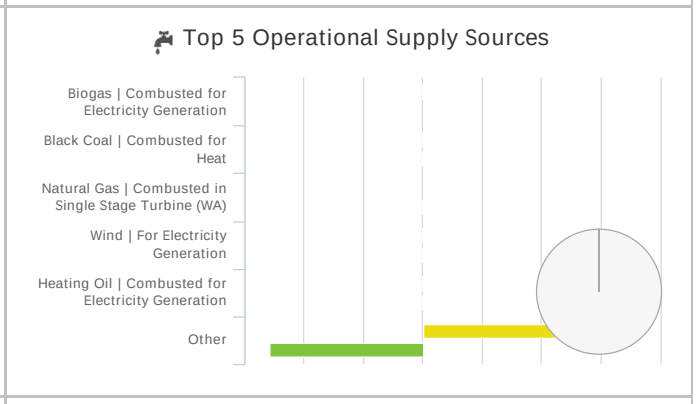
Business as Usual Scenario Design

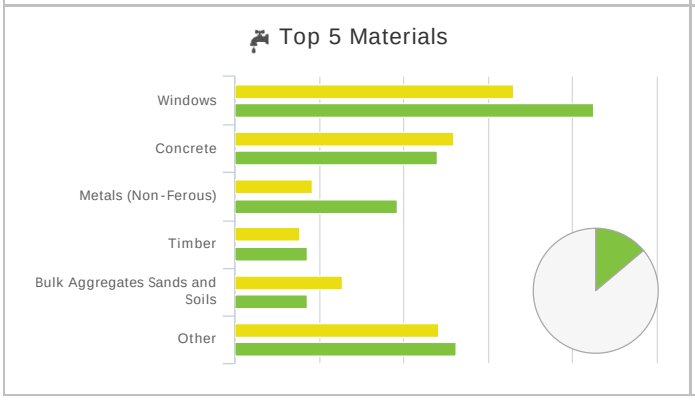


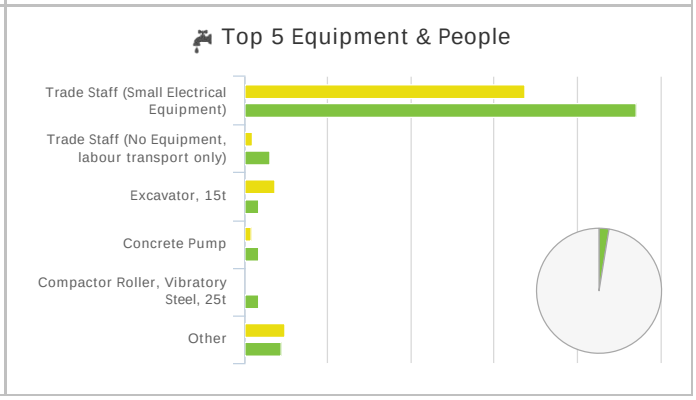












7 Low Impact Strategies

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.

The following low impact strategies are included in the Scenario Design:

Design Strategy Performance	GWP	ODP	AP	EP	POCP	ADPE	ADPF	FW
HVAC: Residential Ceiling Fans Assisted Cooling	0.61%	-0.19%	-0.11%	-0.82%	-0.30%	-0.46%	0.54%	0.05%
Replacement: Recycled Bricks	0.26%	0.15%	0.17%	0.11%	0.26%	0.07%	0.18%	0.01%
Finishes: Reduce Floor Coverings (Tile to Polished concrete/Timber)	4.88%	7.76%	6.62%	5.30%	8.33%	26.89%	5.03%	0.40%
Finishes: Reduce Floor Coverings (Carpet to Polished concrete)	0.13%	0.06%	0.14%	0.08%	0.31%	0.11%	0.13%	0.00%
Open Exposed Ceiling (no plasterboard)	2.41%	5.06%	3.59%	2.76%	4.26%	3.10%	3.02%	0.25%
6.6kW PV system with 5kW Inverter Single Phase Connection (Connected)	60.94%	-4.22%	36.81%	33.93%	13.67%	-24.55%	57.96%	5.23%
Water-wise gardens (minimise lawn/native plants)	0.30%	0.11%	0.23%	0.22%	0.23%	0.10%	0.28%	8.60%
Dripper Irrigation System (in place of sprays)	0.14%	0.05%	0.10%	0.10%	0.10%	0.04%	0.13%	3.87%
2kL Rainwater Tank for Garden Irrigation Water	-0.39%	-0.81%	-0.53%	-0.69%	-0.48%	-0.57%	-0.59%	7.09%
Low Flow Shower Heads (7.5L/min)	0.64%	0.14%	0.26%	0.57%	0.39%	0.17%	0.70%	4.55%
Water efficient fixtures and fittings (Mixers and Toilets only)	0.45%	0.23%	0.37%	0.88%	0.37%	0.28%	0.39%	7.47%
Proposed Design	0%	0%	0%	0%	0%	0%	0%	0%

Table 11: Design Strategies in Scenario Design

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.

7.1 Scenario Design Strategies

7.1.1 HVAC: Residential Ceiling Fans Assisted Cooling

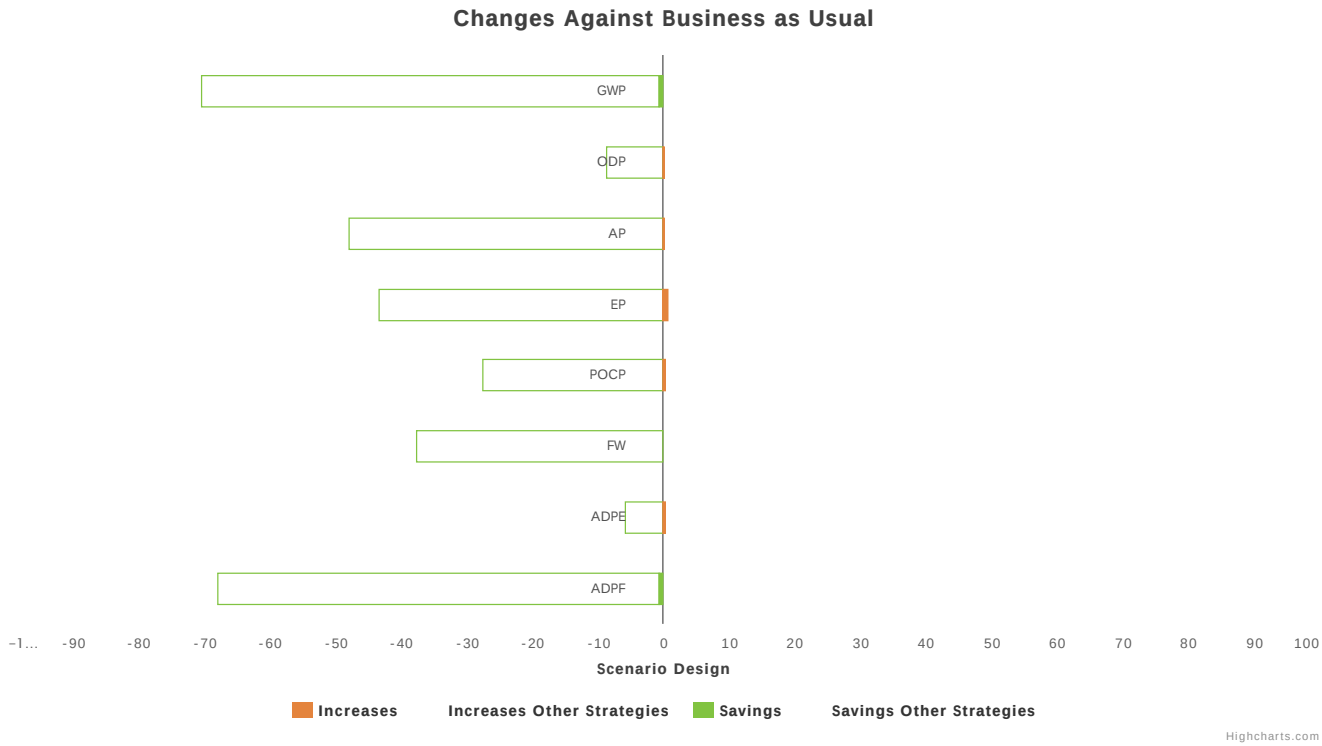


Figure 7: Impact savings (or increases) associated with the HVAC: Residential Ceiling Fans Assisted Cooling as a percentage of the base design.

The cooling requirements of modern code compliant houses can be easily met by low energy ceiling fans which in some ways are equally as effective as HVAC systems for cooling. They cool you by triggering evaporation from your skin. For comparison a central A/C unit runs on about 3000 watts per hour whereas a ceiling fan runs on only 30 watts per hour. Installing ceiling fans will allow occupants to choose this more efficient form of cooling over their costly air conditioning systems. A 20% reduction in air conditioning has been assumed.

If the implementation of this strategy is outside of the project budget the developer may offer the strategy as an upgrade package for purchasers. This eliminates the need for upfront capital while promoting best practices and educating the public.

(Image source: www.bigassfans.com)(Image source: www.bigassfans.com)

7.1.2 Replacement: Recycled Bricks

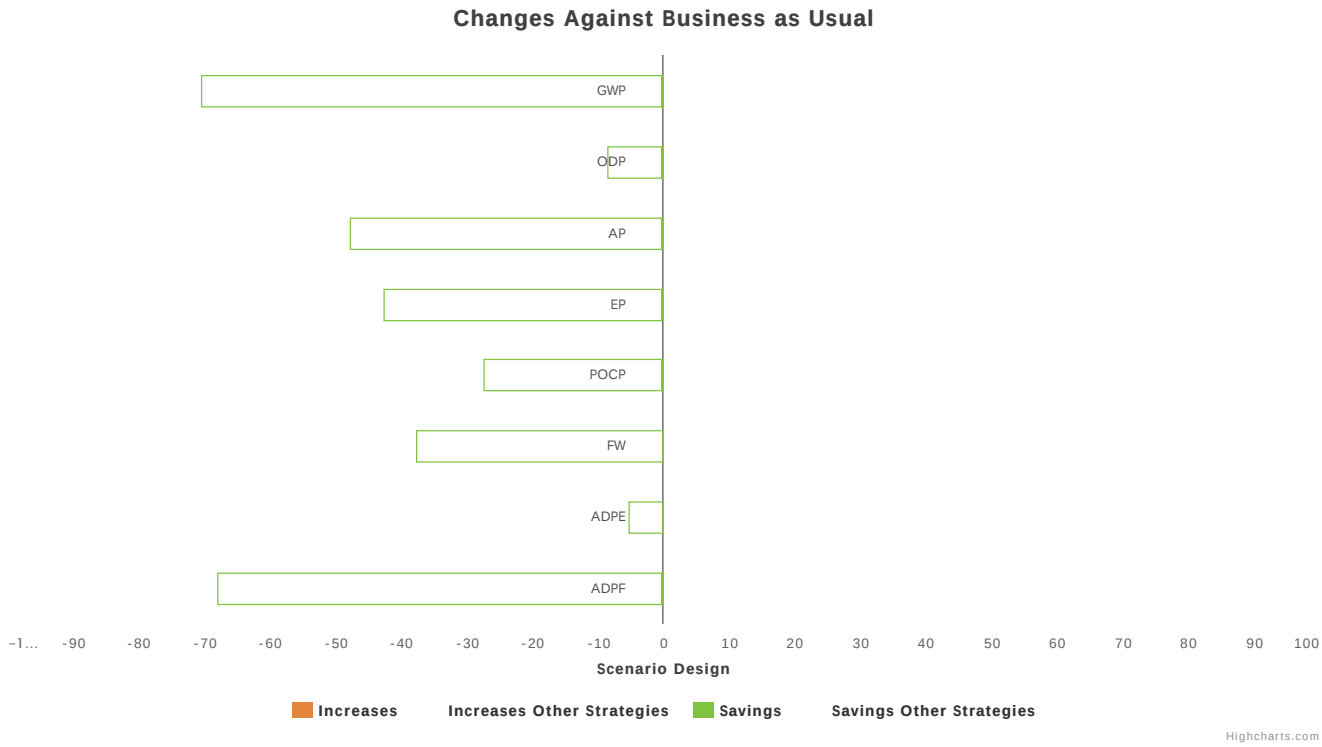


Figure 8: Impact savings (or increases) associated with the Replacement: Recycled Bricks as a percentage of the base design.

Using re-cycled clay bricks in all masonry walls will provide some carbon savings. Although there is a lot of labour involved in sourcing and cleaning bricks, they can be cost competitive with new bricks. The aesthetic look of recycled brick is also very popular in architecturally designed buildings.

For this scenario brick from the original house will be used for the 20m2 of feature facebrick wall.

(Image source: Architizer.com)

7.1.3 Finishes: Reduce Floor Coverings (Tile to Polished concrete/Timber)

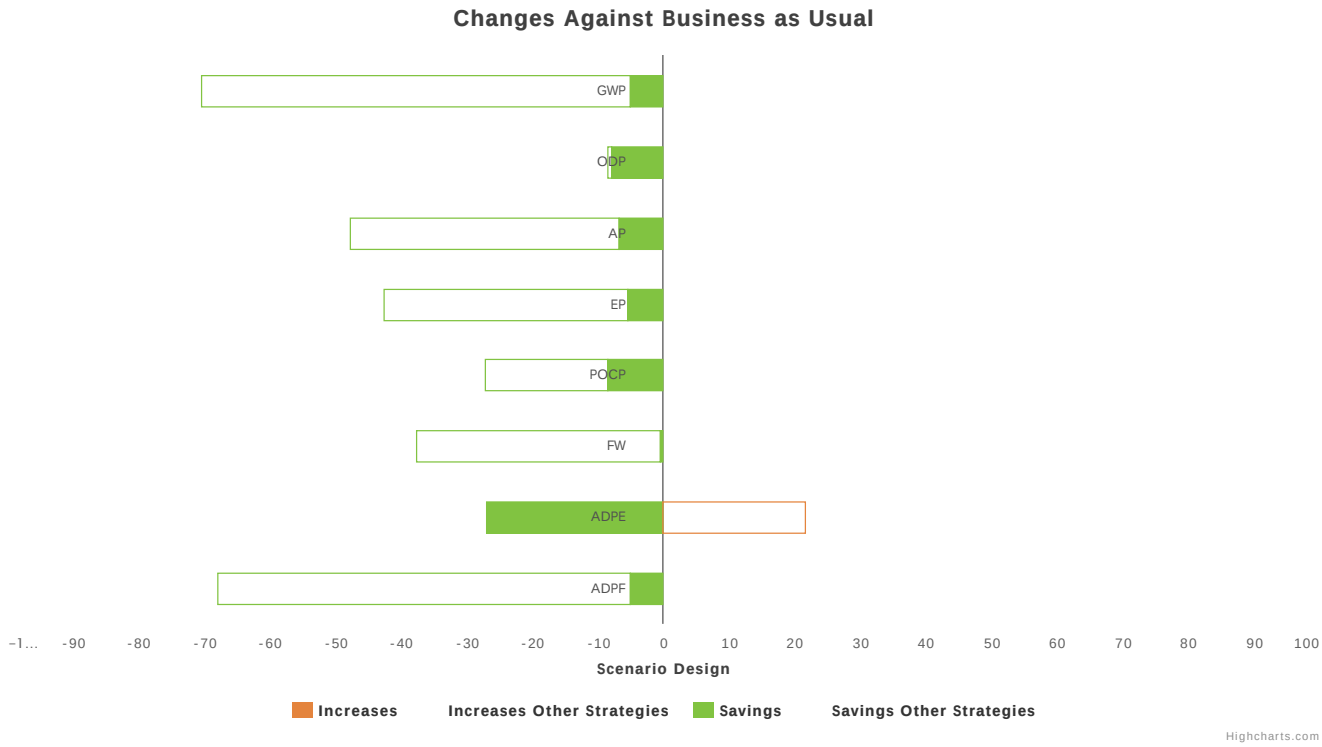


Figure 9: Impact savings (or increases) associated with the Finishes: Reduce Floor Coverings (Tile to Polished concrete/Timber) as a percentage of the base design.

Ceramic floor tiles have a large amount of embodied energy. Specifying polished concrete and timber floorings will have lower recurring impacts. Grind and polish concrete eliminates the use of a polyurethane seal/coating and reduces maintenance associated with a grind and seal finish.

For this recommendation, all tiled areas with the exception of the Games Room (20m2) are changed to grind & polished concrete.

The 20m2 for the Games room is to be a timber floor, which will also be a saving in embodied energy as timber is a unique material, because it enables the permanent capture of carbon. Although doesn't have the same savings and the polished concrete due to manufacturing, transportation elements of the product.

(image source: http://www.switcheroom.com)

7.1.4 Finishes: Reduce Floor Coverings (Carpet to Polished concrete)

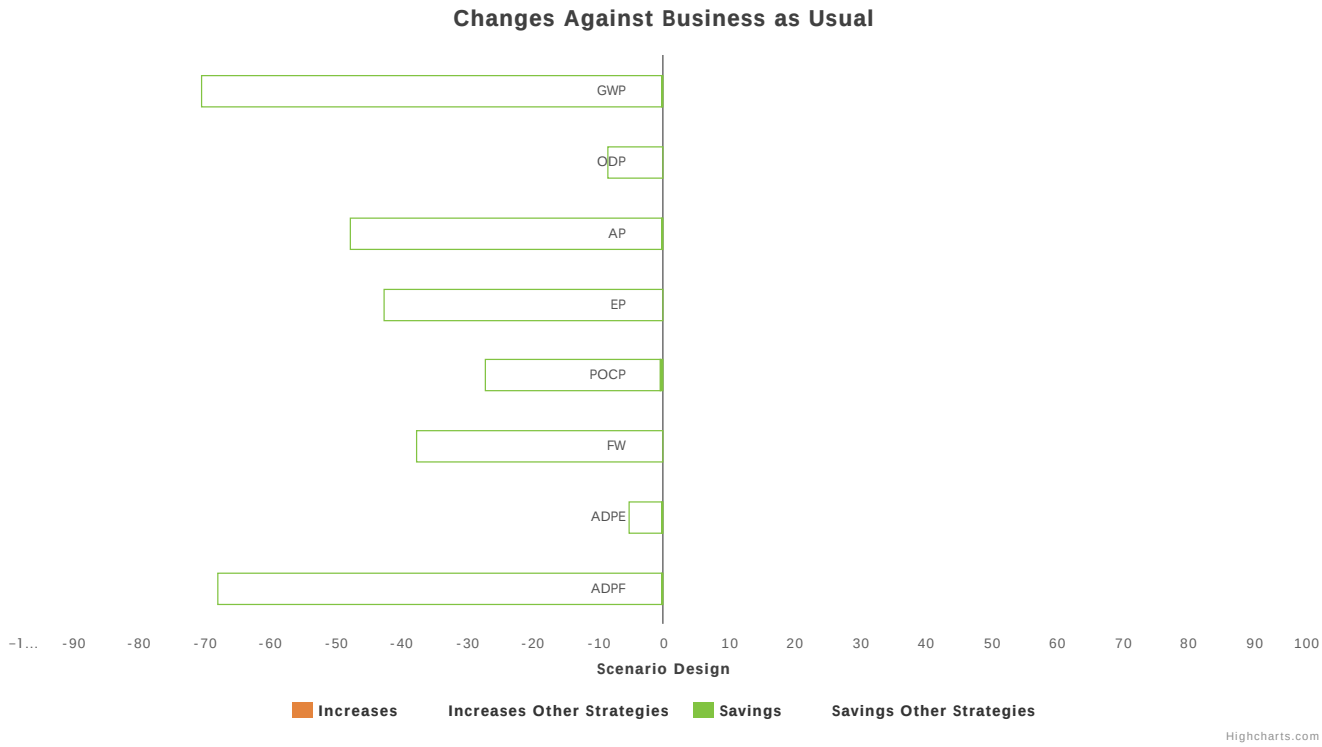


Figure 10: Impact savings (or increases) associated with the Finishes: Reduce Floor Coverings (Carpet to Polished concrete) as a percentage of the base design.

Carpets have significant life cycle impacts due to their heavy use and regular replacement. Specifying polished concrete and timber floorings will have lower recurring impacts. Grind and polish concrete eliminates the use of a polyurethane seal/coating and reduces maintenance associated with a grind and seal finish.

For this recommendation, only a small 6.76m2 of carpeted area has been changed to grind & polished concrete.

It should be noted that carpets have significant life cycle impacts due to their heavy use and regular replacement. If no other material alternatives such as cork, timber or polished concrete are possible then Environmental Product Declaration (EPDs) and/or recycled carpet should be sought. EPDs provide LCA data specific to the product rather than the default industry average. Good suppliers of recycled carpet and floor finishes with EPDs include Interface and Forbo. This has not been modelled.

7.1.5 Open Exposed Ceiling (no plasterboard)

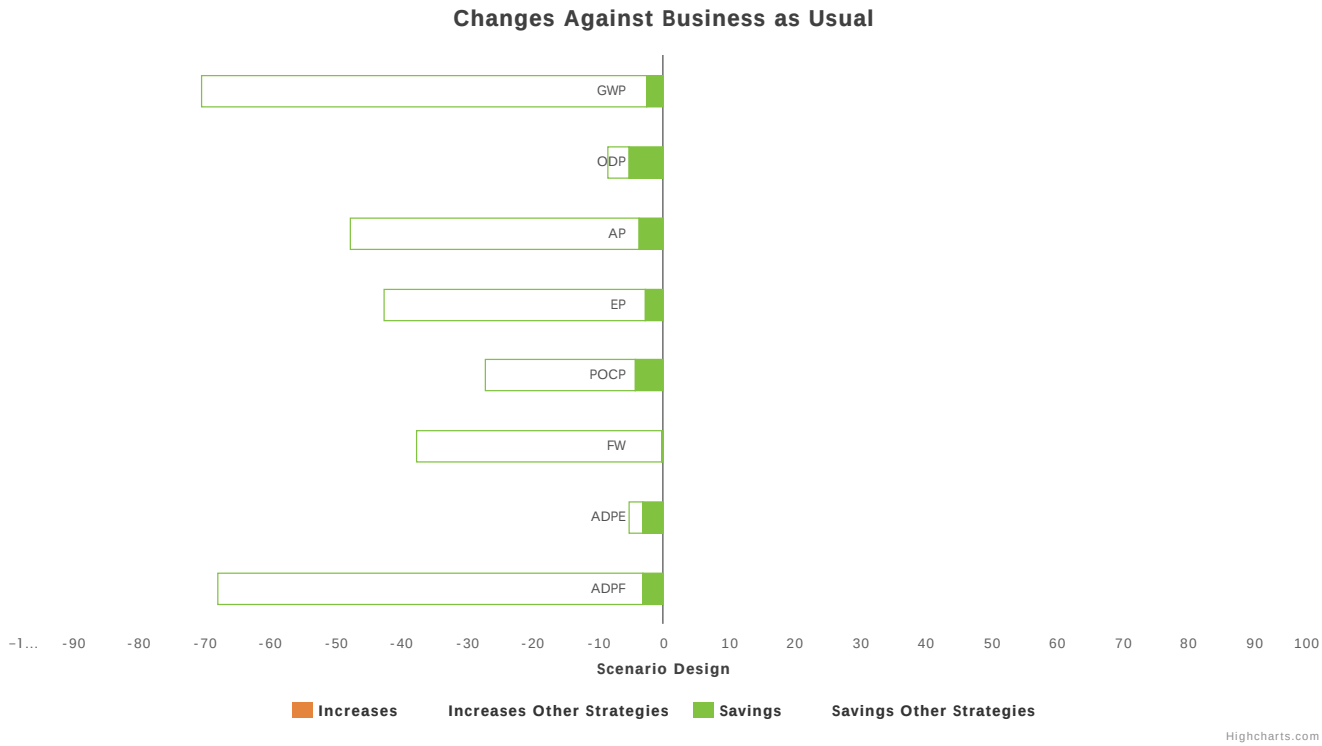


Figure 11: Impact savings (or increases) associated with the Open Exposed Ceiling (no plasterboard) as a percentage of the base design.

Due to the manufacturing process of plasterboard it has very high CO2 embodied impacts. Currently there is an architectural fashion to remove plasterboard ceilings and expose the underside of concrete floor slabs providing large CO2 savings.

Exposed Concrete ceilings bring a rawness and robustness, as well as thermal mass, to spaces with an industrial or contemporary aesthetic. They can be left raw, textured with the use of timber formwork or painted. Services can either be exposed, hidden within bulkheads or cast into the concrete.

For this recommendation, we have assumed that the building is fitted with an open ceiling and direct paint on the concrete.

Open Ceiling in a residential context

7.1.6 6.6kW PV system with 5kW Inverter Single Phase Connection (Connected)

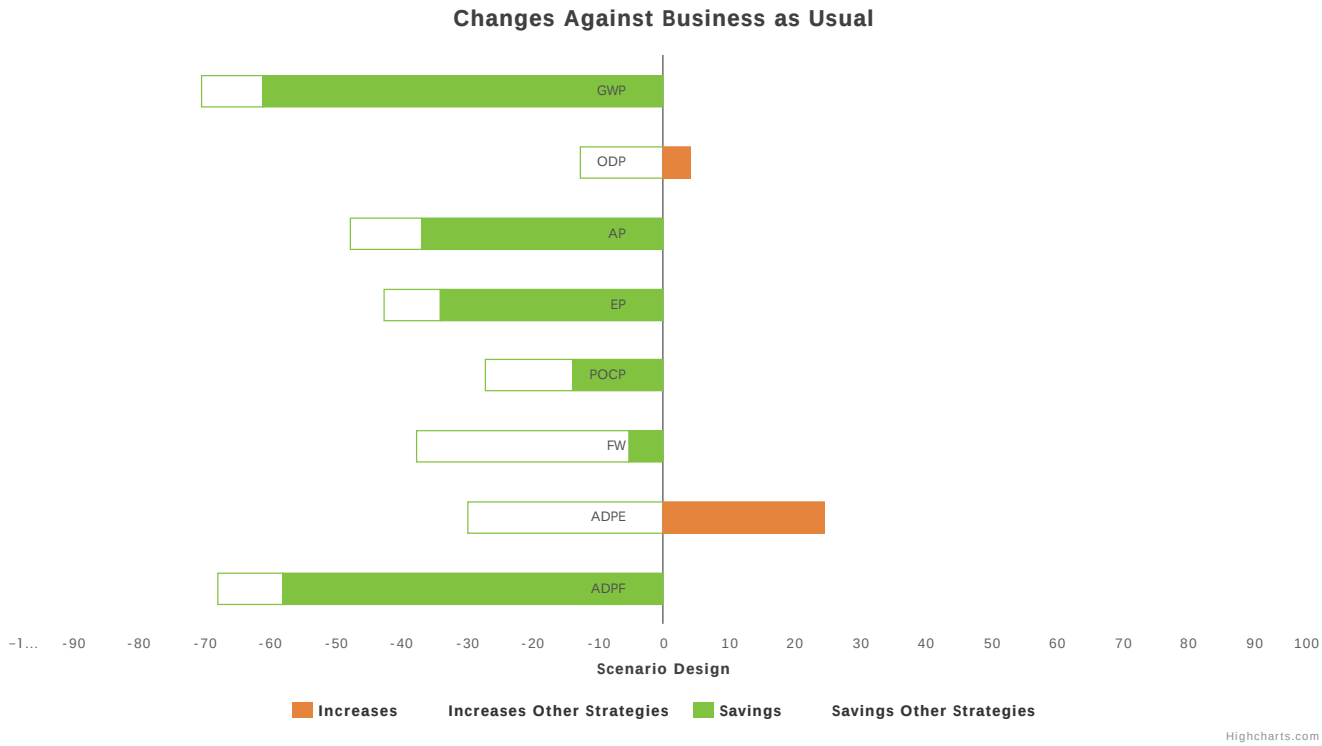


Figure 12: Impact savings (or increases) associated with the 6.6kW PV system with 5kW Inverter Single Phase Connection (Connected) as a percentage of the base design.

With the rising price of electricity, the economics of solar are very favourable and add to the value of the property. 22% of total Australian dwellings now have solar technologies on their roof. Using solar generated power on site results in much lower emissions associated with the dwelling compared to using the fossil fuel powered grid. Feeding out to the grid assumes a net environmental credit as the electricity will be consumed by a neighbouring consumer therefore reducing the demand on the grid.

By connecting the system to the grid electricity it produces that is not used onsite will feed back into the (predominantly fossil fuel fired grid). This can be thought of as offsetting the carbon associated with the materials used in constructing and maintaining the dwelling.

The embodied impacts of the solar PV system is included in the calculations.

eTool have assumed a conservative price of approximately $3000/kW however recent quotes on projects suggest costs more in the range of $1500-$2000/kW. If the implementation of this strategy is outside of the project budget the developer may offer the strategy as an upgrade package for purchasers. This eliminates the need for upfront capital while promoting best practices and educating the public. Another option to save on upfront costs is to consider companies such as Amanda Energy (https://amandaenergy.com.au/) that rent your roof space to install solar PV while passing down the benefits to the tenant in the form of lower power bills.

Worst case panel dimensions 1070mm x 1685mm.

(Image source: www.forceofthesun.com)

7.1.7 Water-wise gardens (minimise lawn/native plants)

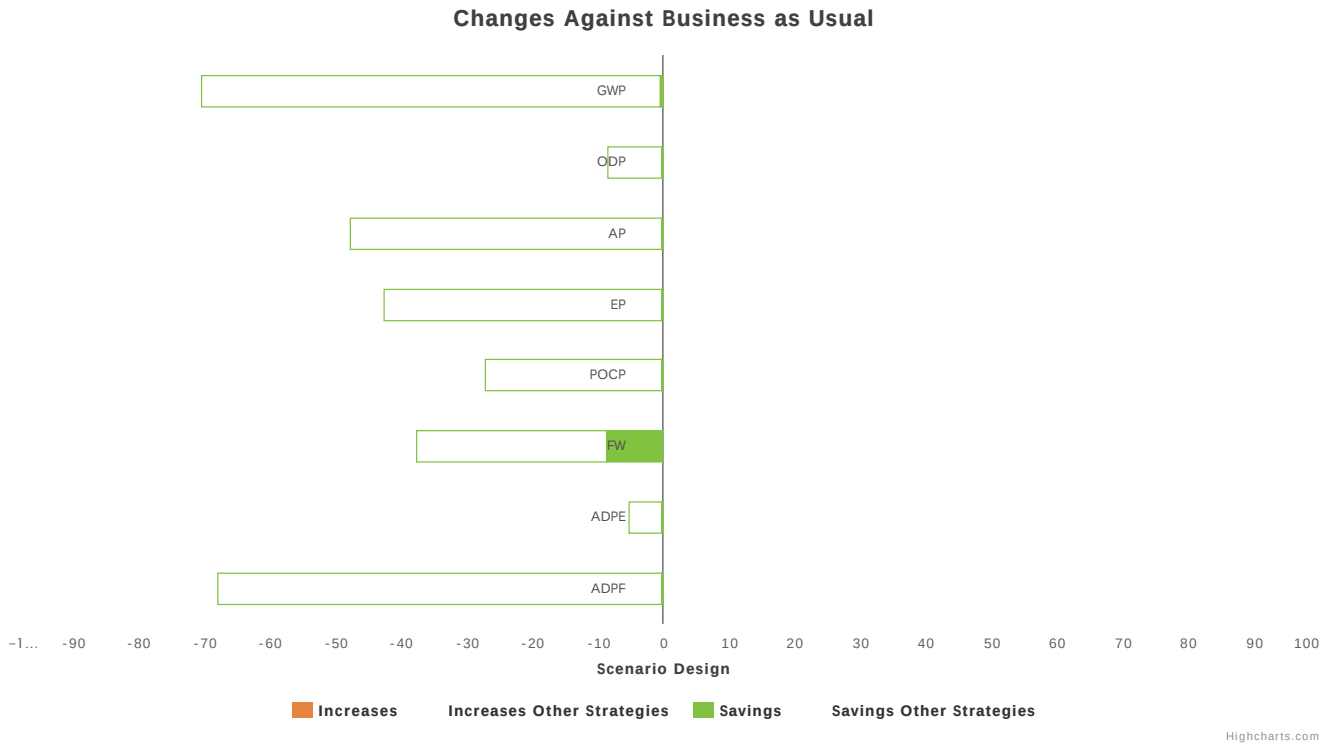


Figure 13: Impact savings (or increases) associated with the Water-wise gardens (minimise lawn/native plants) as a percentage of the base design.

Minimising lawn areas and planting native / drought-resistant plants only will ensure minimal water requirements for the landscape.

For this recommendation we have reduced lawn areas as per DA Drawings resulting in a reduction in irrigation water use. Assumed garden beds use 40% less water than lawns and no irrigation requirements on hard landscaping areas.

7.1.8 Dripper Irrigation System (in place of sprays)

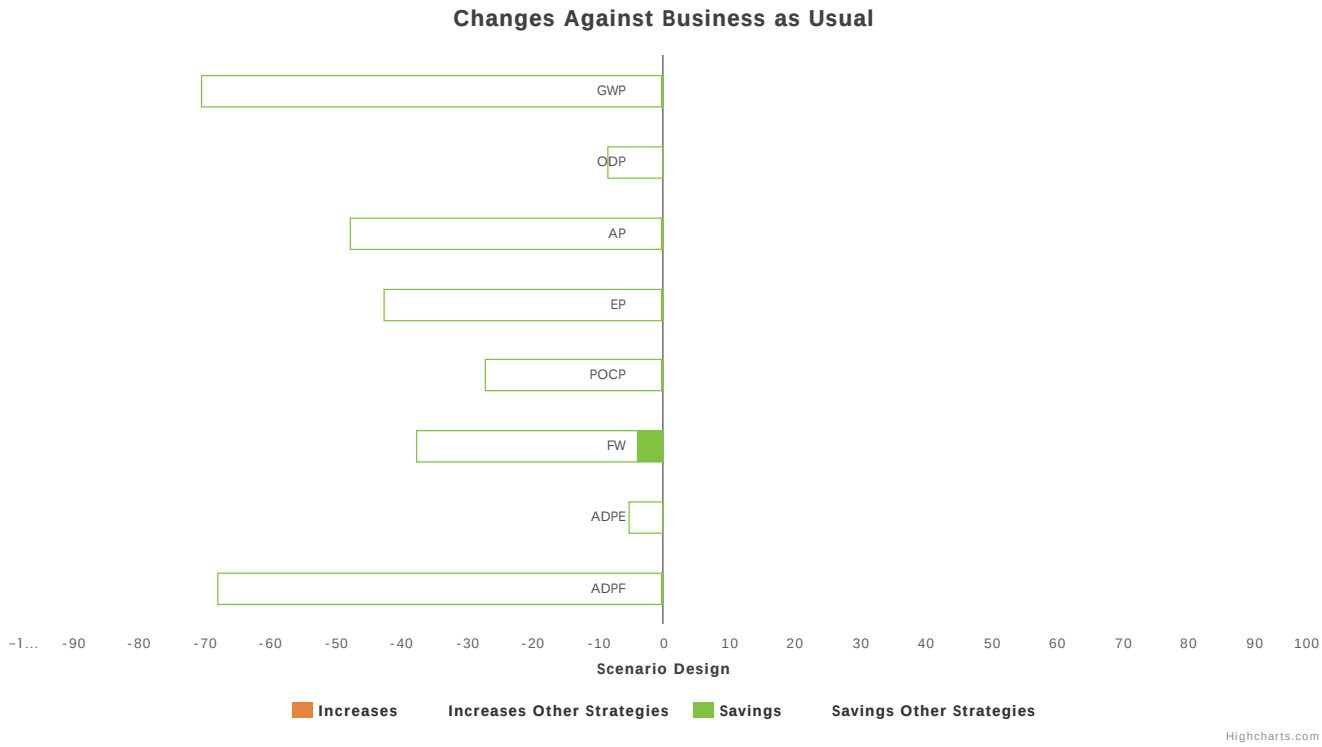


Figure 14: Impact savings (or increases) associated with the Dripper Irrigation System (in place of sprays) as a percentage of the base design.

Dripper irrigation saves between 20% and 50% of water use compared to conventional micro sprays. The savings are achieved due to a more direct application of water to the root zone and less evaporation. In modelling this strategy it is assumed a saving of 30% is achieved against 'business as normal' irrigation water use.

7.1.9 2kL Rainwater Tank for Garden Irrigation Water

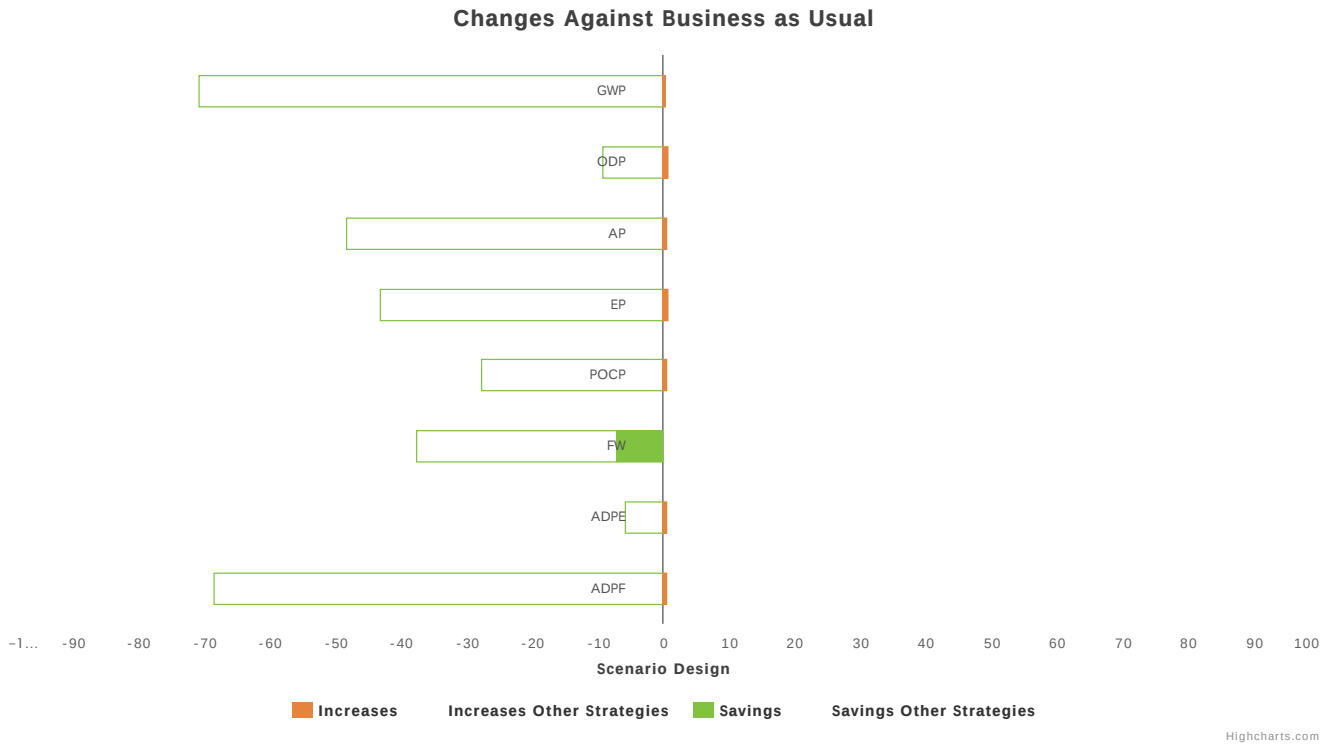
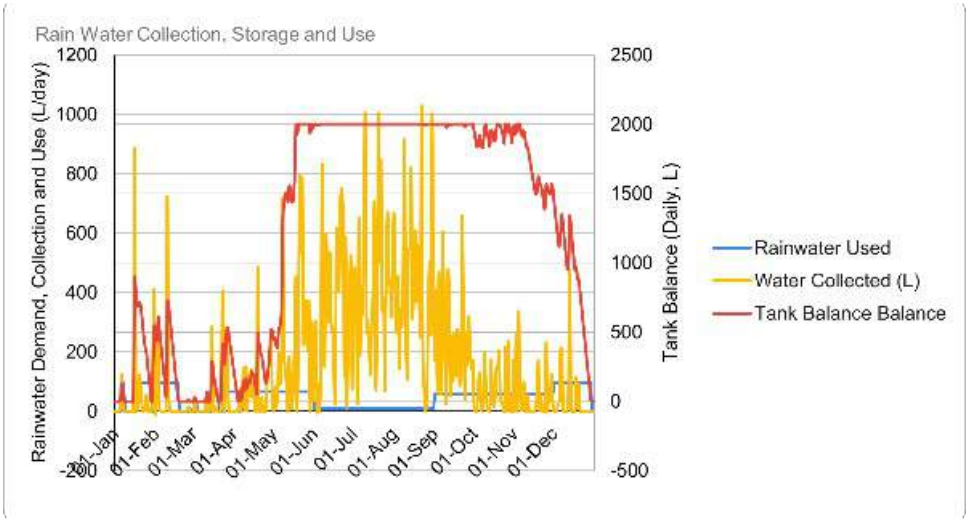


Figure 15: Impact savings (or increases) associated with the 2kL Rainwater Tank for Garden Irrigation Water as a percentage of the base design.

A rain water collection tank reduces water usage (laundry, toilets, outdoor) and water bills. It also reduces the load on storm water systems and reduces the need to build more store water dams.

Calculations are based on occupancy, roof size, storage capacity, size and type of garden. This strategy assumes the rainwater collected is used only for garden irrigation (25% of total water use). The 2kL tank supplies approximately 80% of the garden irrigation water use (see below collection, demand and use chart).



Further water savings could potentially be saved if rainwater is plumbed into the house for use in the toilets and laundry.

(Image source: www.tankworks.com.au)

7.1.10 Low Flow Shower Heads (7.5L/min)

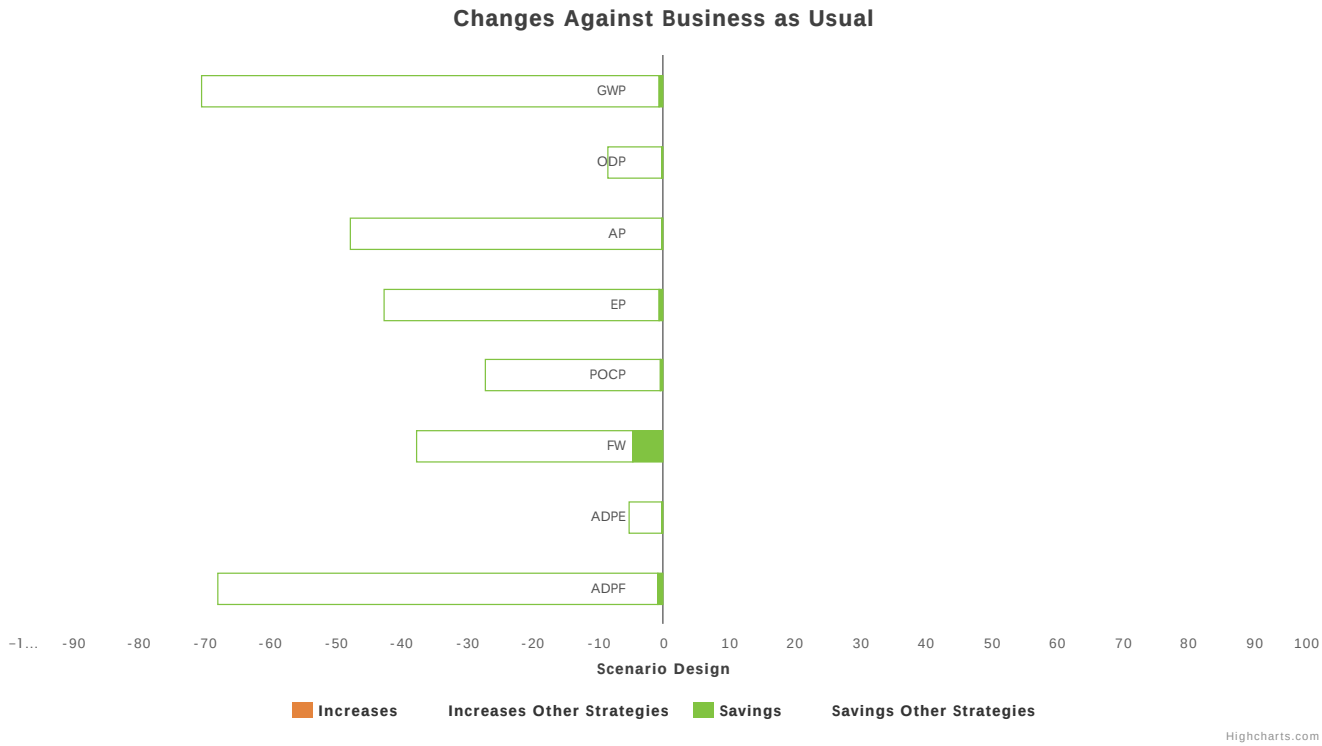


Figure 16: Impact savings (or increases) associated with the Low Flow Shower Heads (7.5L/min) as a percentage of the base design.

By specifying a 7.5L/min shower head, compared to a standard 9L/min, the total shower consumption is reduced by 17% and overall hot water consumption may be reduced by 11% assuming showering takes up 65% of the hot water use, leading to significant energy and water savings. It is recommended that tests are conducted to ensure the shower head chosen provides an adequate shower to avoid the tendency for residents to rip out the shower and replace with a less efficient model. Differentiation between products is based on the nominal flow rate @ 250kPa. However, flow rate measurements are made at 150kPa and 350kPa to determine the flow rate regulation across this pressure range. The shower heads also have to satisfy performance criteria, such as mean spray spread angle and temperature drop, while operating at lower flow rates.

The cost implications for this recommendation ranges from low to high depending on the manufacturer however the payback period is usually relatively quick. For example, the Methven shower head below from Pure Electric (4.5L/min or 5L/min) retails at $135 at the point of writing and claims to have a 3 month payback period. The same manufacture will also be producing a 3L/min showerhead in the near future but for a higher retail price http://etoolglobal.com/wp-content/uploads/2015/09/Low-flowSH.pdf

Satisfying the technical requirements of AS 3662 enables the establishment of a rating based on the 'the average flow rate' as follows:

- *more than 16L/min. or failing the performance requirement are nominated 0 star*
- *more than 12L/min. but not more than 16L/min. are nominated 1 star*
- *more than 9L/min. but not more than 12L/min. are nominated 2 star*
- *more than 7.5L/min. but not more than 9L/min. are nominated 3 star*
- *more than 6.0L/min. but not more than 7.5L/min. are nominated 3 star (including compliance with force of spray requirements) – to be 4 star but currently only 3 star available*
- *more than 4.5L/min. but not more than 6.0L/min. are nominated 3 star (including compliance with force of spray requirements) – to be 5 star but currently only 3 star available*
- *more than 4.5L/min. but not more than 6.0L/min. are nominated 3 star (including compliance with force of spray requirements and having bonus water saving features (e.g., a sensor with auto shut-off) – to be 6 star but currently only 3 star available*

(source: pure-electric.com.au/methven-kiri-satinjet-ultra-low-flow)

7.1.11 Water efficient fixtures and fittings (Mixers and Toilets only)

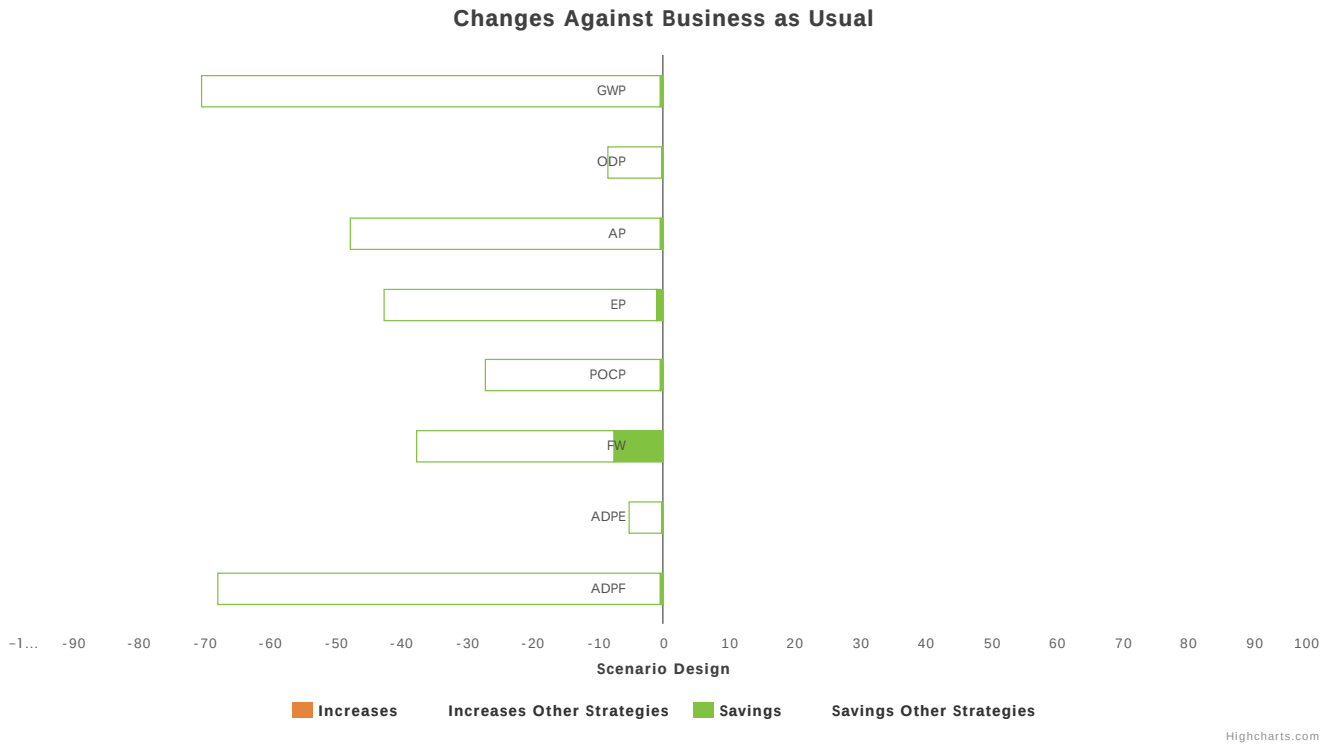


Figure 17: Impact savings (or increases) associated with the Water efficient fixtures and fittings (Mixers and Toilets only) as a percentage of the base design.

The highest WELS rated water fittings can achieve significant water savings compared to code compliant fittings:

- Basin Mixer: WELS 6 Star (50% water saving vs code compliant)
- Sink Mixer: WELS 6 Star (50% water saving vs code compliant)
- Toilet: WELS 4 Star 4.5L/ full flush and 3L/average flush (37.5% saving vs code complaint)
- Shower: Not defined
- Washing Machine: Not defined
- Dish Washer: Not Defined

8 Conclusions

The Scenario Design shows an expected performance improvement against Business as Usual for 5 indicators.

9 References

9.1 Background LCI Data

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9.2 Inventory - Design Documentation

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9.3 Inventory - Assumptions

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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 kgSO2e

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.

Net use of fresh water, FW

The pressure on global freshwater resources arises from the demand for everyday goods and services which use water in their production. The interconnected nature of global economic systems means that water abstraction can occur far from where final consumption occurs. Globally, water use has been increasing at more than twice the rate of population growth, and most withdrawals are in watersheds already experiencing water stress. Managing water resources is extremely important for the health of the environment and our current and future agricultural, industrial and personal water requirements. Fresh water can be derived from renewable sources (rain water) and somewhat non-renewable resources (aquifers). Consumptive water (H2O C) use is abstracted water that is no longer available for other uses because it has evaporated, transpired, been incorporated into products and crops, or consumed by man or livestock.

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	Scenario 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	Scenario 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	Scenario 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	Scenario 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			