NCC VOLUME ONE GLAZING CALCULATOR (first issued with NCC 2014)

HELP

Building name/description: The Star - North Tower - Sky Villas

Application: other

Climate zone: 5

Storey: Level 61

Facade areas

	N	NE	E	SE	S	SW	W	NW	Internal
Option A	31.4m²	32.3m²	58.9m²	31.6m²	8.3m²		37.1m²	27.3m²	
Option B									
Glazing area (A)	*26.7m²*	*27.5m²*	*50.1m²*	*26.9m²*	*7.05m²*	.....	*31.5m²*	*23.2m²*	

Number of rows preferred in table below: 14 *(as currently displayed)*

GLAZING ELEMENTS, ORIENTATION SECTOR, SIZE and PERFORMANCE CHARACTERISTICS								SHADING		CALCULATED OUTCOMES OK (if inputs are valid)					
Glazing element		Facing sector		Size			Performance		P&H or device	Shading		Multipliers		Size	Outcomes
ID	Description (optional)	Option A facades	Option B facades	Height (m)	Width (m)	Area (m²)	Total System U-Value (AFRC)	Total System SHGC (AFRC)	P (m)	H (m)	P/H	G (m)	Heating (S_H)	Cooling (S_C)	Area used (m²)	Element share of % of allowance used
1	PSuite_SW	S		3.20		7.05	2.9	0.25				0.00	1.00	1.00	7.05	100% of 92%
2											ROW SKIPPED (OK if intentional)					
3	PSuite_W	W		3.20		31.54	2.2	0.17				0.00	1.00	1.00	31.54	100% of 92%
4											ROW SKIPPED (OK if intentional)					
5	PSuite_W	NE		3.20		27.49	1.4	0.15				0.00	1.00	1.00	27.49	100% of 100%
6											ROW SKIPPED (OK if intentional)					
7	Suite A_E	E		3.20		50.10	2.8	0.18				0.00	1.00	1.00	50.10	100% of 100%
8											ROW SKIPPED (OK if intentional)					
9	Suite A_SE	SE		3.20		26.89	2.8	0.18				0.00	1.00	1.00	26.89	100% of 98%
10											ROW SKIPPED (OK if intentional)					
11	PSuite_N	N		3.20		26.66	2.8	0.18				0.00	1.00	1.00	26.66	100% of 96%
12											ROW SKIPPED (OK if intentional)					
13	PSuite_NW	NW		3.20		23.23	2.8	0.18				0.00	1.00	1.00	23.23	100% of 95%
14																

IMPORTANT NOTICE AND DISCLAIMER IN RESPECT OF THE GLAZING CALCULATOR

The Glazing Calculator has been developed by the ABCB to assist in developing a better understanding of glazing energy efficiency parameters. While the ABCB believes that the Glazing Calculator, if used correctly, will produce accurate results, it is provided "as is" and without any representation or warranty of any kind, including that it is fit for any purpose or of merchantable quality, or functions as intended or at all. Your use of the Glazing Calculator is entirely at your own risk and the ABCB accepts no liability of any kind.

if inputs are valid

Figure 11.19 NCC Glazing Calculator – Level 61 Glazing

THE STAR ENTERTAINMENT GROUP LTD

Whole Building Life Cycle Assessment

THE STAR, SYDNEY - RITZ CARLTON HOTEL AND RESIDENTIAL TOWER

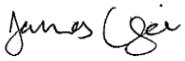
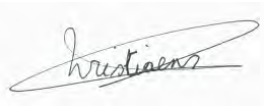
Whole Building Life Cycle Assessment

THE STAR, SYDNEY - RITZ CARLTON HOTEL AND RESIDENTIAL TOWER

The Star Entertainment Group Ltd

REV	DATE	DETAILS
00	28/02/2017	For Planning Submission
01	24/03/2017	Updated For Planning Submission
02	30/06/2017	Updated For Planning Submission

AUTHOR, REVIEWER AND APPROVER DETAILS

Prepared by:	James Logie	Date: 30/06/2017	Signature:	
Reviewed by:	Ruben Christiaens	Date: 30/06/2017	Signature:	
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Filename: 2305180U-ESD-REP-05 Rev02_

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GLOSSARY

General

BCA	Building Code of Australia
NCC	National Construction Code
CoP	Coefficient of Performance
DTS	Deemed to Satisfy
kWp	Kilowatt Peak
kWh	Kilowatt Hour
MJ	Mega joule
HVAC	Heating, Ventilation and Air Conditioning
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
GFA	Gross Floor Area
NLA	Net Lettable Area
t.km	Tonne x Kilometre

EXECUTIVE SUMMARY

The Star Entertainment Group Limited (SEGL) is a leading operator of integrated resorts catering to both local and international visitors and is the operator of The Star, Sydney (The Star). Consistent with The Star's licence obligation to operate the site to an international standard, SEGL is proposing to advance a revitalisation of the existing complex.

SEGL is embarking on a five year redevelopment journey to create a landmark, exemplar integrated resort within the City of Sydney. This proposed redevelopment will occur through the lodgement of two S75W applications with the Department of Planning and Environment, identified as Modification 13 and Modification 14. Modification 13 will involve the design of a new Ritz-Carlton Hotel Tower and associated podium treatment.

SEGL is proposing to attain the highest standard of built form outcomes for the site through the proposed redevelopment by encouraging innovation and best practice approaches in order to achieve an environmentally sustainable development that positively contributes to the overall architecture of both Pyrmont and the City of Sydney. This will be done through the implementation of advanced ESD initiatives, improved people and movement connections, upgrades to the external appearance and presentation of the facility and improved integration with the adjacent urban fabric.

The new Ritz Carlton Hotel and Residential Tower includes:

- Part demolition of existing podium building;
- New approx. 215 m tall hotel and residential tower; and
- Porte Cochere arrangement and coordination of car-park stackers and associated integration works.

The new Ritz Carlton Hotel and Residential Tower proposed at The Star is targeting a 5 Star Green Star Design and As Built Rating, demonstrating Australian excellence in sustainability within the built environment. As part of this ambitious sustainability target, the project is targeting points through a life cycle assessment (LCA) under credit 19A of the Design & As Built rating tool. A preliminary LCA study has been undertaken prior to submission for planning approval. This study has used best available material estimates and will be updated throughout design development as the project design progresses and becomes more detailed.

GREEN STAR RESULTS

The current analysis indicates that the project will achieve a 64% reduction on whole of life greenhouse gas (GHG) emissions and a 327% cumulative impact reduction across the 7 mandatory impact categories. This will achieve the full 7 credit points available under credit 19A. Cumulative impact reduction is rewarded with one point for 30% reduction a further point for each 20% reduction beyond 30%, up to 130% and a maximum of 6 points. One additional point is awarded for additional impact reporting. The predicted Green Star LCA results are shown in Table ES.1.

Table ES.1 Prediction of Green Star LCA results

Impact category	Unit	Reference	Proposed (CEP)	Reduction
Climate change	kg CO2 equivalents	449,496,695	160,542,272	64%
Stratospheric ozone depletion	kg CFC-11 equivalents	0.70	0.69	0%
Acidification potential of land and water	kg SO2 equivalents	1,832,021	288,412	84%
Eutrophication potential	kg PO43- equivalents	165,085	59,767	64%
Photochemical ozone creation potential	kg C2H4 equivalents	121,043	45,367	63%
Mineral depletion	kg Sb equivalents	8,014,392	8,014,425	0%
Fossil fuel depletion	MJ net calorific value	5,144,270,345	2,451,498,248	52%
		Cumulative impact reduction		327%
		Cumulative reduction points		6.00
		Additional impact reporting		1.00
		Points awarded		7.00

The greenhouse gas (GHG) emissions by life cycle stage are shown below in Figure ES.1. Over 60 years of building life time assumed for the life cycle model, operational energy dominates GHG emissions as well as the other mandatory impact categories. Due to energy efficiency and supply of low carbon energy through the tri-generation plant, the proposed building achieves a 69% reduction in operational GHG emissions and a 64% reduction in whole of life GHG emissions.

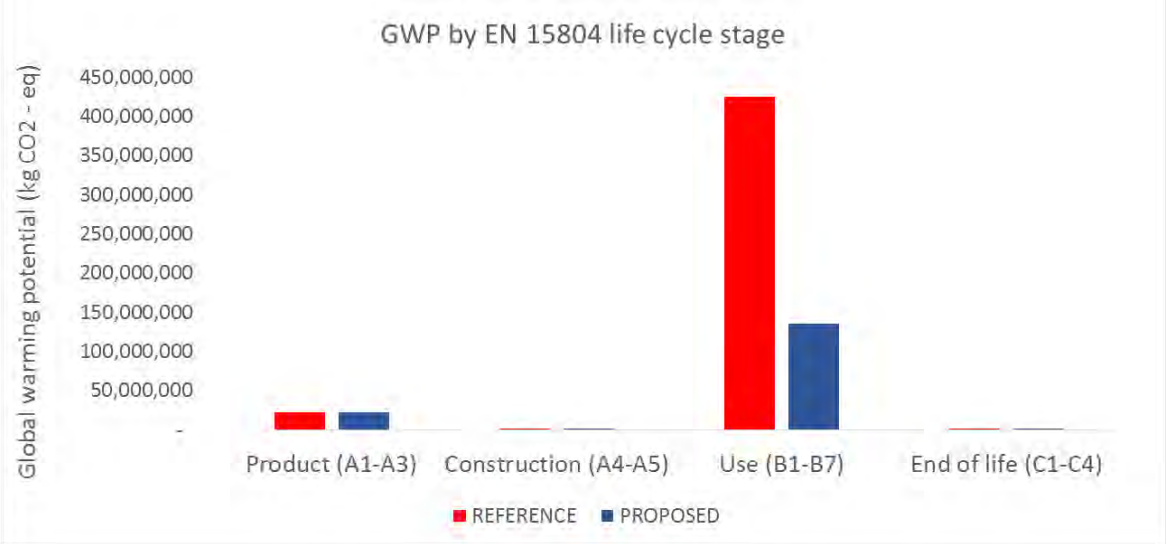

Figure ES.1 Greenhouse gas emissions by life cycle stage

INTERPRETATION

The significant life cycle impact reduction is achieved primarily through the supply of low emission energy from the central tri-generation energy plant. This results in 72% reduction in carbon emissions and global warming potential (GWP) per kWh electricity supplied, as well as significant reduction in emissions causing acidification, eutrophication, photochemical ozone creation potential and fossil fuel resource depletion.

SENSITIVITY ANALYSIS

The LCA model has been tested under the scenario of omitting tri-generation, and utilising a traditional central energy plant with energy supply assumptions used for the Green Star reference building. This assumes a central boiler for hot water and all cooling and electrical loads supplied by grid electricity. This results in a 50% reduction in operational GHG emissions and a 47% reduction in whole of life GHG emissions.

The total cumulative reduction across the 7 mandatory impact categories is 230%, which is well beyond the 130% threshold meaning that the full 7 credit points (6 + 1 additional impact reporting) are still achieved.

OPPORTUNITIES

To achieve further reductions on life cycle impacts it is recommended that the project:

- → Procure concrete with a high portion of Supplementary Cementitious Material (SCM) e.g. 30%
- → Procure structural and reinforcing steel with high recycled content and preferably an Environmental Product Declaration (EPD) which will also allow points to be claimed under credit 21 (Sustainable Products)

ENVIRONMENTAL INDICATORS

The Green Star mandatory environmental indicators used for Credit 19A are explained below in Table ES.2. Points are awarded based on a projects ability to demonstrate a percentage reduction on each environmental indicator when compared to a reference building.

Table ES.2 Description of mandatory indicators

Environmental Indicator		Unit	Description
	Global Warming Potential [a]	kg carbon dioxide equivalents	Increase in the Earth's average temperature, mostly through the release of greenhouse gases. A common outcome of this is an increase in natural disasters and sea level rise.
	Ozone Depletion Potential [b]	kg CFC-11 equivalents	The decline in ozone in the Earth's stratosphere. The depletion of the ozone layer increases the amount of UVB that reaches the Earth's surface. UVB is generally accepted to be a contributing factor to skin cancer, cataracts and decreased crop yields
	Acidification Potential [c]	kg sulphur dioxide equivalents	A process whereby pollutants are converted into acidic substances which degrade the natural environment. Common outcomes of this are acidified lakes and rivers, toxic metal leaching, forest damage and destruction of buildings
	Eutrophication Potential [c]	kg phosphate equivalents	An increase in the levels of nutrients released to the environment. A common outcome of this is high biological productivity that can lead to oxygen depletion, as well as significant impacts on water quality, affecting all forms of aquatic and plant life.
	Photochemical Ozone Creation Potential [c]	kg ethylene equivalents	Ozone in the troposphere is a constituent of smog that is caused by a reaction between sunlight, nitrogen oxide and volatile organic compounds (VOCs). This is a known cause for respiratory health problems and damage to vegetation.
	Abiotic Depletion Potential – Elements /minerals [c]	kg antimony equivalents	The extraction of non-living and non-renewable elements and minerals. These resources are essential in our everyday lives and many are currently being extracted at an unsustainable rate.
	Abiotic Depletion Potential – Fossil Fuels [c]	MJ net calorific value	The extraction of non-living and non-renewable fossil fuels. These resources are essential in our everyday lives and many are currently being extracted at an unsustainable rate.

1 PROJECT BACKGROUND

1.1 Project overview

The Star Entertainment Group Limited (SEGL) is a leading operator of integrated resorts catering to both local and international visitors and is the operator of The Star Sydney (The Star). Consistent with The Star's licence obligation to operate the site to an international standard, SEGL is proposing to advance a revitalisation of the existing complex.

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1.1.1 Building location

The building is located on the existing site of The Star, Sydney (80, Pyrmont Road, Pyrmont, NSW) as shown in Figure 1.1.

Figure 1.1 The Star Sydney site

1.1.2 Area schedule

Presented below in Table 1.1 is the area schedule for the project.

Table 1.1 The Star Ritz Carlton Hotel and Residential Tower Area Schedule

Building use	Gross floor area (m2)
Community	1,294
Retail	42
Ritz-Carlton hotel	17,486
Apartments	22,051
Total	**41,924**

1.2 Objective

The project is targeting a 5 Star Green Star Design & As Built rating and has nominated to target credit 19A (Life Cycle Assessment). There are seven (7) points available under credit 19A (LCA). To claim this credit, the project will:

- Conduct a whole of building LCA for the proposed building which follows EN 15978 guidance and undergo an ISO 14040 compliant independent peer reviewed.
- Compare the whole of life impacts over seven (7) mandatory impact categories between the proposed building and a reference building. The points are awarded on a sliding scale for demonstrating cumulative reduction over the mandatory impact categories. Cumulative impact reduction is rewarded with one point for 30% reduction a further point for each 20% reduction beyond 30%, up to 130% and a maximum of 6 points (although points may also be available for exceeding this benchmark under innovation).
- Report on the optional additional six (6) impact categories. One additional point is awarded for reporting on the additional impact categories.

2 METHODOLOGY

The methodology for this study is governed by the Green Star Design & As Built requirements for credit 19A (Life Cycle Assessment). This requires that an EN 15804 and EN 15978 compliant methodology is followed, as described in sections 2.1 - 2.3. The Green Star Design and As Built Submission Guidelines also stipulate specific requirements for:

- the definition of reference building as described in section 2.4 and Appendix B.
- the life cycle impact assessment (LCIA) categories as described in section 2.5

2.1 Definition of goal and scope

The goal and scope defines the functional unit and has implications for the physical scope of the processes included as well as the timescale spanned by the study.

2.2 Definition of functional unit and system boundary

Based on the goal and scope definition, a diagram of the system is drawn. The system boundary identifies the aspects that lie inside or beyond the scope of the study and determines what to measure at the next step.

2.3 Life cycle inventory (LCI)

2.3.1 Data quality

ISO 14040 provides the following requirements for data quality in the LCI:

- **Relevance:** select sources, data and methods appropriate to assessing the chosen product's LCI;
- **Completeness:** include all LCI items that provide a material's contribution to a product's life cycle emissions;
- **Consistency:** enable meaningful comparisons in life cycle impact assessment (LCIA) information;
- **Accuracy:** reduce bias and uncertainty as far as is practical; and
- **Transparency:** when communicating, disclose enough information to allow third parties to make decisions.
- **Time coverage:** the data collected represents recent practice for the construction of the project.
- **Geographical coverage:** the data collected are representative of the sourcing of materials, whether from Australia or overseas, and are in line with the goal of the study

2.3.2 Inventory of inputs and outputs

The life cycle inventory (LCI) consists of the input or output flows that cross the system boundary. These measurements include the inputs of energy, water, raw materials consumed, manufactured materials or products consumed and the outputs of products/services, co-products, atmospheric emissions, waterborne emissions and solid wastes generated. Life cycle data has primarily been sourced from project specific information, complemented by relevant literature and engineering estimates to complete the whole building and whole of life assessment.

2.3.3 Allocation for co-products

EN 15978 refers to EN 15804 for specific calculations of impacts, which includes the allocation of impacts between co-products. According to EN 15804, allocation should be avoided as far as possible by dividing the unit process into different sub-processes that can be allocated to the co-products and by collecting input and

output data related to these sub-processes. If a process cannot be sub-divided, then the following hierarchy applies for allocation of inputs and outputs between co-products:

- Based on physical properties (e.g. mass, volume) when difference in revenue is low;
- Based on economic value;
- Material flows carrying specific inherent properties e.g. energy content, elementary composition, shall always be allocated reflecting the physical flows.

Where background data does not meet EN 15804 requirements ISO 14044 allocation rules shall be followed. The background data selected for this study has been chosen in a hierarchy that best meets EN 15804 requirements.

The site tri-generation system planned for The Star includes a combined heat and power plant (CHP) in combination with absorption and electric chillers. The CHP plant will generate electricity as a primary product, with heat and chilled water (from an absorption chiller) generated as co-products. The preliminary energy modelling indicates there will be a surplus of heat generated throughout the year when looking at the demand profile for the Ritz Carlton Hotel and Residential Tower.

It is assumed that all energy demand of the Ritz Carlton Hotel and Residential Tower will be met by the CHP plant. Taking a conservative approach, the impacts of gas combustion in the CHP plant are allocated 100% to the Ritz Carlton and Residential Tower, with no burden allocated to the excess heat that may or not be utilised elsewhere in The Star site. For inventory details and assumptions for operational energy, see section 4.3.5.

2.3.4 Allocation procedures for reuse, recycling and recovery

The potential impacts reuse, recycling and recovery under EN 15804/15978 are reported in Module D as potential loads and benefits outside the system boundary. Where a material flow exits the system boundary and has an economic value or has reached the end-of-waste criteria and substitutes another products, then the impacts (loads and benefits) may be calculated and shall be based on:

- Average existing technology;
- Current practice;
- Net impacts.

2.3.5 Background data

The background data used is taken from GaBi 6 LCA software from the GaBi Professional Database and the Construction Materials extension database. The Gabi databases contain mostly EN 15804 compliant processes suitable for whole building life cycle assessment.

GABI PROFESSIONAL DATABASE

The GaBi Professional Database contains a large amount data, the complete ELCD database as well as data from Plastics Europe. It includes 3,560 processes, predominantly cradle-to-gate, as well as parameterised unit processes, including:

- organic and inorganic chemicals
- metals
- plastics
- wood and wood products
- power generation
- transport

- production techniques
- end of life processes

GABI CONSTRUCTION MATERIALS DATABASE EXTENSION

The GaBi Building & Construction Materials Database contains 3,124 processes, including; additives, glue, concrete, mortar, plaster, paints, lightweight aggregate concrete, brick, foam mortar, lime sand brick, building slabs, wood, insulating material, heat insulating bonding systems, metals, plastics, windows, lighting and plumbing, heating and ventilation, elevators and many more.

2.3.6 Criteria for the exclusion of inputs and outputs

It should be noted that this LCA is based on an early concept design and is in the absence of detailed design, procurement and construction information. For this reason the study will exclude many building elements and inputs that will not be known until a later stage in the design process. It is the intent that this study will be updated during the detailed design and construction phase to include more detail in the model.

For significant building elements not included in the current design (e.g. external façade specification and hotel fitout materials) a reasonable estimate for materials has been used. See section 2.3 for detail for how the Life Cycle Inventory was compiled.

According to EN15978 (2011), the assessment shall represent accurately the quantification of the building and scenarios used at the time of the assessment. The criteria for the exclusion of inputs and outputs for the environmental indicators based on this description of the object of the assessment shall follow the rules according to EN 15804.

It is common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a threshold % of the total, but with the exception that where the input/output has a “significant” impact it should be included.

It should be noted that the transport of construction equipment has been excluded from the LCA study as exact information was unknown at the time of the study and the environment impact of the construction equipment transport will be negligible.

Due to insufficient information being available on the use of refrigerants in chillers for the the Ritz Carlton Hotel and Residential Tower, these have been excluded from the current study. This is deemed not to effect the results since no reduction is being claimed, and the reference building would be assumed to have the same or worse refrigerant leakage due to a higher cooling demand.

2.4 Definition of t he reference buil ding

The Green Star Design & As Built credit 19A requires that the reference building is defined as either:

1. Standard Practice Reference Building – A hypothetical building that represents standard contemporary construction practices
2. Actual Reference Building – A building constructed in the last five years and is similar in use, construction and operation to the project.

The project applies option 1 – Standard Practice Reference Building. The detailed Standard Practice Reference Building definition is given in Appendix B.

2.5 Life cycle impact assessment

The life cycle impact assessment results were calculated in GaBi Professional LCA software. Green Star Design & As Built stipulates a set of mandatory and optional additional impact categories. The mandatory impact categories are presented in Table 2.1. A list of the optional additional impact categories are presented in Table 2.2.

Table 2.1 Green Star mandatory impact categories

Impact category	Unit	Method
Global Warming Potential (GWP)	kg CO_2 equivalents	CML (v4.2) based on IPCC AR4
Ozone Depletion Potential (ODP)	kg CFC-11 equivalents	CML (v4.2) based on WMO 1999
Acidification Potential	kg SO_2 equivalents	CML (v4.2)
Eutrophication Potential	kg PO_4^{3-} equivalents	CML (v4.2)
Photochemical Ozone Creation Potential (POCP)	kg C_2H_4 equivalents	CML (v4.2)
Abiotic Resource Depletion Potential (elements)	kg Sb equivalents	CML (v4.2)
Abiotic Resource Depletion Potential (fossil fuels)	MJ net calorific value	CML (v4.2)

Table 2.2 Green Star additional impact categories

Impact category	Unit	Method
Human Toxicity Cancer	CTUh	USE Tox (v1.00)
Human Toxicity Non-Cancer	CTUh	USE Tox (v1.00)
Land Use - Land Transformation	m^2	UNEP/SETAC Land Use Indicator Value Calculation in Life Cycle Assessment
Water Stress Indicator	m^3 water use related to local scarcity of water	Hoekstra et al (2012) – found in SimaPro Water Footprint methods database
Ionising Radiation	kg U^{235} equivalent to air	CML (v4.2)
Particulate Matter	kg PM2.5 equivalent	ReCiPe (v1.10) based on RiskPoll

2.6 Independent peer review

For the Green Star As Built submission, the LCA must be peer reviewed by an independent agent as stated in ISO 14044 6.1 and 6.2; it must be clear that the LCA report submitted by the project is the same LCA report to which the peer reviewer has provided a favourable opinion. This should include a reference to the report name and date by the peer reviewer that corresponds with the LCA report submitted.

The LCA must be peer reviewed by an independent practitioner as stated in ISO 14044 Clauses 6.1 and 6.2. The ISO 14044 Standard requires critical LCA reviews to be performed and this provides an assurance of the credibility of the LCA and its results. In general, the peer review shall include investigation of whether:

- The methods used to carry out the LCA are consistent with ISO 14040 and 14044.
- The methods used to carry out the LCA are scientifically and technically valid.
- The data used are appropriate and reasonable in relation to the goal of the LCA.
- The interpretations reflect the limitations identified and the goal of the LCA.
- The LCA report is transparent and consistent.

The peer review statement must also confirm that the LCA report that has been reviewed is the same LCA report (including any revisions) that has been provided for assessment.

3 GOAL AND SCOPE DEFINITION

3.1 Goal of the study

The immediate objectives for the LCA are to measure and benchmark the Project's whole of life environmental impact and to determine the credit points to be achieved under credit 19A for the Green Star rating. Due to the design being in the early stages, the study is not aimed at being an exact representation of the Ritz Carlton Hotel and Residential Tower for which the design is to be developed over the coming months. The study instead aims to inform the design team of life cycle impacts and opportunities for improvement throughout the design process.

The intended audience of the LCA study results are SEGL and the GBCA. The comparative LCA results are not intended to be disclosed publicly.

3.2 Scope

The scope of the LCA is that defined by EN 15804 and particular calculation rules are set out in EN 15978. These are summarised below in Table 3.1.

Table 3.1 EN 15804 whole of building LCA scope

Life Cycle Stage	Module	Description
Product Stage	A1	Raw material supply
	A2	Transport
	A3	Manufacturing
Construction Stage	A4	Transport
	A5	Construction and installation processes
Use Stage	B1	Material emissions from usage
	B2	Maintenance
	B3	Repair
	B4	Replacement
	B5	Refurbishment
	B6	Operational energy
	B7	Operational water use
End of Life Stage	C1	Deconstruction and demolition
	C2	Transport
	C3	Waste processing
	C4	Disposal
Benefits and loads beyond the building lifetime	D	Reuse, recycling and recovery

3.3 Functional unit

The functional unit used to compare the proposed and reference building is one m^2 of Gross Floor Area (GFA) from cradle to grave over 60 years. This is the unit to which impact assessment results must be reported under the Green Star Design & As Built rating tool.

4 LIFE CYCLE INVENTORY

4.1 Product stage (Module A1-A3)

Prior to planning approval, the following sources of information have been used:

- Structural estimates from structural engineers
- Schedule from building service engineers
- Concept design drawings

During the detailed design stage, the life cycle inventory will be amended to include a detailed bill of quantities (BOQ). At this early stage, all materials apart from central energy plant are assumed to be identical for the reference and proposed buildings.

A detailed life cycle inventory is given in Appendix A.

4.1.1 Structure

The summary of structural material estimates is shown below in Table 4.1. The assumptions were based on a similar design for a residential building.

Table 4.1 Structural materials estimates

Floor Type	Concrete Strength Grade (MPa)	Est Concrete Per GFA (m3/m2)	Est Total Concrete (m3)	Est Total Reinforcing Steel (kg)
Foundations	80	0.24	230	82,558
Basement	80	1.40	5,259	548,854
G - L9	80	0.72	1,689	188,003
L10-40	65	0.53	11,623	1,320,927
L41-60	40	0.53	9,310	1,058,073
Total		**0.61**	**28,110**	**3,198,416**

4.1.2 External façade

A total external façade area of 21,798 m2 was taken from the 3D energy model developed in EDSL TAS v9.4. The façade design is not yet fully developed, as such a typical normalised mass of material per m^2 from a high rise tower was used as a benchmark.

Table 4.2 Material assumptions for external facade

Material	Mass (kg/m2)
Glazing (Heat strengthened laminated low-E coated DGU)	23.0
Structural silicone	2.21
Tremco sealant – Dymonic FS-DS	0.537
Aluminium framing	11.1
Aluminium flashings & cappings	4.44
Aluminium louvres	0.22
Insulation (glass wool)	2.22
Steel structural elements (e.g. secondary support and ancillaries)	2.22
Stainless steel elements	1.11

4.1.3 Mechanical services

The material and equipment required for mechanical services were taken from a schematic design developed for typical hotel and residential floors, and used to estimate the total material and equipment required for total hotel and residential floor area in the building. Since mechanical detail for community and other areas in the building have not yet been developed, these have not been included.

Table 4.3 Inventory of steel ductwork (Including hangers, support, fixings etc) for hotel and residential floors

Area	Description	Dimension	Length (m)	Mass per unit length (kg/m)	Mass (kg)
Hotel	Guestroom Vent	200x200	4,800	5	24,000
	Guestroom AC Duct	1000x300	1,600	14	22,400
	Common Area Ducts	300x300	600	7	4,200
	Vent Risers	1300x1300	770	60	46,200
	Smoke Risers	1000x1000	140	47	6,580
	Kitchen Riser	1200x1200	70	55	3,850
Residential	Resi Vent	200x200	9450	5	47,250
	Resi AC Ducts	1000x300	1050	14	14,700
	Common Area Ducts	300x300	900	7	6,300
	Vent Risers	1300x300	105	20	2,100
	Smoke Risers	1000x1000	210	47	9,870

Area	Description	Dimension	Length (m)	Mass per unit length (kg/m)	Mass (kg)
	Kitchen Riser	1200x1200	105	55	5,775

Table 4.4 Inventory of steel ductwork (Including hangers, support, fixings etc) for podium and basement areas

Area	Area (GBA)	Rate (m/m2)	Length (m)	Mass per unit length (kg/m)	Total Weight (kg)
Podium	5040	0.642	3235.68	7.3	23,620
Basement	850	0.214	181.9	7.3	1,328

Table 4.5 Inventory of steel pipework (including hangers, supports, fixings etc.)

Area	Average Size of pipework	Length (m)	Mass per unit length (kg/m)	Total Weight (kg)
Hotel	50dia	6000	5.1	30,600
Residential	50dia	9000	5.1	45,900
Risers	100dia	880	12.1	10,648

The following mechanical services were also included in the inventory (see Appendix A for full detail):

- Chilled/Heating Fan Coil Units (inc cooling coil, heating coil, filtration)
- Air Handling Units (inc cooling coil, heating coil, filtration)
- Water-Water Plate Heat Exchangers
- Pumps
- Ventilation Fans

4.1.4 Electrical services

Typical electrical services drawings were unavailable at this stage and past project benchmark data was used to assume rates of material required for electrical services per unit area. The rates and total quantities assumed are shown below in Table 4.6.

Table 4.6 Inventory assumptions for electrical services

Description	Material rate	Unit	Total quantity assumed	Unit
Cable Trays - Communication	0.12	m/m2	4,972	m
Cable Trays - Power	0.18	m/m2	7,450	m
Cables - Communication	1.07	m/m2	44,749	m
Cables - Power	1.60	m/m2	67,054	m
Lights - Flourescent	0.09	#/m2	3,951	#

Description	Material rate	Unit	Total quantity assumed	Unit
Lights - downlights	0.05	#/m2	1,983	#

4.1.5 Vertical transport

There are 6 lift cores included in the Ritz Carlton Hotel and Residential Tower which service each floor apart from level 60 which is services by only 4 elevators. Lifts were modelled using GaBi background data based on total equipment required per floor per lift (including lift, counterweight, all structure and framing). For more detail see Appendix A.

4.1.6 Internal walls and floors

Internal walls were assumed to be two sided plasterboard with standard timber framed hob wall construction. All timber was assumed to be 190 x 35 mm softwood and nails galvanised steel. Stud spacing was assumed to be at 450mm and noggins at 1200mm. The total mass of material per square meter of internal wall is shown in Table 4.7. The internal wall area for a typical residential floor was measured to be approximately 377 m^2 and multiplying by 60 floors the total for the whole building assumed to be 22,626 m^2.

Table 4.7 Inventory of internal hob walls

	Mass per m2 wall area
Timber	13.38
Timber nails	0.051
Plasterboard	36

Internal floors were assumed to be 50% carpet, 25% ceramic tiled and 25% parquet timber material.

4.2 Construction process (Module A4-A5)

4.2.1 Material supply (A4)

Specific suppliers and sources are not known during the early design stage, as such typical transport distance assumptions for projects in Sydney shown in Table 4.8 will be used for transport distance to site. These align with what is used in the Transport for NSW Carbon Estimation and Reporting Tool (CERT) (Transport for NSW, 2015). For all material not included in the CERT, a conservative estimate of 150km articulated truck and 8,250 km shipping has been assumed. The total assumed mass and distance transported by each mode is shown in Table 4.9.

Table 4.8 Transport distance and mode assumptions for materials

Material	Reference Building mass (tonnes)	Proposed Building mass (tonnes)	Articulated truck (km)	Rigid Truck (km)	Ship (km)
Sand and aggregate			60		
Concrete, in-situ	67,464	67,464		40	
Concrete, precast				150	

Material	Reference Building mass (tonnes)	Proposed Building mass (tonnes)	Articulated truck (km)	Rigid Truck (km)	Ship (km)
Pavement			50		
Steel	3,240	3,240	150		
Aluminium /Glazing / Facade	1,242	1,242		150	8250
Plant and building services equipment	801	801		500	2500
Other	2,579	2,579	150		8250

Table 4.9 Total material transport to site by mode (t.km)

Transport mode	Reference Building	Proposed Building
Rigid truck (t.km)	4,187,292	4,187,292
Articulated truck (t.km)	889,118	889,118
Train (t.km)	-	-
Ship (t.km)	16,750,723	16,750,723

4.2.2 Construction / installation (A5)

Monitoring will ensure that construction energy is sub-metered and measured during the construction phase. For the early design calculations the following assumptions estimations (Table 4.10) have been used as an approximation. The total amount of concrete pumping and excavation have been modelled using process data available in GaBi (see Appendix A for details).

Table 4.10 Construction assumptions

Construction input	Rate	Source
Construction energy - concrete pumping	28,110 m3	WSP estimate of total concrete volume
Construction energy - excavation	40,000 m3	WSP estimate
Construction energy - other	215 MJ/m2 GFA Assumed 70% diesel and 30% electricity	*Energy and greenhouse gas emissions association with the construction of alternative structural systems* (Cole, 1998)
Construction water	0.000257 m3/week/m2 GFA	Report on *Auditing of water use on construction sites* (WRAP, 2011)

Building material waste was assumed to be 5% of all materials supplied to site with NSW average recycling rates as given in section 4.4.

4.3 Building use (Module B1-B7)

4.3.1 Material Emissions (B1)

Material emissions are considered to be negligible for a building and are not included in this study.

4.3.2 Maintenance (B2)

The maintenance considerations for the building included are:

- → cleaning of internal floors and external windows
- → painting of internal walls

The cleaning assumptions for internal floors and windows are have been taken from literature estimates. Where a range has been given the high end of the range has been taken as a conservative estimate. The cleaning inputs are shown below in Table 4.11. Both hard surface floors (e.g. tiles and vinyl flooring) and carpeted areas are assumed to be 50% of the total GFA. The total glazed area was assumed to be the complete external façade area of 21,798 m^2 as a conservative estimate.

Table 4.11 Cleaning inputs for internal floors and windows

	Hard surface flooring	Carpets	Windows
Area (m2)	20,962	20,962	21,978
Water for wet cleaning (m3/m2/clean)	0.002[a]		0.002[a]
Cleaning agent, e.g. soap (kg/m2)	0.04[a]		0.04[a]
Electricity for vacuuming (kWh/m2)	0.0053	0.0053[b]	
Maintenance frequency	Weekly	Weekly	Monthly

Notes: a – Sourced from Dal-Tile Ceramic Tile EPD (assumed windows use same water and cleaning agent as hard floors) (Dal-tile Corporation, 2014), b – Sourced from Interface Carpet Tile EPD (Interface, 2016).

4.3.3 Repairs (B3)

It is assumed that 5% repair over 60 years for all materials in A1-A3 will be required.

4.3.4 Replacement & Refurbishments (B4 & B5)

Replacement of key materials and equipment was considered using advice from the Mechanical Engineer and conservative assumptions. The design life assumptions for plant and mechanical equipment is given below in Table 4.12.

Table 4.12 Design life for mechanical services

Element	Design Life (years)
Tri-gen plant	15
Boilers	25
Electric chillers	25
Absorption chillers	25
Ductwork	20
Steel pipework	20
Fan Coil Units	20
Air Handling Units	20
Heat exchangers	20
Pumps	20
Ventilation Fans	15

4.3.5 Operational Energy (B6)

A 3D energy model has been developed in EDSL TAS v9.4 to give the demand profile for the reference and proposed buildings (given below in Table 4.13). For key assumptions behind the energy modelling see the Green Star Energy Modelling Report (2305180U-ESD-REP-03-Rev0).

Table 4.13 Energy demand by end use for proposed and reference building

	Reference building	Proposed building	Proposed reduction (%)
HVAC			
Heating (MJ/year)	1,494,964	3,097,115	-107%
Cooling (kWh/year)	645,401	340,431	47%
Heat rejection (kWh/year)	200,089	149,965	25%
Air Conditioning Fans (kWh/year)	4,323,989	1,325,795	69%
Mechanical Ventilation Fans (kWh/year)	-	-	
Pumps (kWh/year)	185,053	143,344	23%
Services			
Domestic Hot Water (MJ/year)	5,240,886	6,170,078	-18%

	Reference building	Proposed building	Proposed reduction (%)
DHW Circulators and Controls (kWh/year)	-	-	
DCW Pumps and Controls (kWh/year)	-	-	
Lifts (kWh/year)	107,900	107,900	0%
Artificial Lighting – Internal (kWh/year)	842,077	521,092	38%
Artificial Lighting – External (kWh/year)	68,836	17,209	75%
Appliances (kWh/year)	388,020	388,020	0%

SEGL is installing a tri-generation plant to service The Star site. This consists of a total 8MWe capacity in a modular system of 1MWe units. The peak demand for the Ritz Carlton Hotel and Residential Tower is expected to be 2MWe. The total energy consumption and generation assumptions (given in Table 4.14) for the proposed and reference buildings were developed using a dynamic system model.

The proposed building energy demand is assumed to be met entirely from gas supply to the CHP, and any surplus heat not used in the Ritz Carlton Hotel and Residential Tower is assumed to be wasted (see section 2.3.3 for treatment of allocation). See section 5.3.1 for a sensitivity analysis to test the omission of a tri-generation system for the proposed building.

Table 4.14 Annual energy consumption proposed and reference building

Use	Reference Building	Proposed Building
Grid electricity (kWh/year)	6,761,365	0
Natural Gas (MJ/year)	6,735,850	33,417,000

4.3.6 Operational Water (B7)

The total potable water consumption has been estimated using the Green Star Potable Water Calculator. The total demand profile is given in Table 4.15.

Table 4.15 Potable water consumption for proposed and reference buildings

Use	Reference Building water demand (kL/year)	Proposed Building water demand (kL/year)
Toilets	4,431.6	5,064.6
Urinals	0.0	1,947.9
Indoor taps	2,739.3	2,739.3
Showers – Occupants	54,524.4	46,735.2
Showers – Sports facilities	0.0	0.0
Washing machines	3,004.7	4,292.4
Dishwashers	84.0	0.0
Heat rejection	0.0	7,255.6
TOTAL	64,783.9	68,035.0

4.4 End of life (Module C1-C4)

4.4.1 Demolition & Deconstruction (C1)

For demolition and deconstruction diesel consumption from operation of machinery was considered. An assumption was made from the Road Greenhouse Gas Assessment Handbook 2011 assuming that 4.8L of diesel was required per m2 GFA (TAGG, 2013), making a total of over 201,235 L for complete deconstruction and demolition.

4.4.2 Transport of waste (C2)

It is assumed that all demolition waste will require 50km of transport by rigid truck to waste processing or disposal and landfill. The total waste transport required at end of life is shown in Table 4.16.

Table 4.16 Transport required to waste treatment at end of life (t.km)

	Reference Building	Actual Building
Waste transport (t.km)	3,785,402	3,785,402

4.4.3 Waste processing (C3) and waste disposal (C4)

For the eventual construction and demolition waste generated from demolition of the building the recycling rates in Table 4.17 are assumed (DSEWPC, 2012).

Table 4.17 Recycling rates for construction and demolition waste in NSW 2011

Material	Recycling rate
Masonry	60%
Metals	89%
Organics	34%
Paper & Cardboard	61%
Plastics	23%
Glass	67%
Average of all waste	59%

4.5 Benefits and loads beyond the building lifetime (Module D)

The potential benefits and loads beyond the building life time have not been included in this study.

5 LIFE CYCLE IMPACT ASSESSMENT RESULTS

Figure 5.1 below shows the global warming potential (GWP) contribution across the life cycle stages. The overwhelming majority of GWP is caused by operational energy consumption during the Use Stage over the 60 year building life time. The Product Stage contributes a significant amount with 14% contribution in the proposed building and 5% contribution for the reference building.

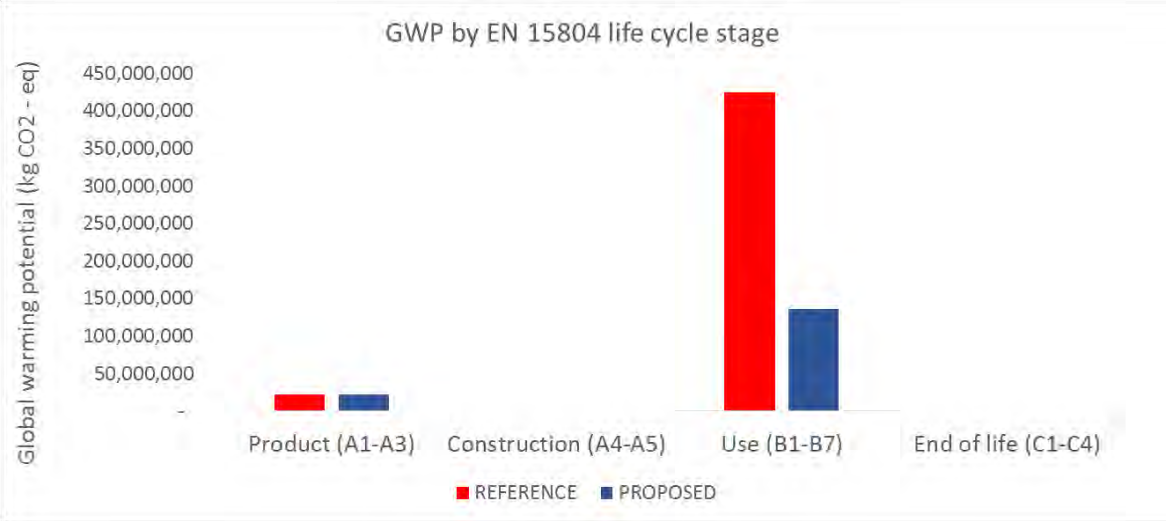

Figure 5.1 Relative impact reduction from reference to proposed building across 7 mandatory categories

The GWP contribution by materials for the Product Stage is shown below in Figure 5.2.

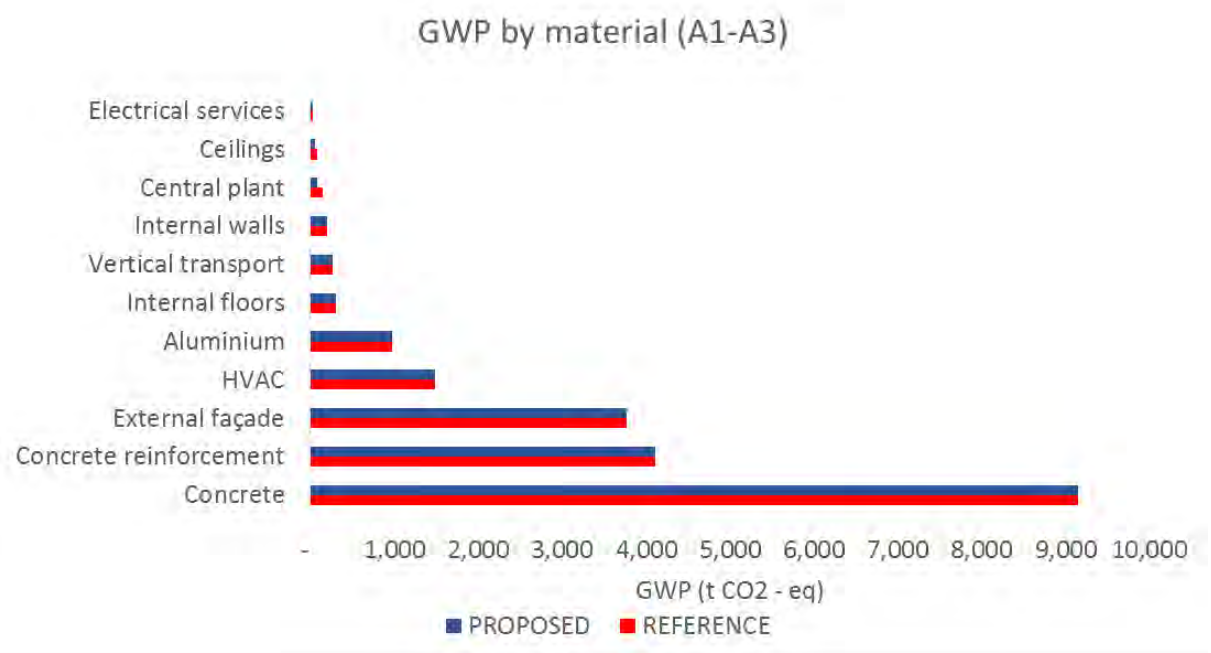

Figure 5.2 Global Warming Potential contribution from materials to the Product Stage (A1-A3)

5.1 Whole building results

Table 5.1 and Table 5.2 give the whole building life cycle impact assessment results for reference and proposed buildings respectively.

Table 5.1 Reference building results (whole building)

Impact category	Product (A1-A3)	Construction (A4-A5)	Use (B1-B7)	End of life (C1-C4)	Beyond the building lifetime (D)	Total
GWP (kg CO2 eq)	22,326,191	573,741	425,210,576	1,386,187	MND	449,496,695
ODP (kg CFC-11 eq)	0.400	3.04E-06	0.296	3.49E-05	MND	0.696
AP (kg SO_2 eq)	58,028	9,356	1,759,308	5,330	MND	1,832,021
EP (kg PO_4^{3-} eq)	6,241	1,280	155,438	2,126	MND	165,085
POCP (kg C_2H_2 eq.)	24,541	-269	96,940	-169	MND	121,043
AD-e (kg Sb eq.)	7,630,328	0.022	381,657	2,407	MND	8,014,392
AD-f (MJ)	126,325,655	4,587,575	5,003,046,759	10,310,356	MND	5,144,270,345

MND = Module Not Declared, GWP = Global Warming Potential, ODP = Ozone Depletion Potential, AP = Acidification Potential, EP = Eutrophication Potential, POCP = Photochemical Ozone Creation Potential, AD-e = Abiotic Depletion – elements, AD-f = Abiotic Depletion – fossil fuels

Table 5.2 Proposed building results (whole building)

Impact category	Product (A1-A3)	Construction (A4-A5)	Use (B1-B7)	End of life (C1-C4)	Beyond the building lifetime (D)	Total
GWP (kg CO2 eq)	22,416,641	573,741	136,165,591	1,386,299	MND	160,542,272
ODP (kg CFC-11 eq)	0.40	3.04E-06	0.30	3.49E-05	MND	0.695
AP (kg SO_2 eq)	58,371	9,356	215,355	5,331	MND	288,412
EP (kg PO_4^{3-} eq)	6,274	1,280	50,087	2,126	MND	59,767
POCP (kg C_2H_2 eq.)	24,573	-269	21,233	-169	MND	45,367
AD-e (kg Sb eq.)	7,630,343	0	381,675	2,407	MND	8,014,425
AD-f (MJ)	127,473,419	4,587,575	2,309,125,375	10,311,879	MND	2,451,498,248

MND = Module Not Declared, GWP = Global Warming Potential, ODP = Ozone Depletion Potential, AP = Acidification Potential, EP = Eutrophication Potential, POCP = Photochemical Ozone Creation Potential, AD-e = Abiotic Depletion – elements, AD-f = Abiotic Depletion – fossil fuels

5.2 Normalised results (per m^2 GFA)

Table 5.3 and Table 5.4 give the normalised (per m2 GFA) life cycle impact assessment results for reference and proposed buildings respectively.

Table 5.3 Normalised Reference building results (per m^2 GFA))

Impact category	Product (A1-A3)	Construction (A4-A5)	Use (B1-B7)	End of life (C1-C4)	Beyond the building lifetime (D)	Total
GWP (kg CO2 eq)	533	14	10,142	33	MND	10,722

ODP (kg CFC-11 eq)	9.54E-06	7.26E-11	7.05E-06	8.33E-10	MND	1.66E-05
AP (kg SO_2 eq)	1.4	0.22	42	0.13	MND	44
EP (kg PO_4^{3-} eq)	0.15	0.031	3.7	0.051	MND	3.9
POCP (kg C_2H_2 eq.)	0.6	-6.42E-03	2.3	-4.03E-03	MND	2.9
AD-e (kg Sb eq.)	182	5.29E-07	9.1	0.057	MND	191
AD-f (MJ)	3,013	109	119,336	246	MND	122,705

MND = Module Not Declared, GWP = Global Warming Potential, ODP = Ozone Depletion Potential, AP = Acidification Potential, EP = Eutrophication Potential, POCP = Photochemical Ozone Creation Potential, AD-e = Abiotic Depletion – elements, AD-f = Abiotic Depletion – fossil fuels

Table 5.4 Normalised Proposed building results (per m^2 GFA)

Impact category	Product (A1-A3)	Construction (A4-A5)	Use (B1-B7)	End of life (C1-C4)	Beyond the building lifetime (D)	Total
GWP (kg CO2 eq)	534.70	14	3,248	33	MND	3,829
ODP (kg CFC-11 eq)	9.53E-06	7.26E-11	7.04E-06	8.33E-10	MND	1.66E-05
AP (kg SO_2 eq)	1.4	0.22	5	0.13	MND	7
EP (kg PO_4^{3-} eq)	0.15	0.031	1.2	0.051	MND	1.4
POCP (kg C_2H_2 eq.)	0.6	-6.42E-03	0.5	-4.04E-03	MND	1.1
AD-e (kg Sb eq.)	182	5.29E-07	9.1	0.057	MND	191
AD-f (MJ)	3,041	109	55,079	246	MND	58,475

MND = Module Not Declared, GWP = Global Warming Potential, ODP = Ozone Depletion Potential, AP = Acidification Potential, EP = Eutrophication Potential, POCP = Photochemical Ozone Creation Potential, AD-e = Abiotic Depletion – elements, AD-f = Abiotic Depletion – fossil fuels

5.3 Uncertainty and Sensitivity analysis

5.3.1 Proposed building central energy plant

The LCA model has been tested under the scenario of omission of the tri-generation central energy plant with energy supply assumptions used for the Green Star reference building. This assumes a central boiler for hot water and all cooling and electrical loads supplied by grid electricity as per the current traditional central energy plant. This results in a 50% reduction in operational GHG emissions and a 47% reduction in whole of life GHG emissions. The total cumulative reduction across the 7 mandatory impact categories is 230%

The GWP contribution by life cycle stage is shown below in Figure 5.3 and the over Green Star LCA results are shown in Table 5.5.

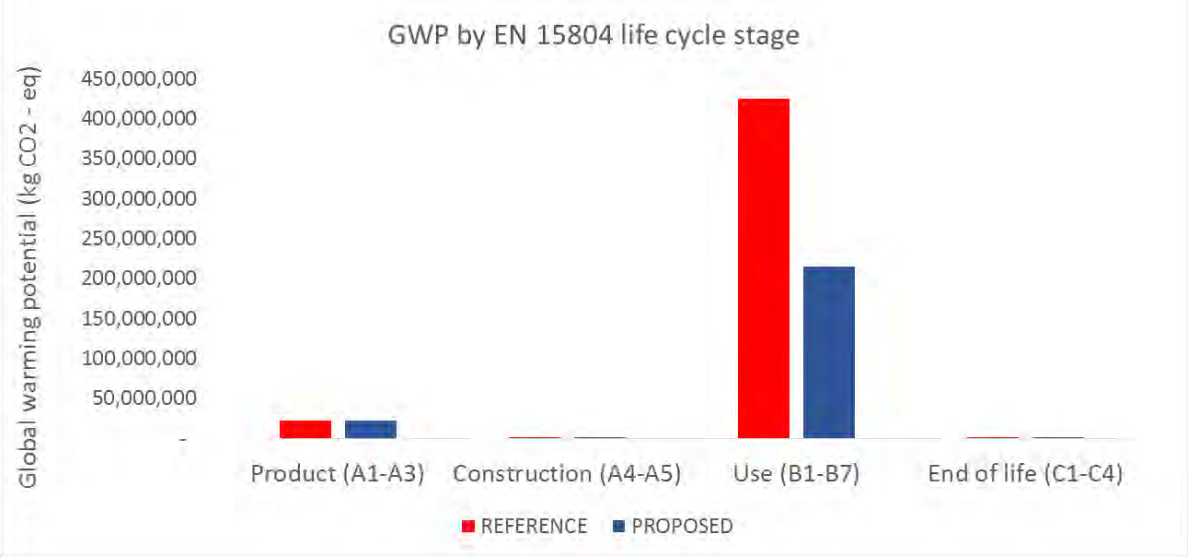

Figure 5.3 GWP contribution by life cycle stage (sensitivity omitting tri-generation plant)

Table 5.5 Green Star LCA results (sensitivity omitting tri-generation plant)

Impact category	Unit	Reference	Proposed (CEP)	Reduction
Climate change	kg CO2 equivalents	448,878,576	239,731,836	47%
Stratospheric ozone depletion	kg CFC-11 equivalents	0.70	0.69	0%
Acidification potential of land and water	kg SO2 equivalents	1,829,489	897,160	51%
Eutrophication potential	kg PO43- equivalents	164,854	88,438	46%
Photochemical ozone creation potential	kg C2H4 equivalents	120,833	72,006	40%
Mineral depletion	kg Sb equivalents	8,014,392	8,014,427	0%
Fossil fuel depletion	MJ net calorific value	5,135,020,236	2,812,979,222	45%

Cumulative impact reduction	**230%**
Cumulative reduction points	**6.0**
Additional impact reporting	**1.0**
Points awarded	**7.0**

6 OPPORTUNITIES

6.1.1 Portland cement substitution

Concrete and steel reinforcement used for the structure dominate the product stage (module A1-A3) impacts and also offer the greatest opportunity for impact reduction. If the proposed building targets an average 30% supplementary cementitious materials (SCM) in all concrete mixes across the project, an 8% reduction (1,966 tonnes of CO_2 –eq) can be made against the reference building product stage. The building material contribution to GWP and the reduction for concrete with 30% SCMS in the proposed building is shown in Figure 6.1.

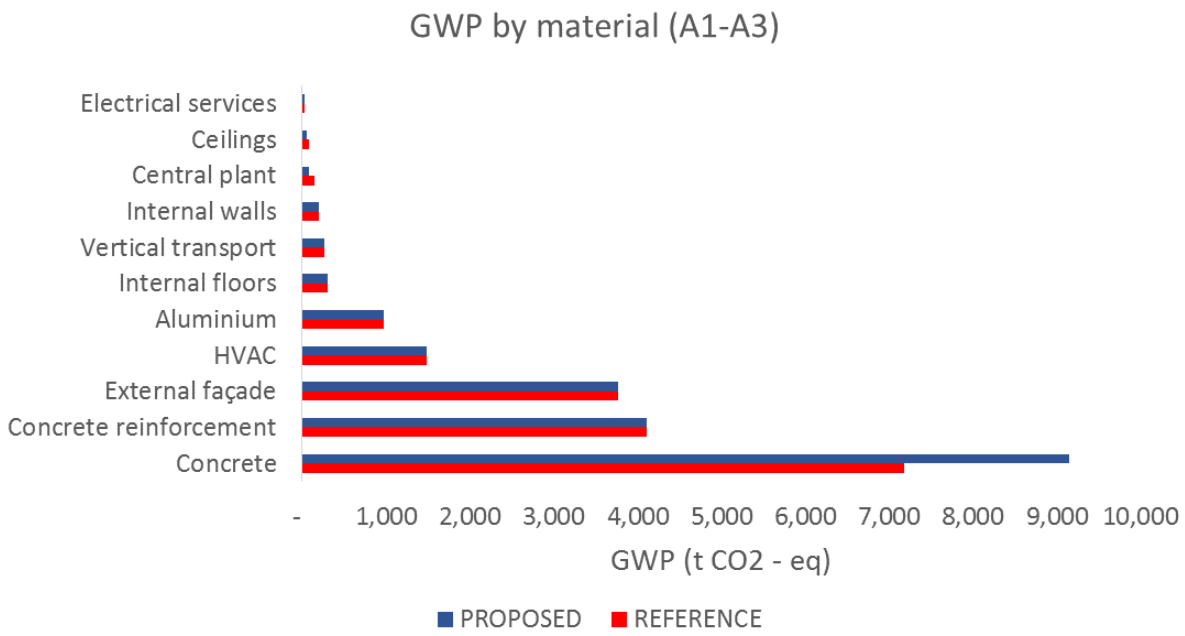

Figure 6.1 Building material contribution to GWP and potential reduction with 30% SCM concrete

6.1.2 Steel procurement

Procurement of steel with a high recycled content will help reduce life cycle impacts across all mandatory categories. There are reinforcing and structural steel products available in Australia with Environmental Product Declarations (EPD) that document a higher recycled content than business as usual. Procurement of products with EPDs also helps to claim points in credit 21 ‘Sustainable Products’.

7 LIMITATIONS

This preliminary LCA model is based on post design competition drawings as developed by FJMT. Since a detailed bill of quantities (BOQ) has not yet been developed, benchmark data from typical high rise projects and preliminary material estimates have been used for the building model. The basis for material estimations include:

- major structure (concrete and steel) estimates from WSP Structures
- mechanical services from WSP Mechanical Engineer
- plant equipment specifications and reference energy modelling assumptions
- lift cores, external façade, internal floors ceilings and walls estimated from the FJMT Plan Set provided following the design competition

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Appendix A

DETAILED LIFE CYCLE INVENTORY

A.1 DETAILED LIFE CYCLE INVENTORY

Table A.1 shows the detailed life cycle inventory for the product stage of the proposed building.

Table A.1 Detailed inventory for Product Stage (A1-A3)

Process	Quantity	Unit	Source
DE: Concrete C45/55 (A1-A3) VDZ-EPD	9,310	m3	GaBi
DE: Concrete C50/60 (A1-A3) VDZ-EPD	18,571	m3	GaBi
GLO: Steel rebar worldsteel	3,240,340	kg	GaBi
DE: Steel sheet HDG (EN 15804 A1-A3) ts <p-agg>	8,280	kg	GaBi
DE: Aluminium extrusion profile mix ts	99,380	kg	GaBi
EU-27: Air ventilation duct (zinc coated steel plate) (EN15804 A1-A3) ts <p-agg>	229,993	kg	GaBi
EU-27: Circulating pump 250-1000W (EN15804 A1-A3) ts <p-agg>	9	#	GaBi
EU-27: Circulating pump 50-250W (EN15804 A1-A3) ts <p-agg>	9	#	GaBi
EU-27: Electric heat pump (Water-Water) 70 kW (EN15804 A1-A3) ts <p-agg>	160	#	GaBi
EU-27: Steel pipe (EN15804 A1-A3) ts <p-agg>	102,183	kg	GaBi
EU-27: Ventilation system central 10.000 m3/h (EN15804 A1-A3) ts <p-agg>	10	#	GaBi
EU-27: Ventilation system central with heat recovery 1.000 m3/h (EN15804 A1-A3) ts <p-agg>	320	#	GaBi
EU-27: Cable 1 wire (EN15804 A1-A3) ts	45	km	GaBi
EU-27: Cable 3 wire (EN15804 A1-A3) ts	67	km	GaBi
EU-27: Fluorescent lamp T8 18W (EN15804 A1-A3) ts	3950.53	#	GaBi
EU-27: Fluorescent lamp T8 18W (EN15804 A1-A3) ts	1983.33	#	GaBi
Daiken Magnitude magnetic bearing centrifugal chiller	1023.64	Ton cooling capacity	Daiken EPD
EU-27: Gas low temperature boiler 120-400 kW (upright unit) (EN15804 A1-A3) ts <p-agg>	63.63	#	GaBi
EU-27: Elevator component (dependent on floor) (EN15804 A1-A3) ts <p-agg>	358	floors	GaBi
Nylon 6 Modular Carpet	41,924	m2	Interface EPD
Timber stud wall, 2 sided plasterboard (no insulation)	22,626	m2	GaBi custom assembly model

Table A.2 Detailed Life Cycle Inventory for the Construction Phase (A4-A5)

Process	Quantity	Unit	Source
EU-27: Articulated lorry transport ts	889,118	t.km	GaBi

EU-27: Lorry transport ts	4,187,292	t.km	GaBi
GLO: Container ship ts <u-so>	16,750,723	t.km	GaBi
EU-27: Excavated soil with digger (EN15804 A5) ts	40,000	m3	GaBi
DE: Pumping of concrete (EN 15804 A5) ts <p-agg>	28,110	m3	GaBi

Table A.3 Detailed Life Cycle Inventory for the Operational Phase (B6 & B7)

Process	Quantity	Unit	Source
AU: Thermal energy from natural gas ts	2,005,020	GJ	GaBi
EU-27: Tap water ts	64,784	m3	GaBi

Appendix B

STANDARD PRACTICE REFERENCE BUILDING

B.1 STANDARD PRACTICE REFERENCE BUILDING

The Green Star Design & As Built credit 19A requires that the reference building is defined as either:

1. Standard Practice Reference Building – A hypothetical building that represents standard contemporary construction practices
2. Actual Reference Building – A building constructed in the last five years and is similar in use, construction and operation to the project.

This study uses a standard practice reference building, for which the key comparison to the proposed building is shown in Table B.1. All other building characteristics are assumed to be the same for the proposed and reference buildings.

The reference building is to be defined using conventional materials predominant for the building and deemed to satisfy current National Construction Codes (NCC), as detailed in the NCC Volume 1 Building Code of Australia. Building fabric must be compliant with NCC V1 Section J Deemed-to-Satisfy (DTS) requirements.

Modelled energy consumption must be based on BCA Section J deemed to satisfy (DTS) compliance. Maximum permissible lighting levels in line with BCA must be used. Heating and cooling appliances must comply with efficiencies which meet the latest Minimum Energy Performance Standards (MEPS) and where relevant BCA Section J DTS requirements. Building fabric must also be compliant with BCA Section J DTS requirements.

Both the reference building and project must have the same structural requirements, scale, function and location, tenant requirements, aesthetics, site conditions including underlying geology, planning constraints, orientation and assumed to be constructed at the same season. The reference case is to be agreed through consultation with structural, mechanical, electrical and architectural professionals.

To ensure the reference building is appropriate, projects are required to submit signed declarations from the principal architect or principal engineer or design manager for the project, confirming the reference building was constructed in accordance with the specific guidance above. Also confirming the reference building design, technologies and construction are true representation of contemporary practice for the type and function of the project.

Table B.1 Standard Practice Reference Building Definition

Category	Module	Proposed Building	Reference Building
Description		60 story Hotel and Residential Tower	As per proposed building
Structure type		Concrete framed. No Portland cement substitution assumed at this stage	As per proposed building
Concrete	A1-A3	Assumed no Portland cement substitution	As per proposed building
Steel	A1-A3	Assumed standard structural and reinforcing steel with no sustainability credentials	As per proposed building
Façade system	A1-A3	As per JV3 report. Aluminium framed double glazed unit.	As per JV3 report. Aluminium framed double glazed unit.

Category	Module	Proposed Building	Reference Building
Central energy plant	A1-A3	Gas turbine combined heat and power plant (CHP) in combination with absorption and electric chillers to supply cooling.	Heating met through central boiler plant and all other loads met from grid electricity
Glazing	A1-A3	Double glazed	Double glazed
Other Materials	A1-A3	TBC during detailed design	TBC during detailed design
Construction waste	A5	Assumed 5% waste of material supplied to site and NSW average recycling rates for construction waste	As per proposed building
Operational Energy	B6	As per preliminary Green Star energy modelling results. All energy supply by CHP	As per preliminary Green Star energy modelling results. Heating supplied by gas and electrical loads by grid electricity
Operational Water	B7	As per potable water calculator Reduced heat rejection water from harbour heat rejection system	As per potable water calculator reference assumptions
End of life waste	C1-C4	Assumed NSW recycling rates for key materials	As per proposed building.

Appendix C

LIFECYCLE IMPACT ASSESSMENT FACTORS

C.1 LIFECYCLE IMPACT ASSESSMENT FACTORS

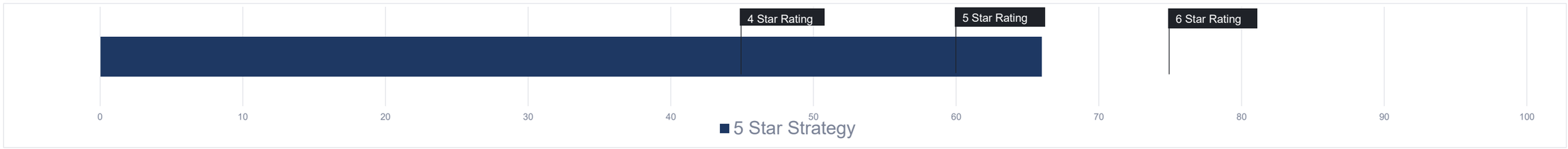
GaBi Process / Source	Unit	CML2001 - Apr. 2013, Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2-Equiv.]	CML2001 - Apr. 2013, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]	CML2001 - Apr. 2013, Acidification Potential (AP) [kg SO2-Equiv.]	CML2001 - Apr. 2013, Eutrophication Potential (EP) [kg Phosphate-Equiv.]	CML2001 - Apr. 2013, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP elements) [kg Sb-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP fossil) [MJ]	USEtox 2.01, Human toxicity, cancer (recommended and interim) [CTUh]	USEtox 2.01, Human toxicity, non-canc. (recommended and interim) [CTUh]	Land Transformation Indicator [sqm]	ReCiPe 1.08 Midpoint (H) - Water depletion [m3]	Ionizing radiation midpoint, human health (v1.06) [kBq U235 eq]	TRACI 2.1, Human Health Particulate Air [kg PM2,5-Equiv.]
EU-27: Excavated soil with digger (EN15804 A5) ts	m3	1.09E+00	4.89E-12	1.07E-02	2.32E-03	2.30E-03	7.09E-08	1.47E+01	6.67E-09	9.17E-08	9.21E-02	2.17E-02	3.07E-03	2.57E-03
DE: Pumping of concrete (EN 15804 A5) ts <p-agg>	m3	8.95E-01	5.38E-11	1.28E-03	2.04E-04	9.47E-05	0.00E+00	0.00E+00	6.62E-10	2.45E-08	8.35E-02	2.17E-02	1.05E-01	1.03E-04
DE: Crushed stone 16/32 ts	kg	1.27E-02	6.48E-13	2.03E-05	3.72E-06	1.41E-06	0.00E+00	0.00E+00	2.20E-11	6.72E-10	1.22E-03	1.63E-02	1.25E-03	1.16E-03
EU-27: Sand 0/2 ts	kg	2.32E-03	6.29E-13	1.34E-05	2.25E-06	1.48E-06	0.00E+00	0.00E+00	1.71E-11	1.09E-09	3.38E-04	0.00E+00	3.83E-04	1.15E-05
EU-27: Asphalt pavement (EN15804 A1-A3) ts	kg	6.41E-02	4.98E-12	2.25E-04	2.55E-05	1.84E-05	0.00E+00	0.00E+00	1.45E-09	6.65E-09	1.84E-03	2.64E-02	3.01E-03	5.27E-04
EU-27: Asphalt supporting layer (EN15804 A1-A3) ts	kg	5.63E-02	4.78E-12	1.82E-04	2.26E-05	1.02E-05	0.00E+00	0.00E+00	1.03E-09	5.09E-09	1.61E-03	2.27E-02	2.88E-03	5.30E-04
DE: Cement screed - IWM (A1-A3) ts-EPD <p-agg>	kg	1.51E-01	1.30E-11	2.17E-04	4.00E-05	1.26E-05	1.72E-07	9.82E-01	1.13E-10	1.26E-08	1.16E-04	1.63E-02	2.94E-03	5.92E-03
DE: Normal masonry mortar - IWM (A1-A3) ts-EPD <p-agg>	kg	9.53E-02	1.34E-11	1.73E-04	2.73E-05	1.04E-05	1.51E-07	5.81E-01	8.40E-11	9.11E-09	3.24E-06	3.01E-02	2.75E-03	3.09E-05
DE: Concrete C20/25 (A1-A3) VDZ-EPD	m3	1.91E+02	6.67E-07	2.73E-01	4.35E-02	3.30E-02	3.39E-04	5.01E+02	1.68E-07	1.30E-05	1.86E-03	1.11E-01	3.66E+00	4.55E-01
DE: Concrete C25/30 (A1-A3) VDZ-EPD	m3	2.11E+02	6.92E-07	2.97E-01	4.72E-02	3.61E-02	3.78E-04	5.35E+02	1.73E-07	1.41E-05	2.00E-03	6.05E-02	3.92E+00	4.42E-01
DE: Concrete C45/55 (A1-A3) VDZ-EPD	m3	3.14E+02	8.16E-07	4.20E-01	6.46E-02	5.06E-02	5.17E-04	8.07E+02	2.97E-07	1.95E-05	2.95E-03	2.30E-02	5.73E+00	4.46E-01
DE: Concrete C50/60 (A1-A3) VDZ-EPD	m3	3.35E+02	9.41E-07	4.52E-01	6.90E-02	5.40E-02	5.47E-04	8.21E+02	3.68E-07	2.06E-05	3.05E-03	6.18E-02	5.93E+00	4.56E-01
DE: Reinforcement (synthetic resin trowel) (EN15804 A1-A3) ts	kg	4.14E-01	2.30E-11	9.27E-04	1.44E-04	2.08E-03	1.22E-06	9.57E+00	4.67E-09	2.48E-07	2.46E-02	2.64E-02	1.83E-02	2.08E-03
GB: Stainless Steel Rebar - Outokumpu (A1-A3) ts-EPD	t	4.34E+03	-3.96E-06	2.46E+01	1.51E+00	1.66E+00	2.54E-01	4.10E+04	5.15E-05	1.97E-03	4.46E+00	0.00E+00	3.67E+02	2.84E+00
GLO: Steel rebar worldsteel	kg	1.27E+00	1.11E-08	3.54E-03	2.80E-04	5.49E-04	-6.81E-08	0.00E+00	2.42E-09	2.08E-07	0.00E+00	0.00E+00	2.19E-03	3.16E-04
DE: EAF Steel billet / Slab / Bloom ts <p-agg>	kg	4.14E-01	1.83E-11	1.07E-03	9.96E-05	1.15E-04	1.34E-07	4.72E+00	3.84E-10	1.93E-08	2.97E-02	2.10E-02	3.49E-02	1.35E-04
BlueScope EPD - Steel welded beams and columns	kg	2.85E+00	1.18E-10	1.13E-02	1.18E-04	1.75E-03	2.21E-07	3.14E+01						
DE: Stainless Steel slab (X6CrNi17) ts <p-agg>	kg	3.60E+00	9.59E-11	2.74E-02	1.48E-03	1.61E-03	1.59E-03	3.94E+01	3.11E-08	3.68E-07	1.02E-01	1.55E-02	8.36E-02	4.59E-03
DE: Steel billet (20MoCr4) ts <p-agg>	kg	6.72E-01	2.99E-11	2.59E-03	2.25E-04	2.27E-04	4.13E-04	7.46E+00	1.93E-09	4.58E-08	4.28E-02	1.30E-02	4.09E-02	5.84E-04
DE: Steel hot rolled coil (EN15804 A1-A3) ts <p-agg>	kg	1.95E+00	1.21E-11	7.10E-03	5.98E-04	1.02E-03	1.24E-08	2.21E+01	1.12E-08	8.84E-07	2.22E-02	0.00E+00	1.10E-02	1.62E-03
DE: Steel sheet EG ts <p-agg>	kg	2.19E+00	1.57E-11	7.28E-03	6.44E-04	1.05E-03	1.14E-05	2.50E+01	1.14E-08	8.91E-07	2.61E-02	0.00E+00	1.56E-02	1.64E-03
DE: Steel sheet HDG (EN 15804 A1-A3) ts <p-agg>	kg	2.28E+00	4.38E-11	7.81E-03	6.70E-04	1.09E-03	1.82E-04	2.59E+01	1.20E-08	9.16E-07	3.62E-02	0.00E+00	3.66E-02	1.70E-03
DE: Aluminium extrusion profile mix ts	kg	9.83E+00	4.08E-09	3.53E-02	2.39E-03	2.27E-03	4.33E-06	1.07E+02	2.11E-08	6.11E-07	1.72E-01	2.17E-02	2.20E+00	5.63E-03
RER: Stainless steel - Hot rolled coil ts-EPD	t	2.93E+03	2.08E-04	3.45E+01	1.06E+00	2.36E+00	9.79E-02	0.00E+00	3.43E-05	2.63E-03	0.00E+00	0.00E+00	4.09E+01	1.68E+00
DE: Concrete bricks (EN15804 A1-A3) ts	kg	1.13E-01	1.15E-12	2.02E-04	3.24E-05	8.20E-06	1.63E-07	5.12E-01	1.54E-10	7.41E-09	3.59E-03	1.12E-01	2.20E-03	3.58E-05
EU-27: Aerated concrete block ts	kg	5.35E-01	4.52E-11	8.87E-04	1.03E-04	1.11E-04	6.56E-07	3.79E+00	1.22E-09	8.44E-08	7.71E-03	0.00E+00	2.73E-02	1.67E-04
EU-27: Lightweight concrete block ts	kg	2.91E-01	2.84E-12	1.33E-03	8.79E-05	6.24E-05	3.94E-07	2.40E+00	2.15E-09	1.96E-07	2.04E-02	0.00E+00	5.44E-03	1.51E-04
BE: Dry construction panel HYDROPANEL 12mm - Eternit (A1-A3) ts-	m2	7.70E+00	5.26E-09	2.17E-02	3.15E-03	1.84E-03	8.37E-06	8.01E+01	8.95E-09	6.22E-07	1.56E-04	2.17E-02	6.35E-01	7.10E-03
BE: Dry construction panel HYDROPANEL 9mm - Eternit (A1-A3) ts-E	m2	5.77E+00	3.94E-09	1.63E-02	2.36E-03	1.38E-03	6.28E-06	6.01E+01	6.71E-09	4.67E-07	1.17E-04	1.63E-02	4.76E-01	5.33E-03
BE: Facade panel CEDRAL - Eternit (A1-A3) ts-EPD	m2	7.39E+00	4.95E-09	1.74E-02	2.65E-03	5.86E-03	1.24E-03	7.78E+01	1.71E-08	1.59E-06	6.17E-04	1.74E-02	5.18E-01	3.70E-03
DE: Acoustic panel, StoSilent Panel Aluminium 15mm - StoVerotec G	m2	9.84E+00	1.92E-08	2.11E-02	3.23E-03	3.37E-03	6.95E-05	1.38E+02	1.86E-08	1.37E-06	3.62E-04	2.11E-02	4.97E-01	1.49E-02
DE: Acoustic panel, StoSilent Panel Aluminium 25mm - StoVerotec G	m2	1.22E+01	2.08E-08	2.64E-02	4.32E-03	3.70E-03	7.48E-05	1.68E+02	2.00E-08	1.45E-06	4.64E-04	2.64E-02	6.09E-01	2.21E-02
DE: Ceramic cladding elements incl. substructure TONALITY® - CRE	m2	4.40E+01	6.32E-09	1.12E-01	8.82E-03	9.04E-03	3.46E-04	6.08E+02	3.98E-08	2.09E-06	1.18E-03	1.12E-01	1.45E+00	1.78E-02
DE: Ceramic facade panels Argeton - Wienerberger GmbH (Module A	m2	4.35E+01	2.71E-09	1.11E-01	1.03E-02	6.68E-03	2.47E-04	5.99E+02	9.20E-08	3.19E-06	2.01E-02	1.11E-01	1.81E+01	1.88E-02
DE: Construction panel Eterplan - Eternit (A1-A3) ts-EPD	m2	3.23E+01	1.10E-08	6.05E-02	7.68E-03	2.83E-02	3.21E-05	3.67E+02	2.00E-07	2.23E-05	1.01E-02	6.05E-02	1.17E+00	9.43E-03
US: Insulated metal panel (IMP), CF architectural wall panel - Metl-Spa	m2	4.75E+01	1.01E-05	1.55E-02	1.11E-03	2.21E-03	3.67E-06	1.95E+01	4.77E-09	2.83E-07	2.76E-05	1.30E-02	6.05E-02	2.15E-03
US: Insulated metal panel (IMP), CF roof panel - Metl-Span ts-EPD	m2	3.83E+01	8.05E-06	1.30E-02	9.32E-04	1.85E-03	3.03E-06	1.59E+01	3.93E-09	2.37E-07	2.11E-05	1.18E-02	4.92E-02	1.78E-03
BE: Plaster baseboard BLUCLAD - Eternit (A1-A3) ts-EPD	m2	6.51E+00	4.93E-09	1.84E-02	2.65E-03	5.17E-03	1.05E-05	6.84E+01	7.65E-09	5.28E-07	1.68E-04	1.84E-02	5.34E-01	5.96E-03
DE: Particle board, StoVentec 12mm- StoVerotec GmbH (A1-A3) ts-E	m2	1.01E+01	9.44E-08	2.10E-02	3.16E-03	2.30E-03	5.20E-05	1.29E+02	1.94E-08	1.55E-06	3.12E-04	3.01E-02	4.49E-01	1.32E-02
DE: Particle board, StoVentec 20mm- StoVerotec GmbH (A1-A3) ts-E	m2	1.47E+01	1.02E-07	3.01E-02	4.73E-03	3.21E-03	6.74E-05	2.03E+02	3.02E-08	2.48E-06	4.75E-04	2.64E-02	6.36E-01	2.14E-02
DE: Polypropylene pipe (PP) (EN15804 A1-A3) ts	kg	2.87E+00	8.96E-11	4.42E-03	5.44E-04	7.53E-04	1.08E-06	7.78E+01	1.91E-08	1.11E-07	1.62E-01	2.17E-02	1.73E-01	3.55E-04
DE: Door fittings from Aluminium - FVSB (A1-A3) ts-EPD	kg	1.14E+01	6.06E-10	8.08E-02	7.36E-03	5.78E-03	9.29E-06	1.22E+02	5.49E-08	1.74E-06	4.98E-04	2.17E-02	1.08E-01	1.73E-02
DE: Door fittings from stainless steel, HHF FS 255/288/283 - HAFI (A	kg	3.25E+00	1.86E-10	2.22E-02	1.34E-03	1.40E-03	7.57E-05	3.97E+01	4.18E-08	5.52E-07	7.25E-04	1.63E-02	6.88E-02	3.06E-03
DE: Elastomer joint tape, polysulphide (EN15804 A1-A3) ts	kg	7.12E+00	1.75E-10	1.77E-02	1.71E-03	2.09E-03	2.70E-05	1.43E+02	8.12E-08	6.04E-06	9.50E-01	1.74E-02	3.29E-01	1.30E-03
DE: Elastomer joint tape, polyurethane (EN15804 A1-A3) ts	kg	4.90E+00	2.60E-10	8.84E-03	1.87E-03	1.71E-03	3.90E-05	8.87E+01	2.24E-08	3.46E-07	2.80E-01	1.84E-02	3.11E-01	8.23E-04
DE: Elastomer joint tape, silicone rubber (EN15804 A1-A3) ts	kg	6.18E+00	5.37E-10	1.40E-02	1.61E-03	1.35E-03	2.77E-04	8.31E+01	1.90E-08	5.55E-07	2.22E+00	2.11E-02	5.26E-01	6.43E-03
DE: Fitting brass - FSB ts-EPD	kg	7.23E+00	7.03E-07	2.65E-02	2.16E-03	2.40E-03	1.99E-06	0.00E+00	6.87E-08	1.66E-05	0.00E+00	2.64E-02	1.36E-01	1.73E-03

GaBi Process / Source	Unit	CML2001 - Apr. 2013, Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2-Equiv.]	CML2001 - Apr. 2013, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]	CML2001 - Apr. 2013, Acidification Potential (AP) [kg SO2-Equiv.]	CML2001 - Apr. 2013, Eutrophication Potential (EP) [kg Phosphate-Equiv.]	CML2001 - Apr. 2013, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP elements) [kg Sb-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP fossil) [MJ]	USEtox 2.01, Human toxicity, cancer (recommended and interim) [CTUh]	USEtox 2.01, Human toxicity, non-canc. (recommended and interim) [CTUh]	Land Transformation Indicator [sqm]	ReCiPe 1.08 Midpoint (H) - Water depletion [m3]	Ionizing radiation midpoint, human health (v1.06) [kBq U235 eq]	TRACI 2.1, Human Health Particulate Air [kg PM2,5-Equiv.]
DE: Lock- SSF ts-EPD	#	1.92E+00	1.05E-07	3.95E-03	3.86E-04	5.10E-04	3.40E-07	0.00E+00	1.04E-09	6.64E-08	0.00E+00	2.27E-02	2.07E-02	2.07E-04
DE: Window frame PVC-U (EN15804 A1-A3) ts <p-agg>	m	7.37E+00	1.01E-09	2.02E-02	2.32E-03	3.67E-03	1.79E-04	1.22E+02	7.50E-08	6.69E-06	4.18E-01	1.12E-01	5.43E-01	3.31E-03
EU-27: Aluminium casement frame section, powder coated (205) 1m (	m	1.12E+01	3.26E-09	5.40E-02	3.61E-03	3.26E-03	8.78E-05	1.30E+02	3.68E-08	1.24E-06	2.14E-01	1.11E-01	1.80E+00	8.88E-03
EU-27: Aluminium frame profile, powder coated (EN15804 A1-A3) ts	m	1.16E+01	3.38E-09	5.60E-02	3.73E-03	3.38E-03	9.09E-05	1.34E+02	3.80E-08	1.27E-06	2.21E-01	6.05E-02	1.87E+00	9.23E-03
EU-27: Aluminium frame profile, thermically isolated, powder coated (E	m	1.47E+01	4.17E-09	6.31E-02	4.60E-03	4.23E-03	7.54E-05	1.76E+02	6.82E-08	3.86E-06	2.97E-01	2.30E-02	2.06E+00	1.05E-02
EU-27: Aluminium window fitting combination (turn-tilt) (EN15804 A1-A	#	8.00E+00	7.82E-10	2.66E-02	2.25E-03	3.18E-03	9.91E-04	8.98E+01	3.49E-08	2.46E-06	2.07E-01	6.18E-02	5.12E-01	5.37E-03
EU-27: Aluminium wing frame profile, thermically isolated, powder coat	m	1.57E+01	4.52E-09	6.93E-02	4.95E-03	4.54E-03	7.87E-05	1.87E+02	6.83E-08	3.63E-06	3.13E-01	2.10E-02	2.29E+00	1.14E-02
EU-27: Double glazing unit (EN15804 A1-A3) ts	m2	3.07E+01	2.12E-09	1.32E-01	2.48E-02	1.13E-02	1.77E-04	3.61E+02	3.65E-08	4.72E-07	4.61E-01	3.01E-02	1.31E+00	1.28E-01
EU-27: Fixing material screws galvanized (EN15804 A1-A3) ts	kg	3.17E+00	7.76E-11	9.56E-03	8.65E-04	1.26E-03	1.87E-04	3.35E+01	1.42E-08	1.05E-06	8.84E-02	2.64E-02	1.00E-01	1.96E-03
EU-27: Fixing material screws stainless steel (EN15804 A1-A3) ts	kg	3.82E+00	1.92E-10	2.47E-02	1.32E-03	1.44E-03	7.69E-04	4.30E+01	2.86E-08	3.48E-07	1.14E-01	1.55E-02	1.71E-01	3.54E-03
EU-27: Metal fitting for double casement windows (EN15804 A1-A3) ts	#	8.02E+00	1.98E-09	3.34E-02	2.55E-03	2.48E-03	1.27E-03	9.98E+01	3.21E-08	5.72E-07	2.26E-01	1.30E-02	1.15E+00	4.84E-03
EU-27: Metal fitting for horizontal sliding window (EN15804 A1-A3) ts	#	5.34E+00	1.12E-09	2.10E-02	1.80E-03	1.74E-03	1.08E-03	7.04E+01	2.65E-08	3.52E-07	1.69E-01	1.18E-02	6.75E-01	2.81E-03
EU-27: Metal fitting for vertical sliding window (EN15804 A1-A3) ts	#	1.02E+01	2.10E-09	6.06E-02	3.18E-03	3.87E-03	1.41E-03	1.19E+02	7.95E-08	7.32E-07	3.64E-01	0.00E+00	1.27E+00	8.60E-03
EU-27: Window fitting (tilt-turn aluminium-window) - FV S+B (A1-A3) ts	#	1.13E+01	2.76E-09	5.85E-02	3.47E-03	3.82E-03	3.79E-03	1.34E+02	6.45E-08	1.06E-06	4.75E-01	0.00E+00	1.70E+00	8.14E-03
EU-27: Window glass simple (EN15804 A1-A3) ts	m2	8.47E+00	6.98E-10	6.85E-02	6.98E-03	-7.66E-03	2.21E-05	9.95E+01	1.02E-08	1.69E-07	1.12E-01	0.00E+00	4.22E-01	4.26E-02
EU-27: Solid construction timber (softwood) (EN15804 A1-A3) ts	m3	1.62E+02	5.43E-08	8.47E-01	1.57E-01	1.14E-01	3.14E-05	1.93E+03	6.15E-07	9.40E-06	3.41E+03	1.18E-02	3.27E+01	8.36E-01
EU-27: Timber larch (12% moisture; 10.7% H2O content) (EN15804 A1-A	m3	1.70E+02	5.46E-08	8.19E-01	1.65E-01	4.24E-02	3.21E-05	2.03E+03	6.26E-07	1.00E-05	3.60E+03	0.00E+00	3.29E+01	8.85E-01
EU-27: Timber oak (12% moisture; 10.7% H2O content) (EN15804 A1-A	m3	1.19E+02	3.83E-08	3.85E-01	6.55E-02	6.48E-01	2.26E-05	1.41E+03	4.10E-07	5.97E-06	3.61E+03	0.00E+00	2.31E+01	9.11E-01
EU-27: Timber pine (12% moisture; 10.7% H2O content) (EN15804 A1-A	m3	1.03E+02	2.93E-08	4.79E-01	9.89E-02	1.52E-02	1.88E-05	1.24E+03	4.09E-07	7.02E-06	2.99E+03	0.00E+00	1.78E+01	7.20E-01
EU-27: Timber spruce (12% moisture; 10.7% H2O content) (EN15804 A1	m3	9.03E+01	2.58E-08	4.20E-01	8.68E-02	1.33E-02	1.65E-05	1.09E+03	3.59E-07	6.16E-06	2.62E+03	0.00E+00	1.56E+01	6.32E-01
BR: Timber pine ts	m3	4.78E+01	2.42E-09	2.90E-01	4.84E-02	2.58E-02	1.23E-05	4.52E+02	3.26E-07	3.33E-06	1.21E+03	2.11E-02	9.01E-01	7.03E-01
CN: Timber teak ts	m3	1.36E+02	6.11E-11	6.99E-01	1.01E-01	7.43E-02	7.63E-06	1.52E+03	1.46E-06	1.43E-05	4.52E+00	2.64E-02	5.91E-01	1.07E+00
AT: KLH A1-A3 - 320 mm ts-EPD	m2	7.37E+01	2.19E-06	1.26E-01	2.39E-02	1.43E-02	1.26E-05	0.00E+00	5.16E-08	8.15E-07	0.00E+00	2.17E-02	4.30E-01	8.49E-03
AT: KLH A1-A3 - 57mm ts-EPD	m2	1.37E+01	4.17E-07	2.35E-02	4.43E-03	2.72E-03	3.56E-06	0.00E+00	9.71E-09	1.54E-07	0.00E+00	1.63E-02	8.19E-02	1.56E-03
DE: Laminate Flex - Egger ts-EPD	m2	3.23E+00	1.14E-07	5.17E-03	1.32E-03	1.04E-03	1.94E-06	0.00E+00	7.84E-09	3.32E-08	0.00E+00	2.27E-02	2.24E-02	2.37E-04
DE: Laminate flooring DPL (Mix) - Egger (A1-A3) ts-EPD <p-agg>	m2	6.07E+00	9.23E-10	1.55E-02	5.32E-03	8.13E-03	2.43E-06	1.00E+02	5.95E-08	1.77E-06	1.24E-04	1.12E-01	2.49E+00	1.01E-03
DE: Laminate MED - Egger ts-EPD	m2	4.16E+00	1.49E-07	6.64E-03	1.58E-03	1.33E-03	2.25E-06	0.00E+00	1.15E-08	4.49E-08	0.00E+00	1.11E-01	2.92E-02	3.07E-04
DE: Laminate Micro - Egger ts-EPD	m2	1.57E+00	5.72E-08	2.56E-03	7.50E-04	5.82E-04	1.37E-06	0.00E+00	4.17E-09	1.46E-08	0.00E+00	6.05E-02	1.12E-02	1.14E-04
EU-27: Five-Layer laminated wood board, pine (EN15804 A1-A3) ts	m3	6.26E+01	-7.71E-09	1.03E+00	2.24E-01	1.03E-01	9.51E-05	9.38E+02	8.73E-07	3.24E-05	3.75E+03	2.30E-02	-3.67E+00	8.71E-01
EU-27: Three-Layers laminated wood panel pine (EN15804 A1-A3) ts	m3	8.68E+01	-5.86E-09	1.21E+00	2.45E-01	1.62E-01	1.48E-04	1.43E+03	1.01E-06	3.82E-05	3.74E+03	0.00E+00	-2.30E+00	8.69E-01
EU-27: Glued laminated timber (EN15804 A1-A3) ts	m3	1.89E+02	5.99E-08	8.95E-01	1.64E-01	1.15E-01	8.09E-05	2.48E+03	7.36E-07	1.07E-05	3.34E+03	6.18E-02	3.64E+01	8.24E-01
EU-27: Laminated veneer lumber (EN15804 A1-A3) ts	m3	3.04E+02	4.48E-08	1.49E+00	2.77E-01	6.68E-02	1.24E-04	5.86E+03	1.71E-06	3.91E-05	4.34E+03	2.10E-02	2.36E+01	1.06E+00
EU-27: Laminated woodboard softwood (EN15804 A1-A3) ts	m3	1.86E+02	6.01E-08	8.92E-01	1.64E-01	1.14E-01	7.08E-05	2.39E+03	7.14E-07	1.05E-05	3.36E+03	3.01E-02	3.64E+01	8.27E-01
EU-27: Particle board ts	m3	1.54E+02	3.83E-08	9.60E-01	2.34E-01	2.64E-01	5.87E-05	2.67E+03	4.63E-06	3.25E-05	7.79E+02	1.55E-02	2.17E+01	2.68E-01
EU-27: Plywood board (EN15804 A1-A3) ts	m3	1.27E+02	4.02E-09	1.00E+00	1.83E-01	1.16E-01	6.17E-05	2.20E+03	7.64E-07	3.91E-05	4.97E+03	1.30E-02	2.60E+01	8.49E-02
EU-27: Multi layer parquet (EN15804 A1-A3) ts	m2	4.96E+00	1.28E-09	2.45E-02	4.86E-03	8.95E-03	2.70E-06	6.84E+01	2.05E-08	3.11E-07	9.80E+01	2.64E-02	7.87E-01	2.46E-02
EU-27: Strip parquet (EN15804 A1-A3) ts	m2	5.03E+00	6.77E-10	3.24E-02	6.91E-03	3.16E-02	8.47E-07	6.31E+01	2.45E-08	3.72E-07	1.79E+02	0.00E+00	4.21E-01	4.55E-02
EU-27: Air ventilation duct (zinc coated steel plate) (EN15804 A1-A3) ts	kg	2.40E+00	4.91E-11	7.94E-03	7.02E-04	1.12E-03	9.54E-05	2.74E+01	1.22E-08	9.44E-07	3.50E-02	1.63E-02	3.86E-02	1.75E-03
EU-27: Brine-Water (geothermal collector) 20 kW (EN15804 A1-A3) ts	#	9.36E+03	2.47E-04	2.48E+01	2.23E+00	5.51E+00	4.13E-02	3.24E+05	1.02E-04	5.62E-04	2.52E+02	1.74E-02	1.06E+03	2.16E+00
EU-27: Circulating pump < 50W (EN15804 A1-A3) ts <p-agg>	#	1.12E+01	1.74E-09	6.75E-02	3.78E-03	4.54E-03	1.82E-03	1.47E+02	1.46E-07	2.60E-06	7.94E-01	1.84E-02	9.44E-01	1.38E-02
EU-27: Circulating pump 250-1000W (EN15804 A1-A3) ts <p-agg>	#	1.12E+02	1.74E-08	6.75E-01	3.78E-02	4.54E-02	1.82E-02	1.47E+03	1.46E-06	2.60E-05	7.94E+00	2.11E-02	9.44E+00	1.38E-01
EU-27: Circulating pump 50-250W (EN15804 A1-A3) ts <p-agg>	#	2.24E+01	3.48E-09	1.35E-01	7.57E-03	9.08E-03	3.65E-03	2.93E+02	2.91E-07	5.20E-06	1.59E+00	2.64E-02	1.89E+00	2.76E-02
EU-27: Copper pipe mix, bare (A1-A3) ts	kg	4.20E+00	3.70E-10	4.11E-02	6.90E-03	2.18E-03	5.63E-03	4.96E+01	5.21E-08	2.75E-06	2.51E-01	2.27E-02	1.75E-01	6.23E-03
EU-27: Direct expansion air conditioner (per 1 kW) (EN15804 A1-A3) ts	kW	4.05E+01	5.38E-05	2.48E-01	3.53E-02	1.80E-02	2.40E-02	5.23E+02	4.35E-07	1.67E-05	1.75E+00	3.13E-02	3.09E+00	5.38E-02
EU-27: Electric heat pump (Brine-Water, geothermal collector) 10 kW (	#	4.72E+03	2.46E-04	1.28E+01	1.13E+00	2.77E+00	3.98E-02	1.61E+05	5.08E-05	3.25E-04	1.27E+02	1.12E-01	5.25E+02	1.19E+00
EU-27: Electric heat pump (Brine-Water, geothermal collector) 70 kW (	#	3.28E+04	8.64E-04	8.64E+01	7.78E+00	1.93E+01	1.15E-01	1.14E+06	3.59E-04	1.82E-03	8.89E+02	1.11E-01	3.76E+03	7.40E+00
EU-27: Electric heat pump (Brine-Water, geothermal probe) 10 kW (EN	#	1.31E+03	2.45E-04	4.52E+00	3.72E-01	6.67E-01	3.89E-02	3.20E+04	1.15E-05	2.84E-04	3.84E+01	6.05E-02	1.33E+02	6.97E-01
EU-27: Electric heat pump (Brine-Water, geothermal probe) 20 kW (EN	#	3.39E+03	2.46E-04	1.10E+01	9.62E-01	1.75E+00	4.00E-02	8.82E+04	3.08E-05	6.59E-04	1.02E+02	2.30E-02	3.81E+02	1.59E+00
EU-27: Electric heat pump (Brine-Water, geothermal probe) 70 kW (EN	#	1.15E+04	8.60E-04	3.66E+01	3.22E+00	5.93E+00	1.10E-01	3.07E+05	1.07E-04	2.07E-03	3.50E+02	6.18E-02	1.33E+03	5.18E+00
EU-27: Electric heat pump (Water-Water) 10 kW (EN15804 A1-A3) ts <p-	#	5.21E+02	2.45E-04	2.10E+00	1.42E-01	2.71E-01	4.59E-02	1.10E+04	4.22E-06	1.36E-04	1.34E+01	2.10E-02	3.53E+01	3.47E-01

GaBi Process / Source	Unit	CML2001 - Apr. 2013, Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2-Equiv.]	CML2001 - Apr. 2013, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]	CML2001 - Apr. 2013, Acidification Potential (AP) [kg SO2-Equiv.]	CML2001 - Apr. 2013, Eutrophication Potential (EP) [kg Phosphate-Equiv.]	CML2001 - Apr. 2013, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP elements) [kg Sb-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP fossil) [MJ]	USEtox 2.01, Human toxicity, cancer (recommended and interim) [CTUh]	USEtox 2.01, Human toxicity, non-canc. (recommended and interim) [CTUh]	Land Transformation Indicator [sqm]	ReCiPe 1.08 Midpoint (H) - Water depletion [m3]	Ionizing radiation midpoint, human health (v1.06) [kBq U235 eq]	TRACI 2.1, Human Health Particulate Air [kg PM2,5-Equiv.]
EU-27: Electric heat pump (Water-Water) 20 kW (EN15804 A1-A3) ts <p	#	8.82E+02	2.45E-04	3.03E+00	2.27E-01	4.85E-01	4.60E-02	2.37E+04	8.17E-06	1.55E-04	2.30E+01	3.01E-02	7.70E+01	4.23E-01
EU-27: Electric heat pump (Water-Water) 70 kW (EN15804 A1-A3) ts <p	#	2.97E+03	8.58E-04	9.48E+00	7.33E-01	1.67E+00	1.24E-01	9.05E+04	3.07E-05	3.42E-04	8.38E+01	2.64E-02	3.01E+02	1.20E+00
EU-27: Electric instantaneous water heater (21 kW) (EN15804 A1-A3) ts	#	1.29E+01	1.48E-09	1.05E-01	4.43E-03	6.54E-03	5.16E-03	2.08E+02	1.05E-07	5.33E-06	3.73E-01	1.55E-02	8.88E-01	1.15E-02
EU-27: Flat solar collector (EN15804 A1-A3) ts <p-agg>	m2	8.48E+01	1.84E-08	7.94E-01	2.93E-02	3.96E-02	6.42E-03	9.13E+02	2.46E-07	1.14E-05	2.81E+00	1.18E-02	1.15E+01	1.48E-01
EU-27: Gas condensing boiler < 20 kW (upright unit) (EN15804 A1-A3) t	#	6.41E+02	7.21E-08	3.66E+00	2.52E-01	2.79E-01	8.68E-02	8.31E+03	6.99E-06	1.43E-04	5.48E+01	0.00E+00	2.98E+01	6.60E-01
EU-27: Gas condensing boiler < 20 kW (wall unit) (EN15804 A1-A3) ts <	#	2.07E+02	2.33E-08	1.18E+00	8.14E-02	9.01E-02	2.81E-02	2.69E+03	2.26E-06	4.62E-05	1.77E+01	0.00E+00	9.63E+00	2.13E-01
EU-27: Gas condensing boiler 120-400 kW (upright unit) (EN15804 A1-A	#	2.88E+03	2.72E-07	1.43E+01	1.02E+00	1.22E+00	3.97E-01	3.57E+04	2.16E-05	7.41E-04	2.10E+02	0.00E+00	1.22E+02	2.69E+00
EU-27: Gas condensing boiler 20-120 kW (upright unit) (EN15804 A1-A3	#	1.07E+03	1.13E-07	5.78E+00	4.04E-01	4.62E-01	1.47E-01	1.37E+04	1.01E-05	2.55E-04	8.61E+01	0.00E+00	4.80E+01	1.06E+00
EU-27: Gas heat pump (air) 20-70 kW (EN15804 A1-A3) ts <p-agg>	#	2.93E+02	7.93E-04	1.00E+00	8.23E-02	1.12E-01	1.84E-02	3.64E+03	1.94E-06	7.52E-05	1.02E+01	0.00E+00	1.01E+01	3.84E-01
EU-27: Gas low temperature boiler < 20 kW (upright unit) (EN15804 A1-	#	3.57E+02	9.06E-08	1.51E+00	1.17E-01	1.26E-01	2.16E-02	4.49E+03	5.83E-06	6.42E-05	2.29E+01	0.00E+00	4.79E+01	4.78E-01
EU-27: Gas low temperature boiler 120-400 kW (upright unit) (EN15804	#	2.22E+03	6.35E-07	7.83E+00	6.51E-01	7.24E-01	9.10E-02	2.72E+04	3.65E-05	4.07E-04	1.18E+02	0.00E+00	3.49E+02	3.08E+00
EU-27: Gas low temperature boiler 20-120 kW (upright unit) (EN 15804 A	#	8.82E+02	2.24E-07	3.75E+00	2.89E-01	3.12E-01	5.35E-02	1.11E+04	1.44E-05	1.59E-04	5.67E+01	0.00E+00	1.19E+02	1.18E+00
EU-27: Radiators (EN15804 A1-A3) ts <p-agg>	kg	3.48E+00	3.10E-11	1.07E-02	9.62E-04	1.93E-03	3.16E-08	4.47E+01	1.14E-08	8.95E-07	2.59E-02	0.00E+00	2.28E-02	1.79E-03
EU-27: Steel pipe (EN15804 A1-A3) ts <p-agg>	kg	2.03E+00	6.05E-11	7.32E-03	6.23E-04	1.03E-03	3.67E-08	2.30E+01	1.14E-08	8.87E-07	2.85E-02	0.00E+00	4.00E-02	1.65E-03
EU-27: Ventilation system central 10.000 m3/h (EN15804 A1-A3) ts <p-	#	2.74E+02	3.91E-08	1.32E+00	8.02E-02	1.10E-01	2.00E-02	3.16E+03	1.28E-06	7.18E-05	5.09E+00	0.00E+00	2.18E+01	2.18E-01
EU-27: Ventilation system central 30.000 m3/h (EN15804 A1-A3) ts <p-	#	6.76E+02	9.66E-08	3.25E+00	1.98E-01	2.71E-01	4.93E-02	7.79E+03	3.15E-06	1.77E-04	1.26E+01	0.00E+00	5.38E+01	5.38E-01
EU-27: Ventilation system central 5.000 m3/h (EN15804 A1-A3) ts <p-a	#	1.73E+02	2.48E-08	8.34E-01	5.08E-02	6.96E-02	1.26E-02	2.00E+03	8.08E-07	4.54E-05	3.22E+00	0.00E+00	1.38E+01	1.38E-01
EU-27: Ventilation system central with heat recovery 1.000 m3/h (EN15	#	2.87E+02	3.11E-08	1.21E+00	9.03E-02	1.26E-01	2.76E-03	3.27E+03	1.53E-06	9.71E-05	5.55E+00	0.00E+00	1.71E+01	2.38E-01
EU-27: Ventilation system central with heat recovery 10.000 m3/h (EN1	#	2.17E+03	2.89E-07	9.11E+00	6.65E-01	9.09E-01	9.94E-03	2.44E+04	1.00E-05	6.69E-04	3.50E+01	0.00E+00	1.60E+02	1.77E+00
EU-27: Ventilation system central with heat recovery 5.000 m3/h (EN15	#	1.13E+03	1.46E-07	4.73E+00	3.46E-01	4.75E-01	6.13E-03	1.27E+04	5.34E-06	3.52E-04	1.89E+01	0.00E+00	8.07E+01	9.21E-01
EU-27: Ventilation system decentralized (Wall & ceiling) 60 m3/h (EN15	#	3.64E+00	3.35E-10	1.74E-02	1.06E-03	1.51E-03	5.15E-04	6.17E+01	2.23E-08	9.29E-07	1.38E-01	0.00E+00	2.01E-01	2.35E-03
EU-27: Ventilation system decentralized with heat recovery (wall & ceili	#	2.13E+01	3.65E-09	1.11E-01	6.64E-03	2.30E-02	1.87E-03	3.16E+02	1.53E-07	2.64E-06	7.25E-01	0.00E+00	1.89E+00	1.73E-02
Daiken EPD - http://www.havtech.com/blog/wp-content/uploads/2016	ton cc	4.30E+01	4.89E-07	4.46E-01	1.27E-02	3.18E-02	1.26E-03	4.75E+02						
EU-27: Cable 1 wire (EN15804 A1-A3) ts	km	7.99E+01	5.95E-09	1.09E+00	2.75E-02	5.59E-02	5.00E-02	9.39E+02	7.70E-07	5.24E-05	2.31E+00	1.84E-02	3.42E+00	1.05E-01
EU-27: Cable 3 wire (EN15804 A1-A3) ts	km	3.64E+02	4.90E-08	3.51E+00	1.10E-01	2.49E-01	1.50E-01	5.68E+03	2.91E-06	1.61E-04	1.08E+01	2.11E-02	2.67E+01	3.32E-01
EU-27: Cable 5 wire (EN15804 A1-A3) ts	km	5.38E+02	6.45E-08	5.73E+00	1.68E-01	3.70E-01	2.50E-01	7.88E+03	4.52E-06	2.67E-04	1.59E+01	2.64E-02	3.54E+01	5.43E-01
EU-27: Cable CAT 7 (EN15804 A1-A3) ts	km	2.65E+02	2.61E-08	3.08E+00	9.24E-02	1.63E-01	1.35E-01	3.27E+03	2.26E-06	1.45E-04	8.64E+00	2.27E-02	1.58E+01	3.01E-01
EU-27: Compact fluorescent lamp 18W (external control gear) (EN1580	#	2.39E-01	2.22E-11	9.92E-04	9.27E-05	7.94E-05	1.35E-05	3.42E+00	1.22E-09	1.77E-08	9.51E-03	3.13E-02	1.65E-02	3.31E-04
EU-27: Diffuser (Damp room) T8 36W (LFL) (EN15804 A1-A3) ts	#	1.20E+01	2.35E-09	3.57E-02	5.43E-03	4.32E-03	4.37E-05	2.96E+02	1.07E-07	5.45E-07	3.28E-01	1.12E-01	1.50E+00	4.76E-03
EU-27: Dip-Switch (Light switch) (EN15804 A1-A3) ts	#	4.25E-01	5.69E-11	9.90E-04	1.28E-04	1.43E-04	2.59E-05	6.76E+00	1.85E-09	4.04E-08	1.13E-02	1.11E-01	3.66E-02	1.61E-04
EU-27: Downlight cabinet 18W (CFL, G24D) (EN15804 A1-A3) ts <p-agg	#	3.08E+00	4.67E-10	1.40E-02	9.19E-04	1.16E-03	2.51E-05	3.46E+01	1.10E-08	6.30E-07	4.63E-02	6.05E-02	2.60E-01	2.58E-03
EU-27: Electronic ballast EB (EN15804 A1-A3) ts <p-agg>	#	5.10E+00	6.17E-10	2.84E-02	2.22E-03	2.20E-03	2.91E-04	7.24E+01	7.75E-08	1.61E-06	1.75E-01	2.30E-02	3.35E-01	5.64E-03
EU-27: Fluorescent lamp socket T8-18W (LFL) (EN15804 A1-A3) ts <p-	#	9.29E-01	4.29E-11	3.83E-03	2.71E-04	4.61E-04	5.53E-05	1.20E+01	5.17E-09	3.49E-07	1.74E-02	6.18E-02	2.68E-02	6.51E-04
EU-27: Fluorescent lamp socket T8-36W (LFL) (EN15804 A1-A3) ts <p	#	3.88E+00	6.12E-11	1.29E-02	1.14E-03	1.83E-03	3.97E-05	4.43E+01	2.00E-08	1.56E-06	5.07E-02	2.10E-02	4.80E-02	2.88E-03
EU-27: Fluorescent lamp T5 28W (EN15804 A1-A3) ts	#	3.94E-01	4.33E-11	2.04E-03	1.94E-04	1.43E-04	1.43E-05	4.86E+00	2.10E-09	2.91E-08	1.54E-02	3.01E-02	2.93E-02	8.37E-04
EU-27: Fluorescent lamp T8 18W (EN15804 A1-A3) ts	#	2.86E-01	3.31E-11	1.46E-03	1.32E-04	1.01E-04	1.37E-05	3.55E+00	1.40E-09	2.17E-08	1.02E-02	2.64E-02	2.17E-02	5.59E-04
EU-27: Fluorescent lamp T8 36W (EN15804 A1-A3) ts	#	5.12E-01	5.78E-11	2.68E-03	2.58E-04	1.87E-04	1.49E-05	6.27E+00	2.77E-09	3.72E-08	2.04E-02	1.55E-02	3.91E-02	1.12E-03
EU-27: Louvrelight 2x T8 36W (EN15804 A1-A3) ts <p-agg>	#	2.84E+01	3.51E-09	9.77E-02	8.57E-03	9.21E-03	1.23E-04	3.29E+02	9.08E-08	5.35E-06	7.81E-01	1.30E-02	2.32E+00	1.73E-02
EU-27: Louvrelight integrated into ceiling 2X T5 28W (EN15804 A1-A3)	#	2.53E+01	3.12E-09	8.70E-02	7.63E-03	8.20E-03	1.10E-04	2.93E+02	8.08E-08	4.76E-06	6.95E-01	1.18E-02	2.07E+00	1.54E-02
EU-27: Louvrelight integrated into ceiling 3X T5 14W (EN15804 A1-A3) t	#	2.53E+01	3.42E-09	8.74E-02	7.65E-03	7.81E-03	9.41E-05	2.94E+02	7.56E-08	4.19E-06	7.35E-01	0.00E+00	2.26E+00	1.51E-02
EU-27: Louvrelight integrated into ceiling 3X T8 18W (EN15804 A1-A3) t	#	2.72E+01	3.67E-09	9.40E-02	8.24E-03	8.42E-03	1.02E-04	3.16E+02	8.16E-08	4.53E-06	7.89E-01	0.00E+00	2.42E+00	1.62E-02
EU-27: Low-loss ballast LLB (EN15804 A1-A3) ts	#	3.29E+00	1.24E-10	1.41E-02	9.85E-04	1.43E-03	2.37E-04	4.62E+01	1.53E-08	1.12E-06	1.15E-01	0.00E+00	1.43E-01	2.30E-03
EU-27: Power outlet (EN15804 A1-A3) ts	#	3.37E-01	4.41E-11	9.50E-04	1.01E-04	1.16E-04	1.01E-04	5.33E+00	1.78E-09	4.92E-08	1.18E-02	0.00E+00	2.86E-02	1.95E-04
EU-27: Elevator component (dependent on floor) (EN15804 A1-A3) ts	floor	7.36E+02	8.56E-09	3.30E+00	2.30E-01	3.41E-01	4.64E-02	7.88E+03	4.58E-06	2.45E-04	1.25E+01	0.00E+00	9.86E+00	6.27E-01
EU-27: Escalator component dependent on lifting height (EN15804 A1-	m liftir	1.95E+03	7.42E-08	8.34E+00	6.42E-01	8.18E-01	1.63E-01	2.15E+04	1.16E-05	5.47E-04	1.41E+02	0.00E+00	5.57E+01	2.22E+00
AU: Electricity from natural gas ts	kWh	6.50E-01	2.31E-14	9.77E-04	2.39E-04	9.01E-05	0.00E+00	0.00E+00	1.37E-07	1.28E-09	2.55E-04	1.74E-02	2.50E-05	2.86E-05
AU: Electricity from photovoltaic ts	kWh	2.52E-02	6.52E-12	9.23E-05	7.51E-06	1.36E-05	0.00E+00	0.00E+00	2.97E-10	8.08E-09	5.37E-03	1.84E-02	3.18E-03	2.72E-05
AU: Electricity from wind power ts	kWh	5.67E-03	9.81E-14	1.71E-05	1.80E-06	9.21E-07	0.00E+00	0.00E+00	3.95E-11	8.71E-10	1.87E-03	2.11E-02	1.82E-04	4.10E-06
AU: Electricity grid mix ts	kWh	9.68E-01	1.77E-13	4.19E-03	3.53E-04	2.22E-04	4.48E-08	1.10E+01	3.01E-08	2.65E-08	1.37E-02	2.64E-02	1.51E-04	5.36E-04
AU: Thermal energy from light fuel oil (LFO) ts	MJ	8.43E-02	5.14E-15	1.12E-04	1.65E-05	1.28E-05	1.21E-09	1.13E+00	3.73E-10	8.38E-10	6.80E-05	6.05E-02	5.87E-06	6.71E-06

GaBi Process / Source	Unit	CML2001 - Apr. 2013, Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2-Equiv.]	CML2001 - Apr. 2013, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]	CML2001 - Apr. 2013, Acidification Potential (AP) [kg SO2-Equiv.]	CML2001 - Apr. 2013, Eutrophication Potential (EP) [kg Phosphate-Equiv.]	CML2001 - Apr. 2013, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP elements) [kg Sb-Equiv.]	CML2001 - Apr. 2013, Abiotic Depletion (ADP fossil) [MJ]	USEtox 2.01, Human toxicity, cancer (recommended and interim) [CTUh]	USEtox 2.01, Human toxicity, non-canc. (recommended and interim) [CTUh]	Land Transformation Indicator [sqm]	ReCiPe 1.08 Midpoint (H) - Water depletion [m3]	Ionizing radiation midpoint, human health (v1.06) [kBq U235 eq]	TRACI 2.1, Human Health Particulate Air [kg PM2,5-Equiv.]
AU: Thermal energy from natural gas ts	MJ	6.49E-02	2.96E-15	9.76E-05	2.38E-05	8.99E-06	3.90E-09	1.11E+00	1.36E-08	1.31E-10	3.72E-05	6.18E-02	3.75E-06	2.89E-06
EU-27: Thermal energy from LPG ts	m3	8.47E-02	3.98E-13	1.24E-04	1.50E-05	1.96E-05	2.60E-09	1.18E+00	5.21E-10	2.11E-09	4.10E-04	2.64E-02	2.52E-04	1.05E-05
EU-27: Process water ts	m3	3.74E+00	7.57E-10	8.54E-03	1.88E-03	7.95E-04	3.94E-05	4.96E+01	1.38E-08	2.20E-07	2.67E-01	2.10E-02	5.95E-01	7.72E-04
EU-27: Tap water ts	m3	3.51E-01	2.35E-11	8.58E-04	2.48E-04	8.52E-05	2.45E-07	5.38E+00	3.03E-09	5.59E-08	1.16E-02	3.01E-02	1.92E-02	2.25E-03
EU-27: Articulated lorry transport ts	tkm	4.74E-02	2.16E-13	2.99E-04	7.49E-05	-1.26E-04	3.12E-09	6.46E-01	2.94E-10	4.04E-09	4.06E-03	2.17E-02	1.35E-04	9.96E-06
EU-27: Lorry transport ts	tkm	6.01E-02	2.73E-13	3.72E-04	9.34E-05	-1.56E-04	3.96E-09	8.18E-01	3.72E-10	5.12E-09	5.14E-03	1.63E-02	1.71E-04	1.30E-05
GLO: Car diesel ts <u-so>	km	8.99E-02	0.00E+00	5.31E-04	1.40E-04	-2.04E-04	0.00E+00	0.00E+00	7.99E-14	2.02E-14	0.00E+00	1.84E-02	0.00E+00	3.94E-05
GLO: Car petrol ts <u-so>	km	1.36E-01	0.00E+00	1.11E-04	2.61E-05	1.65E-07	0.00E+00	0.00E+00	2.95E-13	7.48E-14	0.00E+00	2.11E-02	0.00E+00	5.12E-06
GLO: Cargo plane ts <u-so>	tkm	2.09E+00	0.00E+00	4.25E-01	1.01E-01	3.92E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-02	0.00E+00	8.63E-03
GLO: Container ship ts <u-so>	tkm	1.26E-02	0.00E+00	4.22E-04	4.32E-05	2.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E-02	0.00E+00	2.33E-05
EU-27: Municipal waste water treatment (mix) ts	m3	7.55E-01	1.20E-10	4.90E-03	7.25E-03	2.75E-04	-3.41E-07	1.82E+00	7.22E-08	5.59E-07	2.27E-02	2.10E-02	7.77E-02	3.67E-04
<assumed these materials have no recycling process required>	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BlueScope EPD - Steel welded beams and columns	kg	2.37E-02	0.00E+00	7.75E-05	6.01E-06	3.69E-09	3.23E-01	3.23E-01						
DE: Crushed stone 16/32 ts	kg	1.27E-02	6.48E-13	2.03E-05	3.72E-06	1.41E-06	0.00E+00	0.00E+00	2.20E-11	6.72E-10	1.22E-03	1.63E-02	1.25E-03	1.16E-03
BlueScope EPD - Steel welded beams and columns	kg	1.12E-03	3.29E-14	5.17E-06	8.94E-07	6.26E-07	1.73E-10	1.60E-02						
BlueScope EPD - Steel welded beams and columns	kg	-1.22E+00	0.00E+00	-2.91E-03	-8.03E-05	-6.50E-04	-1.67E-07	-1.28E+01						
DE: Inert matter (Construction waste) on landfill ts	kg	1.59E-02	1.58E-13	9.62E-05	1.31E-05	9.24E-06	5.55E-09	2.09E-01	2.23E-10	1.76E-08	1.13E-03	2.17E-02	2.93E-04	2.51E-04
EU-27: Commercial waste (AT, DE, IT, LU, NL, SE, CH) on landfill ts <p	kg	1.23E-01	2.01E-12	2.45E-04	9.14E-04	7.25E-05	1.06E-08	7.58E-01	7.09E-10	2.92E-08	1.72E-03	1.63E-02	1.59E-03	2.96E-04
EU-27: Ferro metals on landfill ts	kg	4.87E-02	1.79E-12	1.39E-04	1.70E-05	1.55E-05	9.36E-09	6.97E-01	3.01E-10	2.20E-08	1.54E-03	1.74E-02	1.41E-03	2.54E-04
EU-27: Glass/inert waste on landfill ts	kg	1.59E-02	1.77E-13	9.63E-05	1.31E-05	9.25E-06	5.54E-09	2.09E-01	2.23E-10	1.76E-08	1.05E-03	1.84E-02	3.00E-04	2.51E-04
EU-27: Plastic waste on landfill ts	kg	7.15E-02	2.68E-12	1.98E-04	1.96E-04	2.57E-05	1.39E-08	1.02E+00	8.72E-10	3.90E-08	2.17E-03	2.11E-02	2.12E-03	3.79E-04
EU-27: Untreated wood on landfill ts <p-agg>	kg	7.25E-02	2.68E-12	3.57E-04	1.77E-04	1.20E-04	1.39E-08	1.02E+00	4.54E-10	3.31E-08	2.17E-03	2.64E-02	2.12E-03	3.90E-04
EU-27: Wood products (OSB, particle board) on landfill ts <p-agg>	kg	7.25E-02	2.68E-12	3.60E-04	1.35E-03	1.21E-04	1.39E-08	1.02E+00	4.54E-10	3.31E-08	2.17E-03	2.27E-02	2.12E-03	3.90E-04
Timber stud wall (no insulation)	m2	8.53E+00	3.27E-07	3.19E-02	5.61E-03	3.82E-03	0.00E+00	0.00E+00	1.93E-08	4.72E-07	8.62E+01	0.00E+00	8.77E-01	2.18E-02
Barangaroo R7 facade	m2	1.73E+02	3.86E-08	7.41E-01	7.25E-02	5.34E-02	2.94E-03	2.09E+03	7.42E-07	3.92E-05	6.41E+00	7.26E-01	2.00E+01	2.45E-01
DE: Mullion-transom system aluminium ts <p-agg>	m2	5.12E+01	1.69E-08	1.79E-01	1.41E-02	1.23E-02	0.00E+00	0.00E+00	1.52E-07	4.74E-06	5.90E+00	0.00E+00	9.54E+00	2.48E-02
DE: Mullion-transom system aluminium with three pane insulation glas	m2	1.12E+02	2.25E-08	4.22E-01	5.47E-02	3.18E-02	0.00E+00	0.00E+00	2.63E-07	7.52E-06	1.34E+01	0.00E+00	1.37E+01	2.12E-01
DE: Mullion-transom system steel and glass facade (3 panes insulatic	m2	8.79E+01	1.55E-09	3.38E-01	5.19E-02	3.19E-02	0.00E+00	0.00E+00	3.15E-07	1.54E-05	1.19E+01	0.00E+00	2.80E+00	2.00E-01
DE: Mullion-transom system steel ts <p-agg>	m2	3.26E+01	8.03E-10	1.15E-01	1.20E-02	1.25E-02	0.00E+00	0.00E+00	1.92E-07	1.08E-05	4.75E+00	0.00E+00	1.16E+00	1.55E-02
LCA of OSRAM halogen lamp - http://www.osram-group.com/en/sust	#	3.29E-01		7.55E-04	6.51E-05	4.81E-04		5.50E+00						
LCA of OSRAM CFL - http://www.osram-group.com/en/sustainability	#	8.80E-01		4.80E-03	2.40E-04	2.80E-04	5.20E-03	1.47E+01						
LCA of OSRAM LED - http://www.osram-group.com/en/sustainability	#	2.40E+00		1.70E-02	8.00E-04	1.30E-03	1.30E-02	3.56E+01						
DE: Sun protection (metal blinds) ts	m2	2.20E+01	7.78E-09	9.68E-02	6.76E-03	6.06E-03	2.87E-04	2.49E+02	6.73E-08	2.66E-06	3.36E+00	0.00E+00	1.83E+00	1.31E-02
DE: Sun protection (textile) ts	m2	4.81E+00	2.05E-10	6.60E-03	1.31E-03	1.49E-03	5.33E-06	8.26E+01	3.61E-08	2.52E-06	3.52E+00	0.00E+00	2.62E-01	6.11E-04
Interface Nylon 6 Modular Carpet	m2	7.31E+00	4.29E-06	3.63E-02	4.72E-03	3.33E-03	1.82E+02	1.12E+02						
Armstrong OPTIMA EPD	m2	1.96E+00	1.14E-07	1.50E-02	4.27E-04	4.42E-01		3.12E+00						
EU-27: Application coating silicate emulsion (building, exterior, white) [	m2	1.24E+00	1.80E-10	6.34E-03	4.28E-04	5.32E-04	6.42E-06	2.27E+01	6.67E-08	6.99E-06	7.97E-02	0.00E+00	1.21E-01	1.46E-03
EU-27: Application coating silicone (building, exterior, white) (A1-A3) ts	m2	1.19E+00	1.16E-10	1.68E-02	3.96E-04	7.66E-04	2.15E-05	1.91E+01	8.15E-09	1.37E-07	1.78E-01	0.00E+00	8.24E-02	3.07E-03
EU-27: Application paint emulsion (building, interior, white, wear resista	m2	2.41E+00	4.02E-10	1.10E-02	7.53E-04	1.46E-03	2.66E-06	5.27E+01	1.35E-07	1.37E-05	9.32E-02	0.00E+00	2.57E-01	1.13E-03
EU-27: Application primer emulsion (building, exterior, white) (A1-A3) ts	m2	8.07E-01	9.36E-11	2.90E-03	2.46E-04	4.14E-04	1.46E-06	1.73E+01	2.76E-08	2.68E-06	3.19E-02	0.00E+00	6.64E-02	2.30E-03
EU-27: Paint emulsion (building, exterior, white) (EN15804 A1-A3) ts	m2	1.90E+00	3.29E-10	9.91E-03	6.49E-04	1.04E-03	2.84E-06	3.88E+01	1.22E-07	1.27E-05	7.56E-02	0.00E+00	2.01E-01	2.44E-03
Apartment fitout (Parkville) <u-so>	m2	4.77E+01	1.96E-07	1.14E-01	1.91E-02	5.83E-03	5.74E-05	3.16E+02	1.94E-07	6.58E-06	4.58E+01	0.00E+00	2.26E+00	9.98E-02
EU-27: Cement (CEM I 32.5) (EN15804 A1-A3) ts	kg		3.84E-11	1.29E-03	1.81E-04	1.47E-04	0.00E+00	0.00E+00	1.38E-09	8.10E-08	6.69E-03	0.00E+00	2.29E-02	1.91E-04
EU-27: Cement (CEM I 42.5) (EN15804 A1-A3) ts	kg	8.42E-01	4.46E-11	1.31E-03	1.83E-04	1.48E-04	0.00E+00	0.00E+00	1.39E-09	8.12E-08	7.36E-03	0.00E+00	2.66E-02	1.93E-04
EU-27: Cement (CEM I 52.5) (EN15804 A1-A3) ts	kg	8.57E-01	5.50E-11	1.35E-03	1.87E-04	1.51E-04	0.00E+00	0.00E+00	1.40E-09	8.17E-08	8.48E-03	0.00E+00	3.28E-02	1.96E-04
EU-27: Cement (CEM II 32.5) (EN15804 A1-A3) ts	kg	6.72E-01	3.50E-11	1.06E-03	1.48E-04	1.18E-04	0.00E+00	0.00E+00	1.10E-09	6.40E-08	6.10E-03	0.00E+00	2.09E-02	1.80E-04
EU-27: Cement (CEM II 42.5) (EN15804 A1-A3) ts	kg	6.81E-01	4.14E-11	1.08E-03	1.50E-04	1.20E-04	0.00E+00	0.00E+00	1.11E-09	6.43E-08	6.79E-03	0.00E+00	2.47E-02	1.82E-04
EU-27: Cement (CEM II 52.5) (EN15804 A1-A3) ts	kg	6.92E-01	4.97E-11	1.12E-03	1.53E-04	1.22E-04	1.36E-06	2.70E+00	1.12E-09	6.47E-08	7.68E-03	0.00E+00	2.96E-02	1.84E-04
EU-27: Cement (CEM II/A) (EN15804 A1-A3) ts	kg	7.47E-01	4.43E-11	1.18E-03	1.64E-04	1.32E-04	1.61E-06	2.78E+00	1.22E-09	7.10E-08	7.19E-03	0.00E+00	2.64E-02	1.87E-04
EU-27: Cement (CEM II/B) (EN15804 A1-A3) ts	kg	6.18E-01	3.98E-11	9.92E-04	1.37E-04	1.08E-04	1.14E-06	2.39E+00	1.00E-09	5.80E-08	6.54E-03	0.00E+00	2.38E-02	1.77E-04

Project Name: The Star - North Tower
Project Number: SYD1533500
Created by: SNH
Checked & Approved by:
Revision (Date issued) Rev 04 (27/02/2017)
Reference Files: SYD1533500 GS D&AB v1.1 The North Tower Scorecard Rev04.xls



Green Star - Design & As Built Scorecard

	Points Targeted
Total base points	58.0
Total score (base points + innovation)	66.0

CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Management						
Green Star Accredited Professional	To recognise the appointment and active involvement of a Green Star Accredited Professional in order to ensure that the rating tool is applied effectively and as intended.	1.0	**Accredited Professional** 1 point is available where a Green Star Accredited Professional (GSAP) has been contractually engaged to provide advice, support and information related to Green Star principles, structure, timing and processes, at all stages of the project, leading to certification.	1	1	WSP to fulfill this role through our engagement on the project
Commissioning and Tuning	To encourage and recognise commissioning, handover and tuning initiatives that ensure all building services operate to their full potential.	2.0	**Environmental Performance Targets** For the project to be awarded points for this credit, documented targets for the environmental performance of the project must be set.	-	Complies	Achievable
		2.1	**Services and Maintainability Review** 1 point is available where a comprehensive services and maintainability review of the project is performed.	1	1	Requires review of design and implementation of recommendations by the owners representitive for: Comisisonability; Controllability; Maintainability; Operability, including 'Fit for Purpose'; and Safety.
		2.2	**Building Commissioning** 1 point is available where a comprehensive services and maintainability review of the project is performed.	1	1	Achievable
		2.3	**Building Systems Tuning** 1 point is available where a tuning process is in place that addresses all nominated building systems.	1	1	Achievable. Requires comitment to tuning process prior to occupation and during the first 12 months after occupation
		2.4	**Independent Commissioning Agent** 1 additional point is available for utilisation of an Independent Commissioning Agent (ICA) to advise, monitor and verify the commissioning and tuning of the nominated building systems throughout the design, tender, construction, commissioning and tuning phases.	1	1	Requires the appointment of an independent comissioning agent from Schematic design stage onwards.

Green Star - Design & As Built Scorecard

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Adaptation and Resilience	To encourage and recognise projects that are resilient to the impacts of a changing climate and natural disasters.	3.1	**Implementation of a Climate Adaptation Plan** 2 points are available where: • A project specific climate adaptation plan has been developed in accordance with a recognized standard • Solutions have been included into the building design and construction that specifically address the risk assessment component of the adaptation plan	2	2	Climate Action Plan has been developed in accordance with the credit criteria.
Building Information	To recognise the development and provision of building information that facilitates understanding of a building's systems, operation and maintenance requirements, and environmental targets to enable the optimised performance.	4.1	**Building Operations and Maintenance Information** 1 point is available where it is demonstrated that comprehensive Operations and Maintenance information is developed and made available to the facilities management team	1	1	Requires development of this documentation and transmittal to building owner.
		4.2	**Building User Information** 1 point is available where relevant and current building user information is developed and made available to all relevant stakeholders	1	1	
Commitment to Performance	To recognise practices that encourage building owners, building occupants and facilities management teams to set targets and monitor environmental performance in a collaborative way.	5.1	**Environmental Building Performance** 1 point is available where strata management commit to set targets and measure results for environmental performance - energy, water , operational waste and indoor environment quality. Results must be reported quarterly.	1	1	Requires commitment to set targets and measure results for the environmental performance of the building
		5.2	**End of Life Waste Performance** 1 point is available where strata management commit to set targets and measure results that minimise construction waste from end of life of interior fitouts or other building attributes.	1	1	Requires commitment to set targets and measure results for the end of life waste construction waste from building interiors
Metering and Monitoring	To recognise the implementation of effective energy and water metering and monitoring systems.	6.0	**Metering Strategy** To qualify for points under this credit it is a conditional requirement that accessible metering be provided to monitor building energy and water consumption, including all energy and water common and major uses, and sources	-	Complies	Requires comprehensive energy and water metering and monitoring system, addressing all major uses, systems and floors
		6.1	**Monitoring Systems** 1 point is available where a monitoring strategy is addressed through a monitoring system, capable of capturing and processing the data produced by the installed energy and water meters, and accurately and clearly presenting data consumption trends	1	1	
Construction Environmental Management	To reward projects that use best practice formal environmental management procedures during construction.	7.0	**Environmental Management Plan** The conditional requirement is met where a comprehensive project-specific Environmental Management Plan (EMP) is in place for construction	-	Complies	Head contractor to have comprehensive Environmental Management Plan
		7.1	**Formalised Environmental Management System** 1 point is available where a formalized systematic and methodical approach to planning, implementing and auditing, is in place during construction, to ensure conformance with the EMP	1	1	Requires a formalised, systematic and methodical approach to planning, implementing and auditing is in place during construction

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Operational Waste	Prescriptive Pathway	8A	**Performance Pathway - Specialist Plan** 1 point is available where a waste professional specialist, prepares and implements an Operational Waste Management Plan (OWMP) for the project in accordance with best practice approaches and this is reflected in the building's design.	1	1	WSP to produce Operational Waste Management Plan (OWMP).
		8B	**Prescriptive Pathway - Facilities** 1 point is available where facilities are in place to collect and separate distinct waste streams, and where these facilities meet best practice access requirements for collection by the relevant waste contractor.	-		
Total				**14**	**14**	

Indoor Environment Quality						
Indoor Air Quality	To recognise projects that provide high air quality to occupants.	9.1	**Ventilation System Attributes** 1 point is available where: The entry of outdoor pollutants is mitigated; the system is designed for ease of maintenance and cleaning; and the system has been cleaned prior to occupation and use	1	1	- Entry of outdoor pollutants is mitigated - System designed for ease of maintenance and cleaning - System is cleaned prior to occupation
		9.2	**Provision of Outdoor Air** 2 points are available where the nominated area is provided with sufficient outdoor air to ensure levels of indoor pollutant are maintained at acceptable levels. Options are available for mechanically and naturally ventilated buildings and for outdoor air provision or contaminant monitoring. For mechanically ventilated, or mixed-mode spaces: • 1 point is awarded where outdoor air is provided at a rate 50% greater than the minimum required by AS 1668.2:2012, or CO2 concentrations are maintained below 800ppm; or • 2 points are available where outdoor air is provided at a rate 100% greater than the minimum required by AS 1668.2:2012, or CO2 concentrations are maintained below 700ppm. For naturally ventilated spaces, two (2) points are awarded where the requirements of AS 1668.42012 are met. The nominated area must be provided with a quantity of outdoor air appropriate for the activities and conditions in the space.	2		Requires increase in size of outside air ductwork, increased cooling capacity, energy penalty. One point may be achieved already through mechanical operational strategy. To be determined as design develops.
		9.3	**Exhaust or Elimination of Pollutants** 1 point is available where nominated pollutants, such as those arising from printing equipment, cooking processes and equipment, and vehicle exhaust, are limited by either removing the source of pollutants from the nominated area, or exhausting the pollutants directly to the outside while limiting their entry into other areas of the project	1	1	Requires the elimination or exhaust of pollutants from printing, cooking and vehicle exhausts

Green Star - Design & As Built Scorecard

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Acoustic Comfort	To reward projects that provide appropriate and comfortable acoustic conditions for occupants.	10.1	**Internal Noise Levels** 1 point is available where internal ambient noise levels in the nominated area are suitable and relevant to the activity type in the room. This includes all sound generated by the building systems and any external noise ingress.	1	1	Requires internal noise levels to comply with AS2107. Ritz-Carlton requirements TBC
		10.2	**Reverberation** 1 point is available where the nominated area has been built to reduce the persistence of sound to a level suitable to the activities in the space.	1	1	Requires reverberation times to comply with AS2107. Ritz-Carlton requirements TBC
		10.3	**Acoustic Separation** 1 point is available where the nominated enclosed spaces have been built to minimise crosstalk between rooms and between rooms and open areas following 10.3A or 10.3B	1	1	Acoustics advise this can be targeted without major design changes BCA requirements
Lighting Comfort	To encourage and recognise well-lit spaces that provide a high degree of comfort to users.	11.0	**Minimum Lighting Comfort** Lights must be flicker free and acurately address the perception of colour in the space.	-	Complies	Lighting to be flicker free and have a CRI of 80 or above
		11.1	**General Illuminance and Glare Reduction** 1 point is available where: - Lighting design includes or permits general fixed lighting that provides good maintained illuminance values for the entire room; AND - The installed fittings all have fittings with rated colour variation not exceeding 3 MacAdam Ellipses, AND - Glare is eliminated	1	1	Lighting to be appropriate level for the task/area and designed to be free from glare
		11.2	**Surface Illuminance** 1 point if available where, in the nominated area, a combination of lighting and surfaces improve uniformity of lighting to give visual interest	1		Multiplex advise that this point can be costly on a prject of this scale
		11.3	**Localised Lighting Control** 1 point is available where, in the nominated area, occupants have the ability to control the lighting in their immediate environment	1	1	Design to allow for occupants to control lighting levels within their immediate environment.
Visual Comfort	To recognise the delivery of well-lit spaces that provide high levels of visual comfort to building occupants.	12.0	**Glare Reduction** The conditional requirement is met where the glare in the nominated area from sunlight through all viewing facades is reduced through a combination of blinds, screens, fixed devices, or other means	-	Complies	Blinds, screens, fixed devices or other means incorporated to provide glare control measures
		12.1	**Daylight** Up to 2 points are available where a percentage of the nominated area receives high levels of daylight during 80% of the nominated areas 40% Nominated Area – 1 point 60% Nominated Area – 2 points	2	2	Building glazing and floor plate orientation to provide at least 60% of the floor area with daylighting
		12.2	**Views** 1 point is available where 60% of the nominated area has a clear line of sight to a high quality internal or external view	1	1	Building glazing and floor plate orientation to provide at least 60% of the floor area with high quality external views
Indoor Pollutants	To recognise projects that safeguard occupant health through the reduction in internal air pollutant levels.	13.1	**Paints, Adhesives, Sealants and Carpets** 1 point is available where at least 95% of all internally applied paints, adhesives, sealants and carpets meet stipulated Total VOC Limits or where no paints, adhesives, sealants, or carpets are used in the building	1	1	95% of all paints, adhesives, sealants, carpets meet the TVOC requirements of the GBCA
		13.2	**Engineered Wood Products** 1 point is available where at least 95% of all engineered wood products meet stipulated formaldehyde limits or no new engineered wood products are used in the building	1	1	95% of all engineered wood products meet the formaldehye emission limits of the GBCA

Green Star - Design & As Built Scorecard

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Total base points	58.0
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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Thermal Comfort	To encourage and recognise projects that achieve high levels of thermal comfort.	14.1	**Thermal Comfort** 1 point is available where a high degree of thermal comfort is provided to occupants in the space, equivalent to 80% of all occupants being satisfied in the space.	1	1	A high degree of themal comfort is provided where 80% of occupants are are satisfied in the space
		14.2	**Advanced Thermal Comfort** 1 additional point is available where a high degree of thermal comfort is provided to occupants in the space, equivalent to 90% of all occupants being satisfied in the space.	1	0	A higher degree of themal comfort is provided where 90% of occupants are are satisfied in the space. May not be achieved due to radiant heat through glass
Total				**17**	**13**	

Energy						
Greenhouse Gas Emissions	E. Modelled Performance Pathway	15E.0	Conditional Requirement: Reference Building Pathway	-	Complies	
		15E.1	**Comparison to a Reference Building Pathway** Up to 20 out of 20 points are available where it is demonstrated that there is a specified reduction in the predicted energy consumption and GHG emissions of the proposed building. Points are awarded based both on improvements to the building's façade, and on the project's predicted ability to reduce its energy consumption and emissions towards net zero	20	9	Will require efficient building fabric, high performance glazing, mechanical services and lighting design system To be achieved through highly efficient façade and services design trigeneration will have major impact Preliminary modelling suggests that more points may be achievable, however conservatively only targeting 9 points at this stage
Peak Electricity Demand Reduction	Performance Pathway	16A	**Prescriptive Pathway - On-site Energy Generation** 1 out of 2 points are available where it is demonstrated that the use of on-site electricity generation systems reduces the total peak electricity demand by at least 15%	-		
		16B	**Performance Pathway - Reference Building** Up to 2 points are available where it is demonstrated that the project's predicted peak electricity demand has been reduced below that of a 'Reference Building': • 0-10%: 0 point • 20%: 1 point • 30%: 2 points	2	2	Achievable through trigeneration system
Total				**22**	**11**	

Green Star - Design & As Built Scorecard

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Transport						
Sustainable Transport	Prescriptive Pathway	17A.1	**Performance Pathway** Up to 10 points are available where the proposed transport solutions on site decreases emissions from transport, decreases mental and social impacts of commuting, and encourages healthier uptake of active transport options.	10		Requires development of sustainable transportation plan which demonstrates a decrease in greenhouse gas emissions from transport, decreases mental and social impacts of commuting and encourages the use of healthier transportation options.
		17B.1	**Access by Public Transport** Up to 3 points are available based on the accessibility of the site by public transport.	3	2	Project location achieves 2 points in the public transportation calculator
		17B.2	**Reduced Car Parking Provision** 1 point is available where there is reduction of car parking spaces in the proposed building.	1	1	Demonstrate a reduced carparking provision compared with a reference building
		17B.3	**Low Emission Vehicle Infrastructure** 1 point is available where parking spaces and/or dedicated infrastructure is provided to support the uptake of low emission vehicles.	1	1	TBC - Difficult to provide preferential treatment in car stacker - recommend submitting CIR to GBCA to confirm approach. Requires 15% of parking dedicated for fuel efficient vehicles and 5% of parking for electric vehicles and charging infrastructure provided. Assuming 150 spaces, this would mean either: - 23 spaces dedicated for fuel efficient vehicles, of which a maximum of 8 are motorcycles - 8 spaces dedicated for electric vehicles and charging infrastructure is provided
		17B.4	**Active Transport Facilities** 1 point is available where bicycle parking and associated facilities are provided to regular occupants and visitors.	1	0	GS requirements as follows - Bicycle parking (DCP requires approximately 20 spaces for staff and 40 for visitors) - 10 parking spaces for regular occupants (staff) - 150 for visitors (hotel, serviced apartments and restaurant guests) End of trip (DCP requires 2 showers nad 20 lockers) - 4 showers - 8 lockers - showers (13-49 staff = 2 showers, 50-149 staff = 4 showers, 150-299 staff = 6 showers, 300-500 staff = 8 showers)
		17B.5	**Walkable Neighbourhoods** 1 point is available where the project is located conveniently to amenities or the project achieves a specified walk score	1	1	Requires a walk score of > 80%. Location achieves requirements for this credit.
Total				**10**	**5**	

Green Star - Design & As Built Scorecard

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Water						
Potable Water	Performance Pathway	18A.1	**Potable Water - Performance Pathway** Up to 12 points are available based on the magnitude of the predicted reduction in potable water consumption, when the project is compared against a reference building.	12		Project team to determine final pathway during detail design phase, currently, the prescriptive pathway is the preferred pathway.
		18B.1	**Sanitary Fixture Efficiency** 1 point is awared where all fixtures are within one star of the WELS rating	1		N/A performance pathway targeted
		18B.2	**Rainwater Reuse** 1 point is awarded when a rainwater tank is installed to collect and reuse rainwater, within the project's site boundary, and the rainwater tank is sized accordingly.	1		N/A performance pathway targeted
		18B.3	**Heat Rejection** 2 points are awarded where no water is used for heat rejection. To comply the project must be either naturally ventilated (allowing for the use of ceilin fans or similar) or the HVAC system must not use water for heat rejection. To claim the project is naturally ventilated, it must be demonstrated that the building is naturally ventilated in accordance with AS1668.4-2012. To claim that no water based heat rejection system is used, it must be demonstrated that the air conditioning needs of the project are met by means other than water based heat rejection.	2	2	achievable through the upgraded harbour heat rejetion system
		18B.4	**Landscape Irrigation** 1 point is awarded where either drip irrigation with moisture sensor override is installed or where no potable water is used for irrigation. The landscaping and associated systems must be designed to reduce the consumption of potable water required for irrigation through the installation of subsoil drip irrigation and moisture sensor controls. In the case of a xeriscape garden, the provision of irrigation systems must be able to be removed within three months of landscaping installation and the landscaping must not require watering after this time	1	1	Xeriscape landscaping to be provided
		18B.5	**Fire System Test Water** 1 point is awarded when one of the following conditions is met: - The fire system does not expel water for testing; or - The fire system includes temporary storage for 80% of the routine fire protection system test water and maintenance drain-downs for reuse on-site. If sprinkler systems are installed, each floor must be fitted with isolation valves or shut-off points for floor by floor testing.	1		N/A performance pathway targeted
Total				**12**	**3**	

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CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Materials						
Life Cycle Impacts	Performance Pathway - Life Cycle Assessment	19A.1	**Comparative Life Cycle Assessment** Up to 6 points are available where a whole-of-building whole-of-life (cradle-to-grave) life cycle assessment (LCA) is conducted for the project and a reference building. Points are awarded based on the extent of environmental impacts reduction achieved against six environmental impacts categories, when compared to a reference building.	6	6	A preliminary cradle to grave life cycle assessment (LCA) has been completed on the project demonstrating reduced impact of 6 environmental targets compared with a reference building.the full 6 points has been confirmed at this stage.
		19A.2	**Additional Life Cycle Impact Reporting** 1 additional point is available where the LCA conducted by project includes reporting of five impact categories in addition to those required under the Comparative Life Cycle Assessment credit element.	1	1	A preliminary cradle to grave life cycle assessment (LCA) has included reporting of 5 additional impact catagories in addition to those required in the above credit
Responsible Building Materials	To reward projects that include materials that are responsibly sourced or have a sustainable supply chain.	20.1	**Structural and Reinforcing Steel** 1 point is available where 95% of the building's steel is sourced from a Responsible Steel Maker; and • For steel framed buildings, at least 60% of the fabricated structural steelwork is supplied by a steel fabricator/steel contractor accredited to the Environmental Sustainability Charter of the Australian Steel Institute (ASI); or • For concrete framed buildings, at least 60% (by mass) of all reinforcing bar and mesh is produced using energy-reducing processed in its manufacture (measured by average mass by steel maker annually.	1	1	Requires steel to be sourced from responsible manufacturers and using energy reducing technologies during manufacture.
		20.2	**Timber Products** 1 point is available where at least 95% (by cost) of all timber used in the building and construction works is either: • Certified by a forest certification scheme that meets the GBCA's Essential' criteria for forest certification; or • Is from a reused source.	1		95% by cost of timber on the project is to be sustainably sourced through either environmental certification or reused. Multiplex advises that this can be costly to achieve during construction phase
		20.3	**Permanent Formwork, Pipes, Flooring, Blinds and Cables** 1 point is available where 90% (by cost) of all cables, pipes, flooring and blinds in a project either: • Do not contain PVC and have an Environmental Product Declaration (EPD); or • Meet Best Practice Guidelines for PVC.	1	1	90 % by cost of all permanent formwork, pipes, flooring
Sustainable Products	To encourage sustainability and transparency in product specification.	21.1	**Product Transparency and Sustainability** Up to 3 points are available when product meet transparency and sustainability requirements under on of the following initiatives: A. Resued Products; B. Recycled Content Products; C. Environmental Product Declarations; D. Third-Party Certification; or E. Stewardship Programs. Points are calculated based on specified benchmarks for the percentage of compliant products used in the project.	3	0	Opportunity to target 3 points by procuring Australian Steel - both One Steel and BlueScope have published Environmental Product Declarations (EPDs) covering structural and reinforcing steel which will score well in PSV calculations due to high portion steel in contract value. Point are achieved where: - 1 point where 3% of the value of product compared against the project contract value are achieved - 2 point where 6% of the value of product compared against the project contract value are achieved - 3 point where 9% of the value of product compared against the project contract value are achieved Some steel manufacturers will provide EPD's in 2017, sourcing from these providors would likely result in up to 3 points for this credit

Green Star - Design & As Built Scorecard

	Points Targeted
Total base points	58.0
Total score (base points + innovation)	66.0

CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Construction and Demolition Waste	Percentage Benchmark	22A	**Fixed Benchmark** 1 point is available where the construction waste going to landfill is reduced by not exceed 10kg/m² GFA	-		N/A
		22B	**Percentage Benchmark** 1 point is available where the construction waste going to landfill is reduced by 90% of waste generated being diverted from landfill	1	1	Achieve 90% recycling rate during construction
Total				**14**	**10**	

Land Use & Ecology						
Ecological Value	To reward projects that improve the ecological value of their site.	23.0	**Endangered, Threatened or Vulnerable Species** To be awarded points in this credit, the project must demonstrate that no critically endangered, endangered, or vulnerable species or ecological communities were present on the site at time of purchase. It is a minimum requirement of this credit that a check is carried out to ensure that the site does not contain 'critically endangered, endangered, or vulnerable species or ecological communities as defined in the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).	-	Complies	Achieved
		23.1	**Ecological Value** Up to 3 points are awarded where the ecological value of the site is improved by the project. The number of points awarded is determined by the Green Star – Change of Ecological Value Calculator based on a comparison of the condition of the site before and after design/construction.	3	0	Site has zero ecological value currently, landscaping will improve ecological value. If native vegetation is planted on club loung terrace then 1.7 points may be achieved
Sustainable Sites	To reward projects that choose to develop sites that have limited ecological value, re-use previously developed land and remediate contaminate land.	24.0	**Conditional Requirement** The Conditional Requirement is met where, at the date of site purchase or date of option contract, the project site did not include old growth forest or wetland of 'High National Importance', or did not impact on 'Matters of National Significance'.	-	Complies	Achieved
		24.1	**Reuse of Land** 1 point is available where 75% of the site was Previously Developed Land at the date of site purchase or (for previously owned land) at the project's Green Star registration date.	1	1	Achieved
		24.2	**Contamination and Hazardous Materials** 1 point is available where the site, or an existing building, was previously contaminated and the site has been remediated in accordance with a best practice remediation strategy.	1	0	Requires survey and existing building remediation where the project site is located

Green Star - Design & As Built Scorecard

	Points Targeted
Total base points	58.0
Total score (base points + innovation)	66.0

CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Heat Island Effect	To encourage and recognise projects that reduce the contribution of the project site to the heat island effect.	25.0	**Heat Island Effect Reduction** 1 point is available if at least 75% of the total project site area comprises: * Landscaping * Roofing materials with 3 year SRI >64 or initial SRI>82 (for roofs with pitch <15°) * Unshaded hardscape with 3 year SRI of >34 or initial SRI>39 * Shaded hardscaping * Water bodies * Areas to the south of the building which are shaded at the summer solstice	1	0	Will require careful selection of external finishes. Assessment of roofplan indicates that the pitched roof would require and SRI > 34. Landscaped area on the roof plan contributes approximately 25% - if greater than 25% a portion will need an SRI > 64

Green Star - Design & As Built Scorecard

	Points Targeted
Total base points	58.0
Total score (base points + innovation)	66.0

CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Total				**6**	**1**	
Emissions						
Stormwater	To reward projects that minimise peak stormwater flows and reduce pollutants entering public sewer infrastructure.	26.1	**Reduced Peak Discharge** 1 point is available where the post-development peak event discharge from the site does not exceed the pre-development peak event discharge.	1	0	Will require on site stormwater detention. Typically a council requirement and may be achieved with existing infrastructure
		26.2	**Reduced Pollution Targets** 1 additional point is available, where the first point has been achieved and all stormwater discharged from site meets specified Pollution Reduction Targets.	1	0	Will require Gross pollutant traps and filtration prior to discharge. Typically a council requirement and may be achieved with existing infrastructure
Light Pollution	To reward projects that minimise light pollution.	27.0	**Light Pollution to Neighbouring Bodies** For the project to be awarded a point for this credit, the project must comply with AS 4282 'Control of the Obtrusive Effects of Outdoor Lighting'.	-	Complies	requires compliance with standards
		27.1	**Light Pollution to Night Sky** 1 point is available where it can be demonstrated that a specified reduction in light pollution has been achieved by the project. Two options are available for demonstrating a reduction in light pollution.	1	0	Limits amount of upward lighting which does not strike a surface on the building
Microbial Control	To recognise projects that implement systems to minimise the impacts associated with harmful microbes in building systems.	28.0	**Legionella Impacts from Cooling Systems** 1 point is available where the building: • Is naturally ventilated; or • Has waterless heat-rejection systems; or • Has water-based heat rejection systems that included measure for Legionella control and Risk Management.	1	1	Achieved provided evaporative heat rejection system is not utilised.
Refrigerant Impacts	To encourage operational practices that minimise the environmental impacts of refrigeration equipment.	29.0	**Refrigerants Impacts** 1 point is awarded where: The combined Total System Direct Environmental Impact of the refrigerant systems in the building is less than 15; OR The combined Total System Direct Environment Impact (TSDEI) of the refrigerant systems is between 15 and 35, AND a leak detection system is in place; OR All refrigerants in the project have ozone depletion potential of zero, and a global warming potential of 10 or less; OR Where there are no refrigerants employed by nominated building systems, this point is awarded.	1	0	Limits amount of refrigerant used on the project and is difficult to achieve.
Total				**5**	**1**	

Green Star - Design & As Built Scorecard

	Points Targeted
Total base points	58.0
Total score (base points + innovation)	66.0

CATEGORY / CREDIT	AIM OF THE CREDIT / SELECTION	CODE	CREDIT CRITERIA	POINTS AVAILABLE	5 STAR POINTS TARGETED	Comments
Innovation						
Innovative Technology or Process	The project meets the aims of an existing credit using a technology or process that is considered innovative in Australia or the world.	30A	Innovative Technology or Process	10	8	Recommended innovations: - Contractor Education - Financial Transparency - Community Benefits (potentially worth multiple points, target 2) - Energy Metering Integrity - High Performance Site Office (Multiplex to comment) - Local Procurement - Exceeding Green Star Benchmarks - LCA Potential innovation challenges: - Building air tightness - Contributing to industry benchmarking - Occupant engagement
Market Transformation	The project has undertaken a sustainability initiative that substantially contributes to the broader market transformation towards sustainable development in	30B	Market Transformation			
Improving on Green Star Benchmarks	The project has achieved full points in a Green Star credit and demonstrates a substantial improvement on the benchmark required to achieve full points.	30C	Improving on Green Star Benchmarks			
Innovation Challenge	Where the project addresses an sustainability issue not included within any of the Credits in the existing Green Star rating tools.	30D	Innovation Challenge			
Global Sustainability	Project teams may adopt an approved credit from a Global Green Building Rating tool that addresses a sustainability issue that is currently outside the scope of this Green Star	30E	Global Sustainability			
Total				**10**	**8**	

APPENDIX E CLIMATE RISKS AND MITIGATIONS

CLIMATE RISK ASSESSMENT - INITIAL

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk
Precipitation	Changes to rainfall (droughts and intense rainfall)	Inundation of drainage infrastructure with resulting flood damage and safety risk	Financial Infrastructure	Major	Moderate	High
	Changes to rainfall (droughts and intense rainfall)	Water damage to substations and electrical circuitry may result in disruption to electricity supply	Financial Infrastructure	Major	Moderate	High
	Changes to rainfall (droughts and intense rainfall)	Increase in extreme rainfall and hailstorm events may overload roof drainage for buildings and result in water damaged structures and damaged facades (breaking glass)	Financial	Minor	Likely	Medium
	Changes to rainfall (droughts and intense rainfall)	Droughts and changes in rainfall may result in water restrictions	Financial	Minor	Moderate	Low
	Increase in frequency and severity of storms	Increase in intense rainfall could result in damage to properties, causing displacement and disruption of tenant/business activity during clean up	Financial	Minor	Moderate	Low
	Increase in frequency and severity of storms	Increase in intense rainfall and runoff could result in flooding causing damage to structures which may lead to increased insurance premiums for assets	Financial	Minor	Very Unlikely	Low
	Increase in frequency and severity of storms	Increased in intense rainfall events leading to reduced comfort and increased complaints from building occupants and general public passing by or entering the building	Social Reputation	Minor	Moderate	Low
	Changes to rainfall (droughts and intense rainfall)	Increase in intense rainfall and runoff may increase the potential for erosion causing potential infrastructure instability and disruption or safety risk in the event of collapse.	Social Infrastructure	Moderate	Very Unlikely	Low
Sea level rise	Increase in sea level	Potential for inundation infrastructure during storms due to sea level rise resulting flood damage and safety risk	Financial Infrastructure	Major	Moderate	High
Temperature	Increase in mean maximum temperature	Ability to cool critical infrastructure may be effected by extreme heat, leading to system failure or service interruptions	Financial Infrastructure	Major	Unlikely	Medium
	Increased number of hot days over 35°C	HVAC system may experience overload, affecting thermal comfort for building occupants, and increasing HVAC maintenance and operating costs	Financial Infrastructure	Major	Unlikely	Medium
	Increase in mean maximum temperature	Increased mean maximum temperature and solar exposure may lead to greater material degradation and need for building maintenance	Financial	Minor	Moderate	Low
	Increased number of hot days over 35°C	Increased in extreme temperatures may lead to urban heat islands	Social Financial	Moderate	Moderate	Medium
	Increase in mean maximum temperature	Structural building materials may be affected by extreme heat, leading to structural fatigue	Financial Infrastructure	Major	Very Unlikely	Medium
	Increased number of hot days over 35°C	Increase in extreme heat days may result in heat related illness and/or heat stress for workers, visitors and residents	Social	Minor	Likely	Medium
	Increase in risk of bushfires	Increase in number of severe fire weather risk days leading to exposure to smoke and particulate pollution for workers, visitors and residents that may cause respiratory distress	Social	Minor	Unlikely	Low
Wind speed	Increased wind speeds	Structural integrity of building materials may be affected by extreme wind speeds	Infrastructure	Minor	Very Unlikely	Low
	Increased wind speeds	Wind damage to electrical and ITC circuitry (overhead wiring) may result in disruption to services and increase maintenance costs	Infrastructure	Minor	Very Unlikely	Low

CLIMATE RISK ASSESSMENT - REASSESSED

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk	Proposed adaptation measure	Consequence	Likelihood	Reassessed Risk
Precipitation	Changes to rainfall (droughts and intense rainfall)	Inundation of drainage infrastructure with resulting flood damage and safety risk	Financial Infrastructure	Major	Moderate	High	Specify vent levels and basement/portal drainage to address predicted increases in rainfall intensity, future food conditions and sea levels As defined by City of Sydney Council the following Habitable floor levels shall be set to a minimum 1% AEP flood level +0.5m Non habitable, retail and business floor levels shall be set to a minimum 1% AEP flood level Critical Facilities and below Ground Parking including all possible ingress points to the car park such as vehicle entrances and exits, ventilation ducts, windows, light wells, lift shaft openings, risers and stairwells shall be set to a minimum PMF level. Should critical threshold be breached resilience measures include: - flood gates/barriers to entrance way - basement pump system and - emergency response plan	Major	Very Unlikely	Medium
	Changes to rainfall (droughts and intense rainfall)	Water damage to substations and electrical circuitry may result in disruption to electricity supply	Financial Infrastructure	Major	Moderate	High	Specify vent levels and basement/portal drainage to address predicted increases in rainfall intensity, future food conditions and sea levels As defined by City of Sydney Council the following Habitable floor levels shall be set to a minimum 1% AEP flood level +0.5m Non habitable, retail and business floor levels shall be set to a minimum 1% AEP flood level Critical Facilities and below Ground Parking including all possible ingress points to the car park such as vehicle entrances and exits, ventilation ducts, windows, light wells, lift shaft openings, risers and stairwells shall be set to a minimum PMF level. Should critical threshold be breached resilience measures include: - flood gates/barriers to entrance way - basement pump system and - emergency response plan	Major	Very Unlikely	Medium
	Changes to rainfall (droughts and intense rainfall)	Increase in extreme rainfall and hailstorm events may overload roof drainage for buildings and result in water damaged structures and damaged facades (breaking glass)	Financial	Minor	Likely	Medium	Stormwater drainage design will be in accordance with BCA, which references AS3500.3. This indicates that building drainage elements are designed for 100 year ARI rainfall events. If a rain event surpasses the capacity of the roof drainage system, there would be overflow to ground level and stormwater would follow overland flow paths Pipework Design is based on pipe flowing 2/3 full at Q100 event, which equates to possible increase of flow capacity (redundancy) of approximately 20% when the hydraulic gradient is calculated into pipework flow. The facade glazing will be designed in accordance with AS1288 to determine loading. Considering the building's exposure, anticipated wind pressures and facade unit sizes, the external pane will be minimum 6mm and likely heat treated or toughened with a laminate which will deal comfortably with hail. Aluminium envisioned for the ribbon cladding, tower sun shades and spandrel panels, however, which is typically 3-4mm thick, will require further analysis to ensure mitigation of hail/storm damage.	Minor	Very Unlikely	Low

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk	Proposed adaptation measure	Consequence	Likelihood	Reassessed Risk
	Changes to rainfall (droughts and intense rainfall)	Droughts and changes in rainfall may result in water restrictions	Financial	Minor	Moderate	Low	Drought tolerant plant species where appropriate have been selected Rainwater harvesting - Existing design currently harvests rainwater collected from site building roofs for reuse in toilet flushing and swimming pool top-up Water sensitive urban design elements have been incorporated to help offset water demand and the potential for scouring at drainage outlets	Minor	Very Unlikely	Low
	Increase in frequency and severity of storms	Increase in intense rainfall could result in damage to properties, causing displacement and disruption of tenant/business activity during clean up	Financial	Minor	Moderate	Low	Evacuation planning - prior to the occupation of any habitable building on the project site, an emergency evacuation and response plan will be developed that addresses preparation, during- and post-disaster communication, safety and response.	Minor	Unlikely	Low
	Increase in frequency and severity of storms	Increase in intense rainfall and runoff could result in flooding causing damage to structures which may lead to increased insurance premiums for assets	Financial	Minor	Very Unlikely	Low	No triggers exist to require any additional insurance company consultation in planning and operation from that which occurs normally	Minor	Very Unlikely	Low
	Increase in frequency and severity of storms	Increased in intense rainfall events leading to reduced comfort and increased complaints from building occupants and general public passing by or entering the building	Social Reputation	Minor	Moderate	Low	Adequate shelter for wind driven rain is provided by building entrance canopy design and primary street frontage awnings There are three primary pedestrian entries serving the tower proposal; The Ritz Carlton lobby off Pirrama Rd, the Resident lobby off Jones Bay Rd, and the Community Facility with entry also off Jones Bay Rd. All entries are situated within a sheltered and recessed zone. Local wind condition analyses will inform amelioration strategies such as low level screening or planting to manage wind tunnelling, and building canopies / awnings to account for downdraft. From a vehicular perspective, resident vehicle access is via the existing internal and subterranean Service Road on Basement level 2. Access from resident parking to apartments is entirely internal. For the Ritz Carlton, vehicular drop off is immediately adjacent to the sheltered lobby entry noted above, utilising the same cover and wind amelioration methods.	Minor	Very Unlikely	Low

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk	Proposed adaptation measure	Consequence	Likelihood	Reassessed Risk
	Changes to rainfall (droughts and intense rainfall)	Increase in intense rainfall and runoff may increase the potential for erosion causing potential infrastructure instability and disruption or safety risk in the event of collapse.	Social Infrastructure	Moderate	Very Unlikely	Low	Structures, embankments and slopes have been designed to be stable in extreme weather events, including factors of safety, in accordance with industry best practice Soil stability assessed as part of the geotechnical analysis. All designs are carried out in accordance with procedures set out in Australian Standards. Load factors and material factors are used to mitigate irregularities in materials and variability and uncertainty of load conditions.	Moderate	Very Unlikely	Low
Sea level rise	Increase in sea level	Potential for inundation infrastructure during storms due to sea level rise resulting flood damage and safety risk	Financial Infrastructure	Major	Moderate	High	Possible increases in sea level rise of up to 0.9m by 2100 as a result of climate change will have no effect on flood levels or flood risk to the development.	Major	Very Unlikely	Medium
Temperature	Increase in mean maximum temperature	Ability to cool critical infrastructure may be effected by extreme heat, leading to system failure or service interruptions	Financial Infrastructure	Major	Unlikely	Medium	The thermal Central Energy Plant is a water cooled chilled water plant with a harbour heat rejection system, providing cooling to critical infrastructure within the development. During periods of increased ambient temperatures the water cooled plant may not provide 100% of the design output, however this risk is very unlikely to eventuate as the peak cooling demand for the development occurs in the evening driven by occupancy levels. At this point in time the water cooled plant is required to run at 100%. Based on Sydney's weather history, the increase in temperature and/or frequency of heat waves is likely to occur in the middle of the day. At this point in time it is unlikely the plant is required to run at 100%. In the rare instance that the peak cooling plant demand occurs during this event it may require non-critical areas to be shut down. This can be captured as an operational procedure in the Central Energy Plant Operations and Maintenance Manual.	Major	Very Unlikely	Medium

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk	Proposed adaptation measure	Consequence	Likelihood	Reassessed Risk
	Increased number of hot days over 35°C	HVAC system may experience overload, affecting thermal comfort for building occupants, and increasing HVAC maintenance and operating costs	Financial Infrastructure	Major	Unlikely	Medium	The thermal Central Energy Plant is a water cooled chilled water plant with a harbour heat rejection system, providing cooling to critical infrastructure within the development. During periods of increased ambient temperatures the water cooled plant may not provide 100% of the design output, however this risk is very unlikely to eventuate as the peak cooling demand for the development occurs in the evening driven by occupancy levels. At this point in time the water cooled plant is required to run at 100%. Based on Sydney's weather history, the increase in temperature and/or frequency of heat waves is likely to occur in the middle of the day. At this point in time it is unlikely the plant is required to run at 100%. In the rare instance that the peak cooling plant demand occurs during this event it may require non-critical areas to be shut down. This can be captured as an operational procedure in the Central Energy Plant Operations and Maintenance Manual.	Major	Very Unlikely	Medium
	Increase in mean maximum temperature	Increased mean maximum temperature and solar exposure may lead to greater material degradation and need for building maintenance	Financial	Minor	Moderate	Low	Ensure building materials are durable under solar radiation loads. Maintenance inspection cycle would identify equipment which is not performing efficiently or is becoming degraded.	Minor	Very Unlikely	Low
	Increased number of hot days over 35°C	Increased in extreme temperatures may lead to urban heat islands	Social Financial	Moderate	Moderate	Medium	In order to decrease heat islanding - Extensive use of cross flow ventilation will utilise available natural ventilation, particularly the increased wind gradient at higher levels of the tower building - Use light coloured materials on roofs and pavements to both shade from and reflect sunlight (SRI 0.4); - Use natural vegetation and building shading to provide relief from direct sunlight. - Shadowing effect of buildings within precinct provide relief	Moderate	Unlikely	Medium
	Increase in mean maximum temperature	Structural building materials may be affected by extreme heat, leading to structural fatigue	Financial Infrastructure	Major	Very Unlikely	Medium	Concrete structure - The design for thermal effects are based on AS5100.2 Generally for concrete structures - thermal design parameters - Average minimum and maximum temperatures are -3°C and 49°C; Total change in temperature = 52°C Steel Structure - The design for thermal effects are based on AS5100.2 Generally for steel structures - thermal design parameters - Average minimum and maximum temperatures are -7°C and 69°C; Total change in temperature = 76°C;	Major	Very Unlikely	Medium

Climate Variable	Climate Risk	Potential Climate Change Impact	Key Criteria	Consequence	Likelihood	Overall Risk	Proposed adaptation measure	Consequence	Likelihood	Reassessed Risk
	Increased number of hot days over 35°C	Increase in extreme heat days may result in heat related illness and/or heat stress for workers, visitors and residents	Social	Minor	Likely	Medium	In the event of extreme heat The Star management will, when possible and in line with Government health warnings, remind people most at risk, in particular older people, young children, pregnant or breastfeeding women, and people with heart disease, high blood pressure or lung disease to drink plenty of water, stay cool spaces or in the shade, and restrict activity.	Minor	Unlikely	Low
	Increase in risk of bushfires	Increase in number of severe fire weather risk days leading to exposure to smoke and particulate pollution for workers, visitors and residents that may cause respiratory distress	Social	Minor	Unlikely	Low	In the event of potential smoke exposure The Star management will, when possible and in line with Government issued health warnings, remind people most susceptible to the effects of air pollution, such as, children, older adults and people with heart and lung conditions to remain inside with the windows and doors closed, preferably in an air-conditioned building.	Minor	Very Unlikely	Low
Wind speed	Increased wind speeds	Structural integrity of building materials may be affected by extreme wind speeds	Infrastructure	Minor	Very Unlikely	Low	The general consensus on wind speeds is that the extreme events would happen more regularly, but the magnitude would not increase. This is particularly true for synoptic winds. Structures comply with Australian Standards and reliant wind loadings. Adopted design wind speeds and wind load calculations are in accordance with AS1170 for structures design. Extreme wind events are accounted for in the ultimate limit state (ULS) design values. Maintenance inspection cycle would identify equipment which is not performing efficiently or is becoming degraded.	Minor	Very Unlikely	Low
	Increased wind speeds	Wind damage to electrical and ITC circuitry (overhead wiring) may result in disruption to services and increase maintenance costs	Infrastructure	Minor	Very Unlikely	Low	Undergrounding of electrical and ITC services within the precinct avoids this wind related damage to overhead wiring risk Cables in buried conduits are designed to resist the influx of water. Conduit joints are sealed to resist water seepage into conduits.	Minor	Very Unlikely	Low