Macquarie University
One Planet Design Brief

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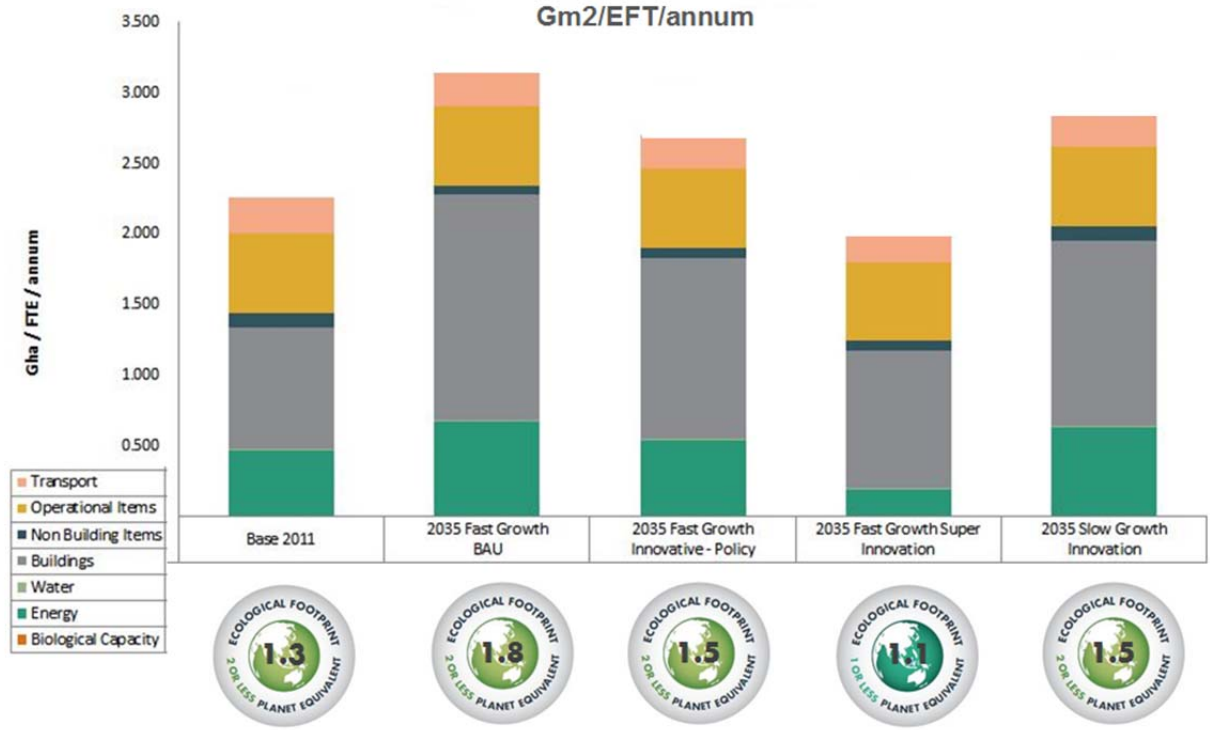
1 Introduction

Macquarie University has committed to a One Planet goal for the campus by 2030. Capital works projects are included in this goal. The footprint from capital works will make up 20% of the increased total campus footprint under the BAU fast growth trajectory model in Figure 1, the majority of which from Fit-outs.

Therefore sustainable building design and responsible material choices are necessary to achieve this goal.

Figure 1: Macquarie University 2035 One Planet Goal



1.1 Purpose of this Performance Specification

The purpose of this document is to ensure all capital work projects are consistent with the OnePlanet 2030 goal. It aims to give contractors tools and knowledge to improve the total ecological footprint of the project they work on.

It is organised to first provide some background to the philosophy and methodology, next it covers coverage of aspects by type as well as overall importance of the impact categories for project types. The document then provides an overview of possible low footprint alternatives to consider by designer, developers and contractors.

1.2 About Ecological Footprint

Currently humanity uses the equivalent of 1.5 planets to provide the resources we use and absorb our waste. This means it now takes the Earth one year and six months to regenerate what we use in a year. Capital formation and operation of the built environment accounts for up to 40% of total consumption, as such it is essential that we understand the impacts to enable informed decision making about design and consumption choices.

To achieve a sustainable state individuals and institutions must begin to plan in recognition of ecological limits. This means investing in technology and infrastructure that will allow us to operate in a resource-constrained world.

The Ecological Footprint is an objective methodology used to quantify and report impacts of economies, businesses, buildings and their individual products. Results are reported in terms of global hectares or global meters square per square meter of functional area. These units represent the physical area of productive land theoretically required to support the capital formation and operational needs of a population, product, organisation or service.

When expressed in terms of Planet Equivalents, it means that if all buildings, activity or fitouts were built and operated in the manner proposed, then it would equate to approximately number of Earth's of productive area as indicated in the report.

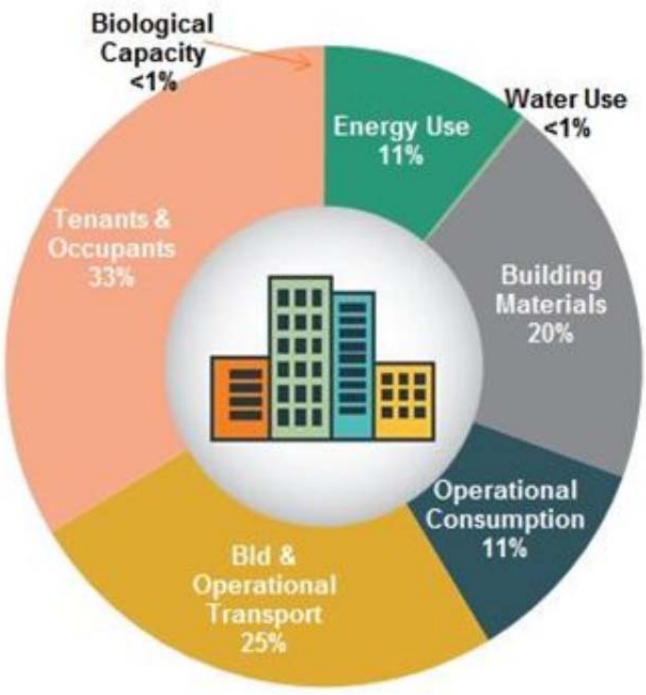
1.2.1 Scope and Coverage

The assessment aims to estimate the Ecological Footprint associated with a project's capital formation, fit out and operation requirements from cradle to gate. The scope of property related assessment includes:

- Land bio-capacity
- Base building built-form
- Tenant fit out
- Operating consumption including energy, water, transport and general consumables

Figure 2 provides a summary of the impact aspects considered and also a sense of their overall importance to the total Ecological Footprint of a built asset.

Figure 2: Impact Aspects and Relative Importance



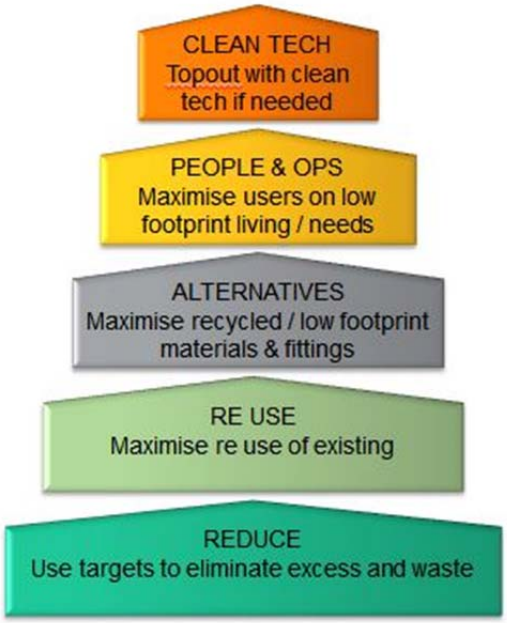
1.2.2 General Design Guidelines

In general, some of the most important design goals to have at the centre of a project team's focus include;

1. Whenever possible reusing existing structures.
2. Using the least amount of material per square meter to achieve the required functional outcome.
3. Using lighter (i.e. less dense or thinner gauge) material with the same functional outcome.
4. Using high recycled material content.
5. Using alternative compositions which avoid the need for finishing during service.
6. Using alternative materials which have been demonstrated to have a lower embodied carbon content.
7. Consider challenging the life cycle or durability needs of an element.
8. Designing the element with simple and low impact replacement in mind.

These principles are demonstrated in Figure 3.

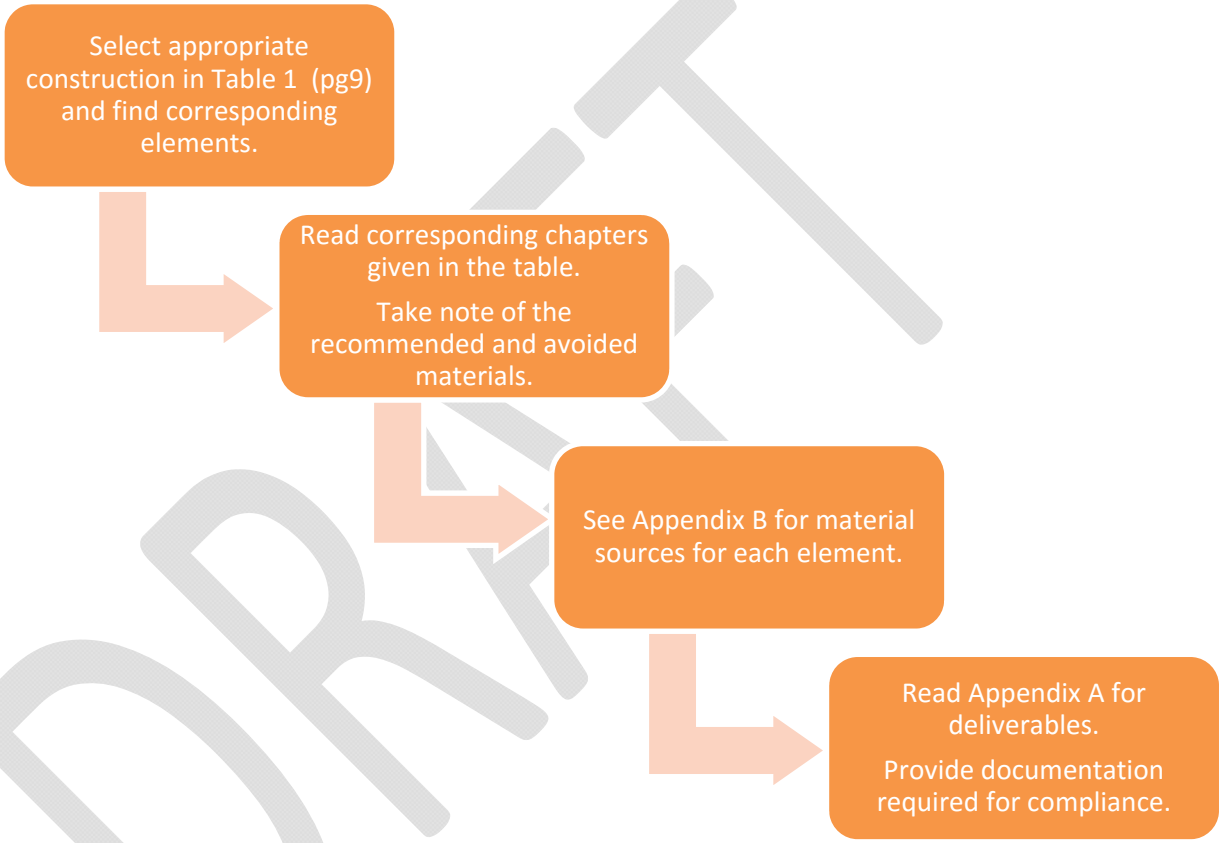
Figure 3: Principles of Design



1.3 How to use this document

The approach to use this document in given in the flow chart in Figure 4. The document is laid out in element chapters, only some of which are relevant for each construction type. Each element type has a not to be exceeded footprint value which will need to be calculated for compliance.

Figure 4: Document Flow Chart



1.4 Application Reference Table

The application reference table, Table 1, is designed to be a quick reference for building contractors and designers. The footprint target is the maximum footprint each element should have. For more information on ideal material choices and overall design for each element refer to the sections outlined in the table.

1. Go to the appropriate project type column.
2. For applicable elements (cells in orange):
    - Refer to the section number given for footprint drivers as well as one planet recommendations.
    - Refer to Appendix B for sources of alternative, low impact materials.
    - Refer to Appendix A for deliverables.

Table 1: Application Reference Table

Element	Retrofit	New Build	Landscaping	Civil Works	Furniture Renewal
Structure		1			
Roof		4			
Façade and External Walls		5			
Internal Walls	6	6			
Internal Ceilings	7	7			
Floor finishes	7	7			
Fitments and Fittings	7	7			
Furniture	7	7			7
Equipment and other items	7	7			
Doors	7	7			
Services		8			
External Works		9	9		
Operational Transport		0			
Operational Energy	0	0			
Operational Water	0	0	0		

1.5 Ecological Footprint Performance Metrics

Each high order element category has targets given in Table 2 in terms of global area required per unit total useable floor area per annum.

Targets were calculated from past performance of Macquarie University buildings. The Retrofit values are based off the Business as Usual refurbishment of level 2 E6A. New build targets take into account the average performance of 24 buildings at the University, leaning towards the more accurate data in the calculator for C4B, E3B, X5B, AHH and E6A.

Deliverables for each element are given in APPENDIX A: Audit Submission Checklist.

Table 2: Summary Performance Metric (Not to Be Exceeded) Table[1]

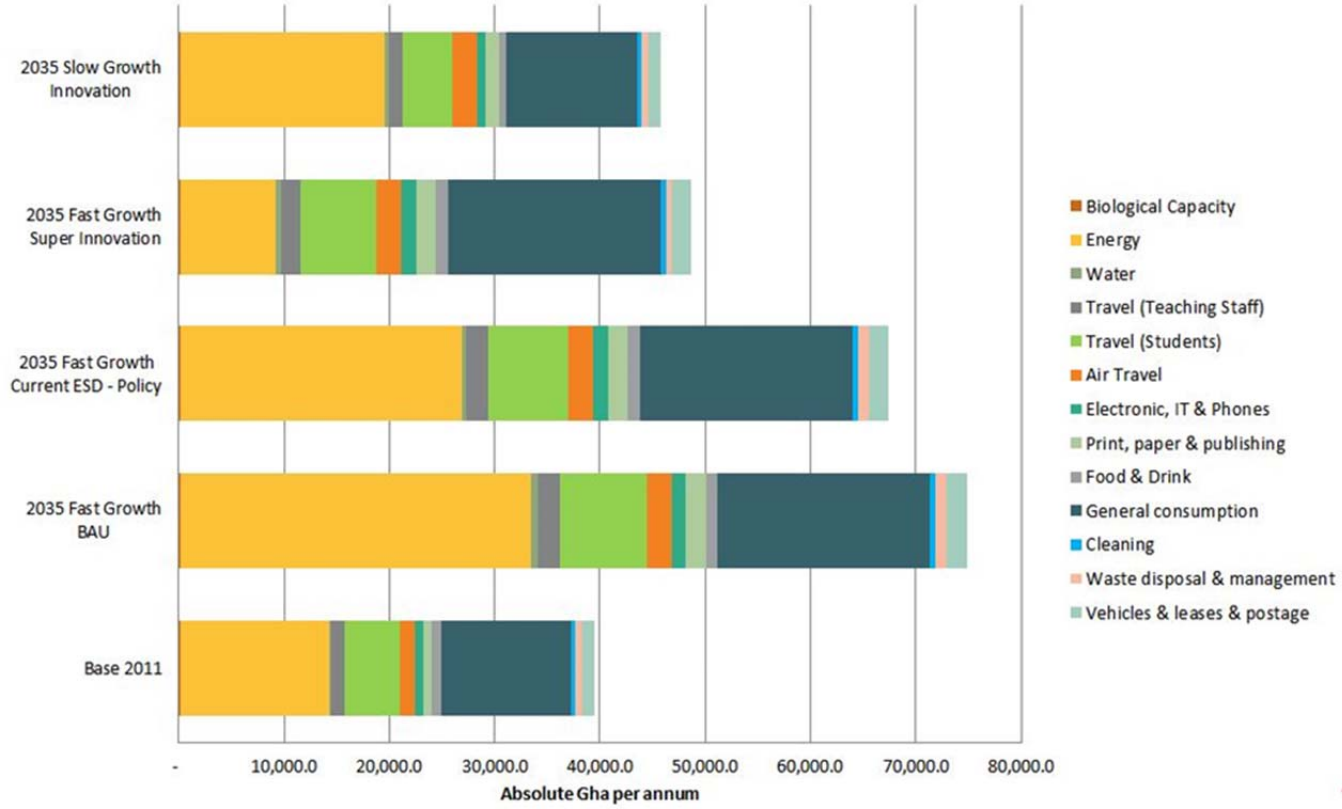
	Footprint Target (gm^2/m^2)				
	Retrofit	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Materials	60-90	350-520			
Operational Energy	600-900	265-400			
Operational Water	0	1-2			
Operational Transport	N/A	75-120			

[1] Where the footprint is measured per m^2 of total useable floor area per annum of the project (retrofit, new build etc).

2 Operational Footprint

Operational elements of the building have a large impact on the total ecological footprint of the campus. While not directly controllable at the design/contractor level, the design of the building will impact the total energy and water use as well as the ease to shift transport. These three elements drive the total operational footprint as shown in Figure 5.

Figure 5: Total Operational Footprint



In this section minimum performance requirements for operational energy (lighting and power), water and transport are described. Refer to the tables for the project type and ensure that designs developed meet the performance targets nominated.

Refer to APPENDIX A: Audit Submission Checklist for documentation to submit on completion of the project which will form part of the final completion approvals.

2.1 Energy

2.1.1 Scope

The project's operational energy use is dependent on:

- Lighting design.
- Power used by appliances and HVAC systems.

Both are in a way dependant on the building's design and material choices. Hence it is crucial to design the construction with operational energy in mind. Table 3 gives the overall energy performance metrics that should not be exceeded.

Table 3: Energy Performance Metric (Not To Exceed)

Element	Footprint Target (gm^2/m^2)				
	Retrofit	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Total	600-900	800-1200			

2.1.2 Impact Drivers

Operational energy is highly dependent on the purpose of the building, but main drivers that can be reduced during the construction stage are:

1. HVAC and Air conditioning systems.
2. Lighting systems.

Cooling and heating systems depend on the heat retained by the building and the heat load from external and internal sources. In terms of lighting energy, it is important to consider passive lighting as well as efficient fittings and design.

2.1.3 Key Opportunities

Key recommendations are presented in Table 4.

In general the building should be designed with passive heating, cooling and lighting in mind. Minimising the solar heat gain through shading reduces cooling demand during the day, while insulation and window glazing reduces the heating demand. Daylighting elements should be incorporated to minimise the need for additional energy use.

The installation of monitoring and control equipment for the building will help reduce operational energy and allow end users to use it efficiently. Devices include:

- Occupancy sensors.
- Daylight sensors.
- Metering equipment

2.1.4 To Avoid

Inefficient light sources such as incandescent and halogen down lights should be avoided, as well as magnetic control gears (ballasts or drivers).

Windows facing north, east and west without any shading devices should be avoided to minimise solar gains and demand on the HVAC system.

Table 4: Operational Energy Design Recommendations

Sub-element	Design Recommendations
Lighting	▪ Efficient lights such as T5s, T8s and LEDs. ▪ Occupancy sensors ▪ Design for natural daylighting to enter rooms, provided: o There is some way to shade windows to minimise glare if needed. o Daylight sensors are installed. ▪ Lights with colour temperatures that are appropriate for the space's purpose. ▪ Efficient control gears (electrical ballasts/drivers).
HVAC	▪ Insulation in the buildings external walls, roof and floors[2]. ▪ Glazing on window elements to reduce external heat gains and losses. ▪ Zone control for parts of building with different heating or cooling loads (i.e. partitions). ▪ Shading elements for north and west facing windows.
General	▪ Install monitoring equipment

[2] Although the reduction in operational energy must be balanced with the additional ecological footprint from a materials standpoint.

2.2 Water

2.2.1 Scope

Water does not contribute to operational energy use significantly, but efficient water use should still be designed for from an operational costs perspective. Table 5 gives overall water metrics that should not be exceeded.

Table 5: Water Performance Metric (Not To Exceed)

Element	Footprint Target (gm^2/m^2)				
	Retrofit	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Total	N/A	3-5			

2.2.2 Impact Drivers

The main drivers of water use in commercial buildings are:

1. Amenities.
2. Leakage (taps, urinals etc)
3. Air Conditioner cooling towers

2.2.3 Key Opportunities

Key recommendations are presented in Table 6.

Table 6: Operational Water Design Recommendations

Sub-element	Design Recommendations
Amenities	▪ Water efficient and low flow amenities with labelling from schemes like; o Water Efficiency Labelling Scheme (WELS). o Smart Approved WaterMark. ▪ Efficient control gears (electrical ballasts/drivers).
Leakage	▪ Sub metering.
Cooling Towers	▪ Install monitoring equipment. ▪ Efficient units.
General	▪ Rainwater / grey water collection/reuse. ▪ Irrigation timers.

2.3 Transport

2.3.1 Scope

As illustrated in Figure 5 transport contributes largely to the operational footprint of the university. This includes both student and staff transport. Figure 7 gives overall water metrics that should not be exceeded.

Table 7: Transport Performance Metric (Not To Exceed)

Element	Footprint Target (gm^2/m^2)				
	Retrofit	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Total	N/A	75-115			

2.3.2 Impact Drivers

The footprint is largely driven by individual transport modes such as cars. Therefore low impact travel methods such as cycling, walking and public transport should be encouraged as much as possible in the design stage.

2.3.3 Key Opportunities

There is little that can be done in the design/construction stage of the project other than providing an enabling environment for public transport and cycling. Bicycle storage should be incorporated into new building designs or landscaping projects. Opportunities to consider include:

- Installing generous amounts of storage.
- Secure locations (i.e. public places or restricted access areas)
- Associated facilities such as showers, lockers.

2.4 How Performance Metrics Relate to NABERS

These benchmarks should be used in accordance with the start ratings given by the National Built Environmental Rating Scheme (NABERS).

NABERS ratings for both energy and water use should achieve at least 4.5 stars.

3 Structure

3.1 Scope

Structure includes core walls, formwork, reinforcements, structural steel and concrete and substructural elements such as sub-soil drainage, kerbs and gutters and drains. The maximum footprint for the structure element for each construction type is given in Table 8.

Table 8: Structural Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Structure	0	80-120			

3.2 Impact Drivers

The structure typically comprises the largest overall impact at (~20%) given the nature of its associated materials. The sub-structure can comprise between 3-5% of the project ecological footprint. The principle drivers of this are:

1. Concrete slabs.
2. Formwork.

The overall mass of the building also drives its footprint. Thus seeking lighter structural systems overall will translate to a lower footprint sub-structure. Optimising the siting of the project to reduce the extent of excavation, taking advantage of the natural ground lines is ideal.

3.3 Key Opportunities

In order of priority the design team should give consideration to:

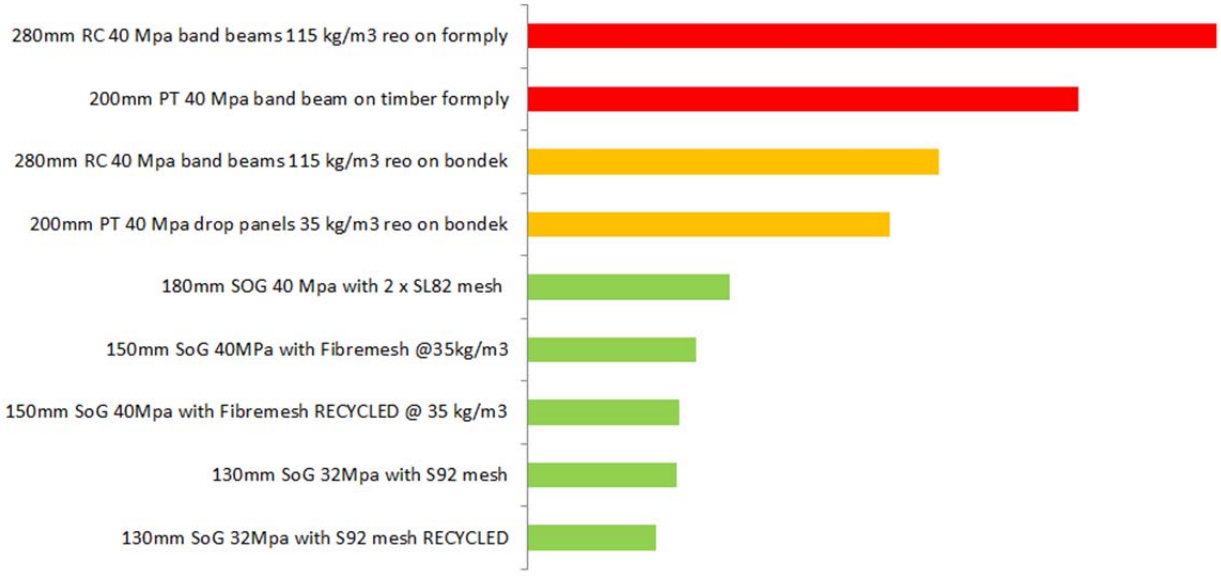
1. Materially efficient design solution (minimal materials).
2. Designing to enable the structure to serve more than one purpose.
    - I.e. hollow core pre-cast enabling service distribution in cores and use of off-form surfaces as finishes.
3. Pre-fabricated structural elements.

3.3.1 Slab Materials

More specifically, Figure 6 shows the ecological impacts of typical structural slab arrangements. Opportunities lie within:

- Increased recycled content.
- Mesh reinforcements rather than beams.
- Thin materials.
- Fibremesh rather than steel.

Figure 6: Ecological Impact of Typical Slab Arrangements



3.3.2 Formwork Materials

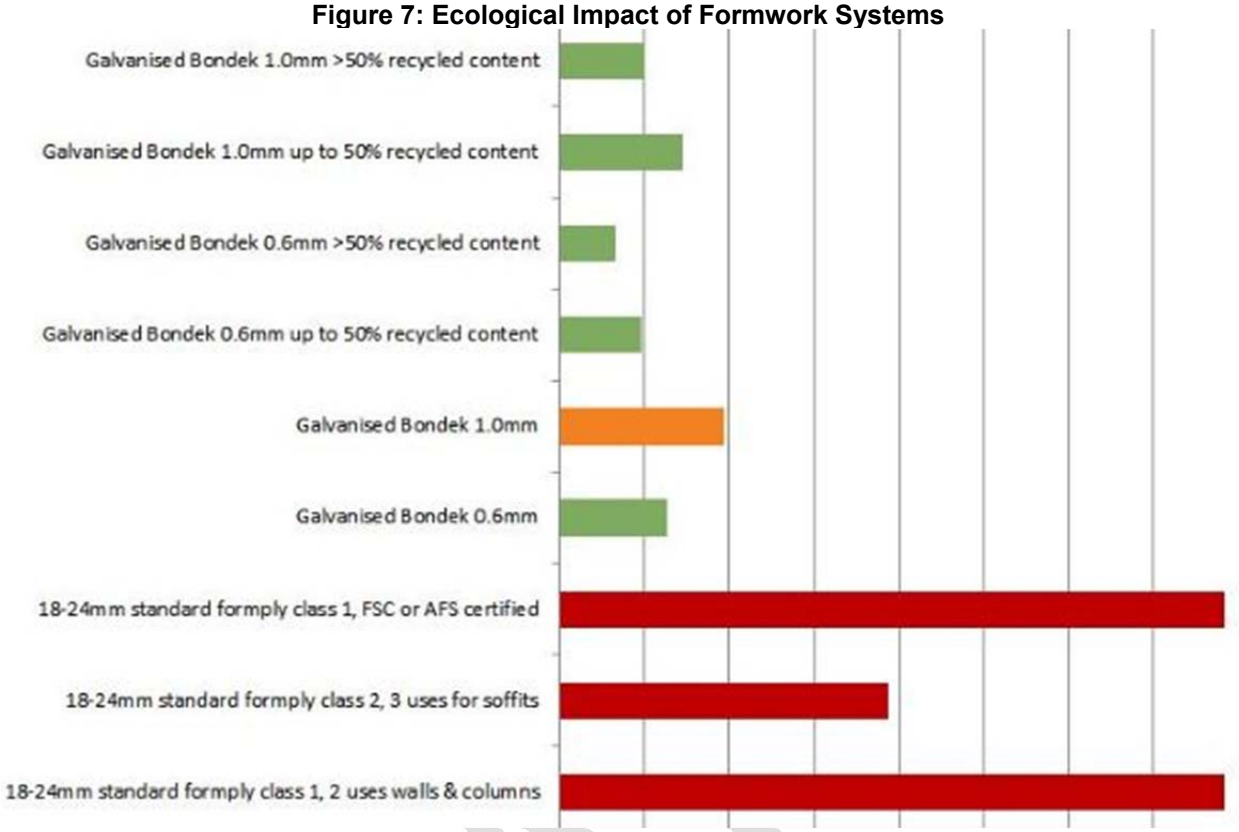
Figure 7 shows the relative ecological impact of common formwork systems. Key material opportunities include:

- Post-tensioned (PT) systems.
- Fly-ash replacement concrete.[3]
- Super high strength concrete.
- Steel permanent forms or pre-cast elements.

It is critical to do a comprehensive analytic study of all structural systems to identify the most efficient pathway and ideally using the Ecological Footprint Calculators to observe the overall impact and dynamics between structure, facade and internal loading designs.

[3] It is important to note that pursuing fly-ash replacement in concrete is not necessarily the most efficient means of reducing the impact of structure. In some cases super high strength concrete (in a super-efficient design) can achieve greater efficiency benefits than lower strength high fly-ash concrete.

Figure 7: Ecological Impact of Formwork Systems



3.3.3 Overall Recommendations

Recommendations to achieve the performance requirements for the structure and sub-structure are outlined in Table 9. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials..

3.4 Materials to Avoid

The following materials should be avoided when possible:

- Conventional unstressed reinforced concrete structures.
- Timber formwork.[4]
- Steel mesh/bar reinforcement.

[4] Irrespective of the managed nature of forests, unless timber is from reclaimed sources, its ecological footprint is significant.

Table 9: One Planet Design Pathway: Structure

Sub-element	Low Footprint Materials
Core walls	▪ Consider Dincell wall system to reduce the overall materials intensity of shear walls over conventional shutters.
Formwork	▪ Prefer recycled content Bondek permanent forms over timber plywood; ▪ Consider pre-fabricated re-useable recycled plastic forms for columns. ▪ Consider pre-fabricated re-useable recycled plastic forms for columns.
Structural concrete	▪ 10%-20% Fly-ash replacement minimum ▪ Investigate the timing consequences of 100% geo-polymer concrete ▪ OR consider high strength concrete
Non-structural concrete	▪ Request high fly-ash replacement; ▪ 100% Eco-polymer alternative ▪ 100% recycled content polyethylene damp proof membranes
Reinforcement bar & mesh	▪ Consider fibermesh as an alternative to steel mesh – prefer recycled content polymer or steel fibres ▪ >75% recycled content
Structural Steel	▪ Request options for recycled content for structural steel members; ▪ Investigate section design which delivers less steel for the same structural strength
Purlins & Girts etc	▪ Investigate section design which delivers less steel for the same structural strength ▪ Consider using alum/zinc galvanising
Bulk Excavation	▪ Retain and re-use excavated material on site; ▪ Consider Dincell retaining wall system to avoid excavation for batters.
Plastic column forms	▪ Consider pre-fabricated re-useable recycled plastic forms for columns.
Kerb & gutter	▪ Recycled content composite plastic alternatives
Grates, drains & rails	▪ Recycled content composite plastic alternatives to cast-iron & stainless steel (Enviro-grate; enviro-channel; enduroplank) ▪ Recycled plastic bollards; car wheel stops; bump rails; trolley bays
Sub-soil drainage	▪ Source recycled content geo-textile fabric ▪ Recycled content drainage cells

4 Roof

4.1 Scope

The roof includes roof sheeting, panelling, drainage, structure (purlins and girts) and access ways. The maximum footprint for the structure element for each construction type is given in Table 10.

Table 10: Roof Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Roof	0	55-85			

4.2 Impact Drivers

The roof impact varies depending on the building type and tends to be larger impact for retail centres and smaller impact for office buildings. Major drivers of the impact include:

1. Roof sheeting
2. The approach to gutters and downpipes (in particular if they are stainless steel).
3. Purlins and other framing.

4.3 Key Opportunities

The opportunities to reduce the footprint of the roof include:

- Recycled content roof sheeting.
- Considering the trade-off between sheet gauge and purlin spacing.
- Composite panels (e.g. Kingspan sandwich panel).
- Steel and lightweight roof structures rather than heavy mass or timber roof structures.
- Aluminium and steel rather than stainless steel, copper and zinc cladding materials.
- High proportion of recycled content or re-claimed cladding materials.
- Recycled composite plastic roof access ways rather than stainless steel and aluminium.

4.3.1 Overall Recommendations

Recommendations to achieve the performance requirements for the roof are outlined in Table 11. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.Materials to Avoid

The following materials should be avoided when possible:

- Stainless steel, copper and zinc cladding.
- Timber roof structures.
- Steel and aluminium roof access ways.
- Virgin materials.

4.4 Further Considerations

“Green-roofing” should only be considered when the life cycle energy and bio-diversity savings are greater than the impact of the structure and waterproofing.

Table 11: One Planet Design Pathway: Roof

Sub-element	Low Footprint Materials
Purlins & Girts etc	▪ Investigate section design which delivers less steel for the same structural strength ▪ Consider using alum/zinc galvanising
Roof Sheeting	▪ Source recycled content roof sheeting ▪ Prefer colourbond over zincalume if possible
Composite panels	▪ Consider a composite panel alternative such as kingspan or similar with no internal ceiling
Roof drainage	▪ Request recycled content colourbond products (avoid stainless steel if possible)
Roof access ways & plant decking	▪ Consider recycled content composite plastic access way, handrails and stairs in place of aluminium or stainless steel
Roof lights	▪ Consider danpalon or similar polycarbonate sheeting for roof lights.

5 Façade and External Walls

5.1 Scope

Façade and external walls include the cladding, insulation, framing and sunscreen of the external walls as well as the block work, flashing and capping materials. The maximum footprint for the structure element for each construction type is given in Table 12.

Table 12: Facade and External Walls Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Façade and External Walls	0	30-50			

5.2 Impact Drivers

The envelope impact varies significantly by building type and would ideally be considered simultaneously with the overall operational energy consumption and services costs via the Footprint Calculators. Key impact drivers are:

1. Solid wall materials.
2. Glazing.
3. Sunshading.

5.3 Key Opportunities

5.3.1 Façade

Façade materials choices have to be considered with both material and operating energy[5] impacts in mind. The key opportunities to reduce the footprint of the facade include:

- Lighter mass materials.
- Low fenestration ratios (i.e. large glass to spandrel proportions)
  - An increase in window area from 50-85% tends to double of impact per square meter / foot of façade.

Specific low carbon or high recycled content aluminium framing systems.**Error! Reference source not found.**

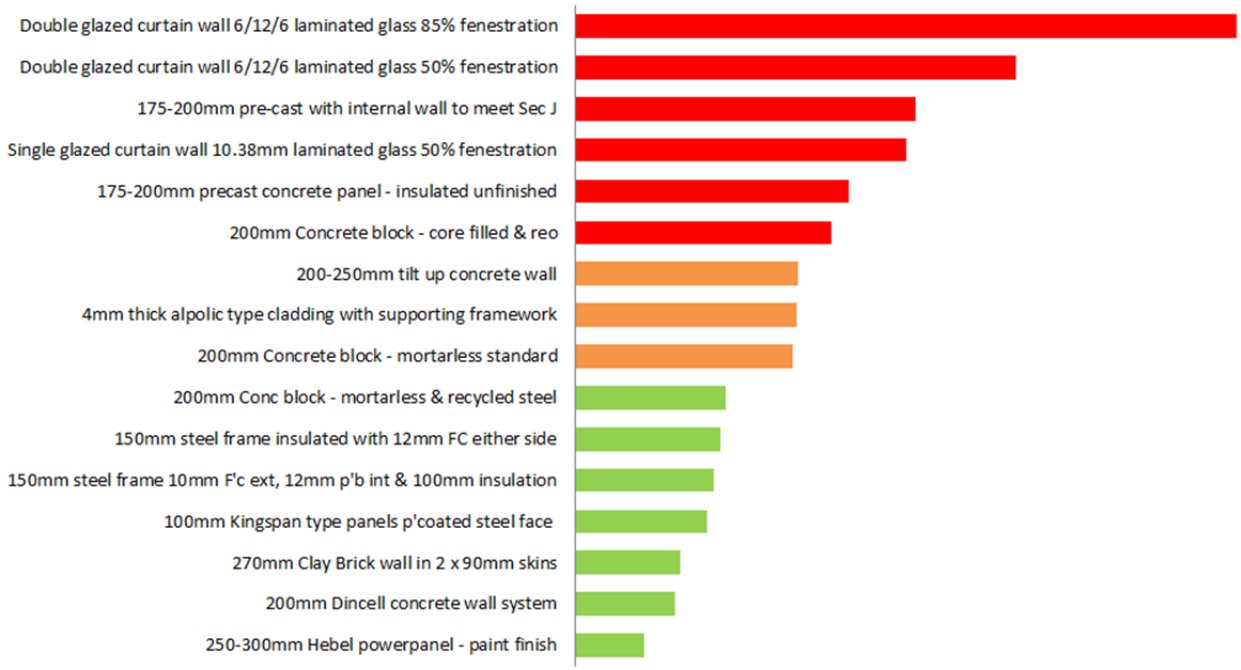
[5] For more information see Chapter 2. Key aspects include the amount of insulation as well as solar heat gain and heat losses through windows.

Figure 8 and Figure 9 show the relative impact of common façade designs. High ecological footprint design (shown in red) should be avoided.

Figure 8: Ecological Impact of Facade Systems

Terracade XP	Alucobond	Alucobond Plus	Innowood	6/12/6 glazing 50%	6/12/6 glazing 85%
					
Terracade XP on stainless steel support frame; sarking; 90mm metal stud; R2.7 insulation; 12mm plasterboard internal facing	Alucobond 4mm (0.5/3/0.5) polyester core; support frame; sarking; 90mm metal stud; R2.7 insulation; 12mm plasterboard internal facing	Alucobond 4mm (0.5/3/0.5) ALCO3 core; support frame; sarking; 90mm metal stud; R2.7 insulation; 12mm plasterboard internal facing	150x25mm innowood paneling; sarking; 90mm metal stud; R2.7 insulation; 12mm plasterboard internal facing	6/12/6 laminated DGU with 150 x 50mm frame spandrel per alucobond	6/12/6 laminated DGU with 250x100mm frame spandrel 6mm laminated glass; aluminium back pan; polyester insulation; metal stud & plasterboard
Ecological Footprint (Gm2 / m2 Finished area)					
797	822	853	603	1,458	2,385

Figure 9: Ecological Impact of Facade Systems



5.3.2 External Walls

Figure 10 compares the impact of external wall designs. Key opportunities to reduce the footprint of external walls include:

- Lighter mass materials such as Hebel panels.
- Mortarless, unfilled concrete in place of filled concrete blocks.

Figure 10: Ecological Impact of External Walls

5.3.3 Overall Recommendations

Recommendations to achieve the performance requirements for the façade and external walls are outlined in Table 13. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.

Table 13: One Planet Design Pathway: Façade & External Wall

Sub-element	Low Footprint Materials
Cladding	▪ Recycled content of aluminium >10%

Sarking & Insulation	▪ Recycled content sisalation foil and or glass ▪ Recycled content polyester batts or blanket (prefer over fiberglass or rockwool)
Wall framing & channel	▪ Thinner gauge steel with alum/zinc galvanising ▪ Request recycled content steel for framing
Flashing & Capping	▪ Colourbond steel with high recycled content
Sunscreens	▪ Consider recycled content composite plastics OR avoid ▪ Request recycled content of 20% or more
Blockwork	▪ Consider mortarless blockwork ▪ Specify high-fly ash replacement cement for mortar and core fill ▪ Specify recycled content reinforcement for core fill ▪ Consider Dincell wall system in lieu of blockwork

5.4 Avoid

The following materials/designs should be avoided when possible:

- High fenestration ratios (i.e. large glass to spandrel proportions).
- Layering facades and consider pre-fabricated elements where possible.
- Virgin aluminium framing systems.

5.5 Further Considerations

Triple and double glazed systems should be evaluated in terms of both operational energy and services saved as well as increased footprint of materials. As should the amount of insulation.

6 Internal Walls

6.1 Scope

Internal walls include the materials used for framing, sarking and insulation of the walls, as well as for portioning, cement linings and plasterboard used. The maximum footprint for the structure element for each construction type is given in Table 14.

Table 14: Internal Wall Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Internal Walls	13-19	30-50			

6.2 Impact Drivers

The main drivers of ecological footprint are:

1. Wall finish.
2. Framing materials.
3. Wall lining materials.

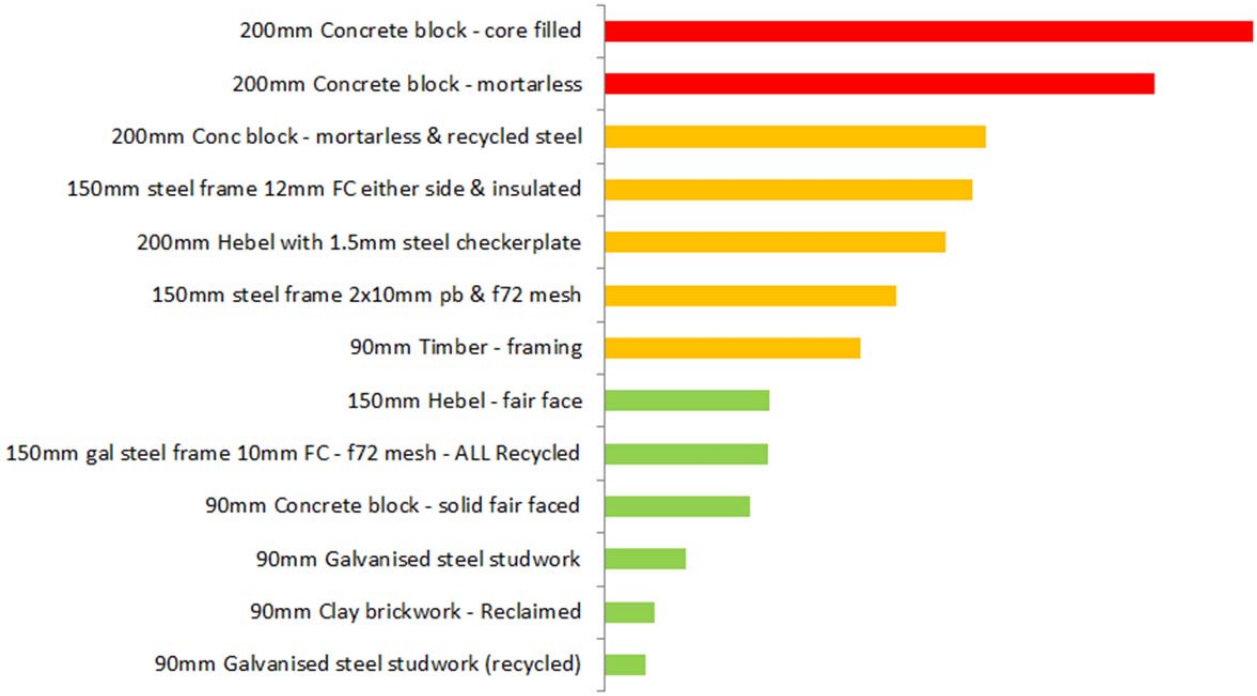
6.3 Key Opportunities

Figure 11 and Figure 12 show the impact of a number of typical internal wall arrangements. There are significant footprint reduction opportunities available through:

- Adoption of light-weight materials such as strawboard.
- When concrete structures are necessary, using motarless with recycled steel support or hebel.

.Figure 11: Ecological Impact of Internal Walls

Figure 12: Ecological Impact of Wall Systems



6.3.1 Overall Recommendations

Further recommendations to achieve the performance requirements for the internal walls are outlined in **Error! Not a valid bookmark self-reference.**. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.

Table 15: One Planet Design Pathway: Internal Wall

Sub-element	Low Footprint Materials
Sarking & Insulation	▪ Recycled content sisalation foil and or glass ▪ Recycled content polyester batts or blanket (prefer over fiberglass or rockwool)
Wall framing & channel	▪ Thinner gauge steel with alum/zinc galvanising ▪ Request recycled content steel for framing ▪ Consider using hebel in place of blockwork for internal walls
Plasterboard	▪ Recycled paper facing ▪ High recycled content >10%
Fibre cement linings	▪ Request recycled content colourbond products (avoid stainless steel if possible)
Solid partitions	▪ Consider use of Hebel in party walls and other areas in place of blockwork ▪ Consider mortarless blockwork ▪ Consider the potential for Ortech strawboard for back of house partitions and trafficable ceilings for service access
Timber	▪ Innowood (recycled plastic composite) in place of timber ▪ Bamboo ply in place of MDF ▪ Consider use of recycled plastic sheeting in place of ply

6.4 Avoid

The following materials/designs should be avoided when possible:

- Core filled concrete structures.
- Timber structural elements.
- Virgin steel framing systems.

6.5 Further Considerations

Insulation should be considered when rooms wither side of the partition have varying heating/cooling requirements. It is essential to consider both the material and operational energy ecological impacts. Increasing energy code requirements can lead to a significant increase in the impact of wall arrangements.

7 Internal Finishes & Fitments

7.1 Scope

The internal finishes and fitments include materials used in internal ceilings, floors, doors, fitments and furniture. The maximum footprint for the structure element for each construction type is given in Table 16.

Table 16: Internal Finishes and Fitments Performance Metric (Not To Exceed)

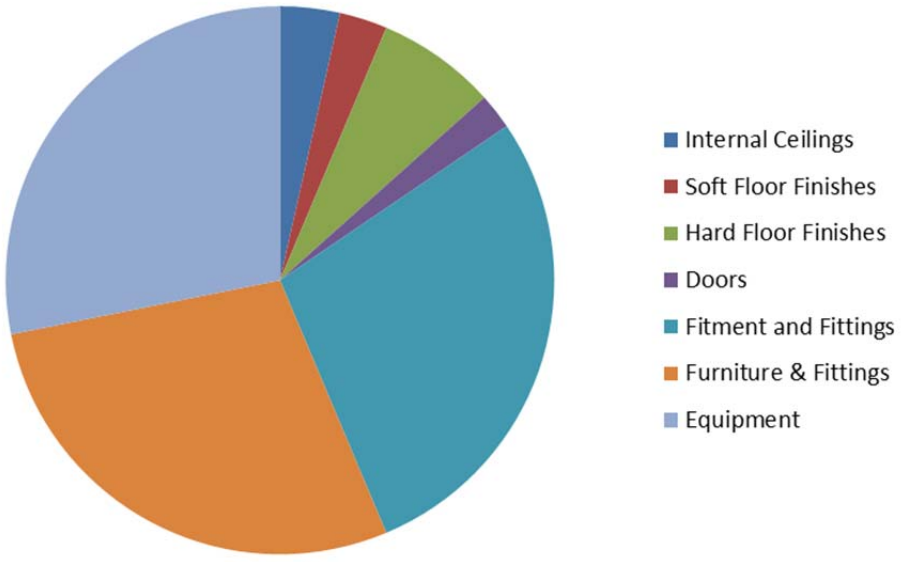
	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Internal Ceilings	3-5	4-6			
Floor Finishes	3-4	12-18			
Doors	1	2-4			
Fitment and Fittings	12-18	30-50			
Furniture & Fittings	10-15	30-50			
Equipment	20-30	30-50			

7.2 Impact Drivers

Internal finishes comprise a large component of a buildings footprint and are also the most likely elements to be replaced multiple times over the buildings life cycle. It is important to not only consider the number of replacements but also the ease of recycling of finishes materials. Impact drivers are shown in Figure 13 and include:

1. Furniture
2. Fitments and Fittings
3. Hard Floor Finishes
4. Internal Ceilings

Figure 13: Breakdown of Internal Finishes and Fitment Sub-Elements



7.3 Key Opportunities

Ideally, the lowest impact materials are selected and designed in such a manner as to enable the least impact removal and replacement.

7.3.1 Floor Finishes

Figure 14 and Figure 15 compare the ecological footprint of typical floor finishes. It is also essential to analyse flooring as a whole system (e.g. the material – tiles as well as its fixing medium, i.e. epoxy, mortar and ideally cleaning) to understand the implications of the whole arrangement. Key opportunities lie in:

- Reusing the existing floor when applicable.
- Minimal floor finished on the base floor i.e. polished concrete.
- Lightweight finishes such as linoleum or cork instead of tiles.

Figure 14: Ecological Impact of Floor Finishes

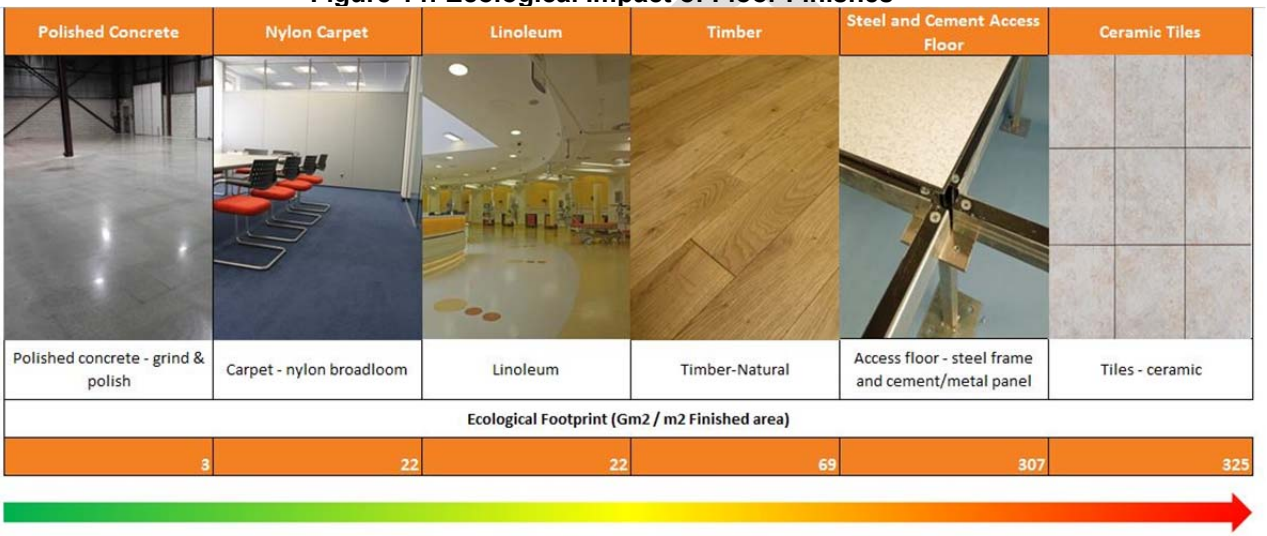
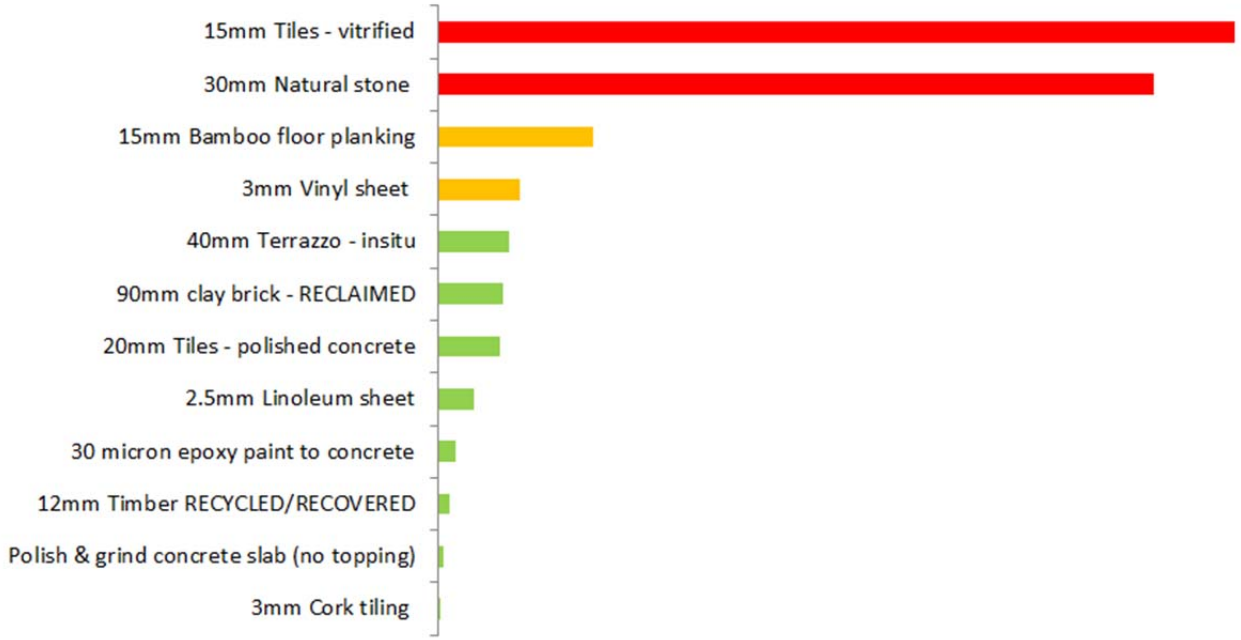


Figure 15: Ecological Impact of Flooring



7.3.2 Internal Ceilings

Figure 16 compares the impact of typical ceiling arrangements. Ultimately, the trend towards no ceilings or painted ceilings is an ecologically preferable solution and should be considered with the approach to services, structure and internal walls.

Figure 16: Ecological Impact of Internal Ceilings

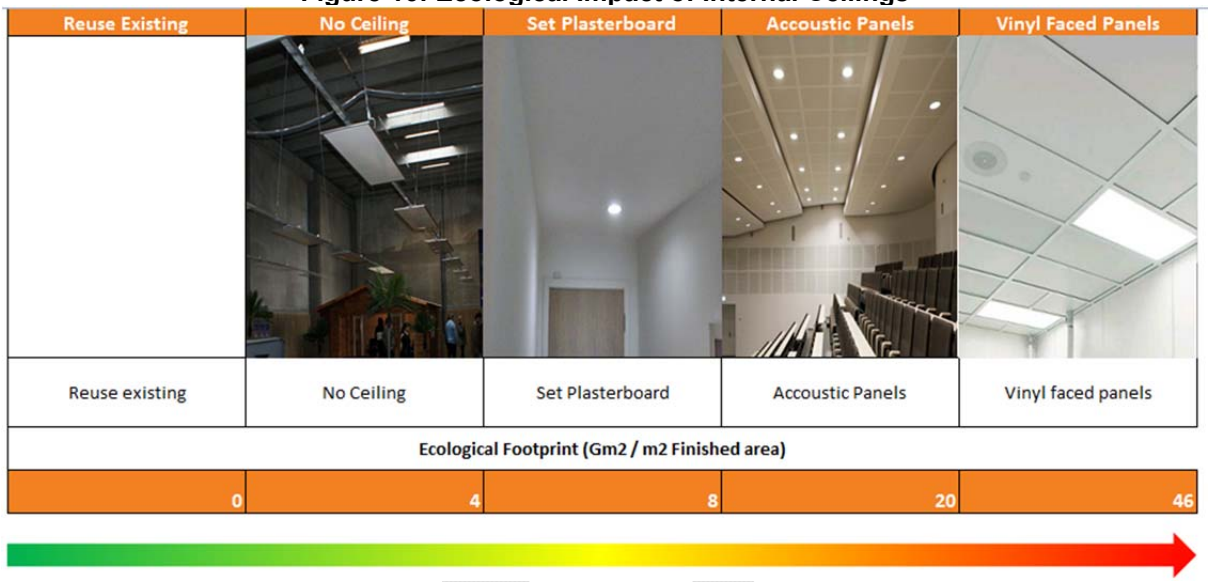


Figure 17 shows a sample of ceiling frame types. Key opportunities include:

- Using recycled content materials for ceiling panels
- Aluminium frames in place of virgin steel.

Figure 17: Ecological Impact of Ceiling Frame Types

7.3.3 Overall Recommendations

Recommendations to achieve the performance requirements for the internal finishes and fitments are outlined in Table 17. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.

Table 17: One Planet Design Pathway: Internal Finishes and Fitments

Sub-element	Low Footprint Materials
Ceilings	▪ Request recycled content ceiling channel and framing ▪ Request recycled content plasterboard and acoustic ceiling panels ▪ Request MDF / HMR with high recycled content >35% ▪ Consider recycled wood composite materials
Resilient Flooring	▪ Consider Keralite 3mm vitrified sheet (or similar) in place of 12mm vitrified porcelain tile ▪ Consider cosentino “Eco” recycled content composite surfaces and tiles ▪ Low VOC epoxy surface finishes to concrete ▪ High recycled low VOC content vinyl sheet flooring
Resilient Finishes	▪ Consider colourback glass in place of vitrified tile ▪ Request recycled content glass mosaic tiles ▪ High recycled content fired porcelain tiles ▪ Carpet to have nylon 66 or other recycled content fibre and backing
Fitments and Cabinets	▪ Consider using Eco-top recycled paper and bamboo countertop material ▪ Dematerialise design ▪ Specify high recycled content HMR / MDF board

7.4 Avoid

The following materials/designs should be avoided when possible:

- Vitrified tiles floor finishes.
- Layering of finishes and fittings.
- Virgin timber products.
- Virgin steel ceiling frames.

7.5 Further Considerations

The principle of dematerialising design for finishes is an essential one as “layering” can add significantly to the overall impact of fittings, finishes and furniture. Minimalistic material design is key to reducing the ecological footprint, and allows for fewer materials with higher individual footprints.

8 Services

8.1 Scope

Services included in this section include mechanical, electrical, vertical and hydraulic, which contains elements like ductwork, insulation, pipework and conduit services. The maximum footprint for the structure element for each construction type is given in Table 18.

Table 18: Services Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
Services	0	130-190			

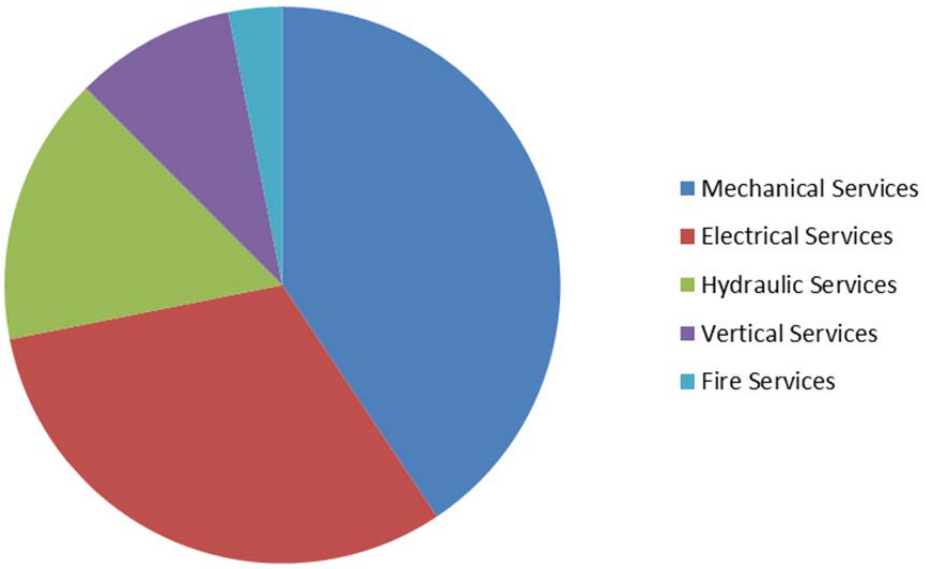
8.2 Impact Drivers

Services ecological footprint is driven by their metals intensity (e.g. copper, stainless steel, zinc) which are difficult to substitute which means right sizing is essential to minimise total materials. Ideally, the design team would use the Footprint Calculators to evaluate the footprint reduction achieved through right sizing. In addition this analysis should also include overall plant room and riser requirements.

The impact proportion of services is shown in Figure 18 and key drivers are:

1. Mechanical services
2. Electrical services
3. Hydraulic Services

Figure 18: Breakdown of Services Sub-Elements



8.3 Key Opportunities

The design team may be able to achieve a reduction through detailed discussions during the procurement phase of the project for key items such as; pipework; cabling; ductwork and mechanical plant.

In general, key opportunities include:

- High performance, correctly sized VAV ducted mechanical systems.
- Chose VAV ducted or chilled beam[6] mechanical systems over displacement systems[7].
- Recycled plastic for insulation, pipework, conduit and gutters.

8.3.1 Overall Recommendations

Recommendations to achieve the performance requirements for the construction services are outlined in Table 19. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.

Table 19: One Planet Design Pathway: Services

Sub-element	Low Footprint Materials
Ductwork	▪ Right size HVAC systems ▪ Request thin gauge or recycled content sheet steel for ductwork ▪ High recycled content glass fibre to flex duct insulation
Insulation	▪ Consider use of 100% recycled polyethylene / polyester for all insulation requirements ▪ Recycled content sisalation and foil facing
Pipework	▪ Recycled content HDPE; PE; pipework ▪ Consider using RPET in place of copper or galvanised pipework if possible
Conduit	▪ Specify recycled polyethylene (rHDPE) ▪ Consider using glass fibre recycled plastic alternatives to galvanised steel cable tray
Kerb and gutters	▪ Consider using Enviro-kerb and grates in place of concrete kerb and guttering ▪ If concrete request 100% fly-ash replacement or recycled concrete

8.4 Avoid

The following materials/designs should be avoided when possible:

- Oversizing HVAC systems.
- Virgin materials for insulation, pipework, conduit and gutters.

8.5 Further Considerations

Embedded services (e.g. recycled water and energy systems) can add more embodied footprint than they are able to deliver in operational performance and should be considered over the life cycle.

[6] Choose chilled beam systems over VAV systems only if beams have recycled content aluminium.
[7] Displacement systems are the most ecologically intense, except where an access floor is otherwise required.

9 External Works and Landscaping

9.1 Scope

External works include materials used outside the building such as pavers, binds, street furniture and the kerb and gutters. External works and services can account for up to 10% of total materials footprint. The maximum footprint for the structure element for each construction type is given in Table 20.

Table 20: External Works and Landscaping Performance Metric (Not To Exceed)

	Maximum Footprint Target (gm2/m2)				
	Refurbishment	**New Build**	**Landscaping**	**Civil Works**	**Furniture Renewal**
External Works	0	1			

9.2 Impact Drivers

Key drivers of the impact for this element include:

1. Pavements and roads.
2. Street furniture and equipment.

9.3 Key Opportunities

The public realm design generally sees the use of concrete pavers on top of concrete ground slabs which adds considerably to the total footprint. The design team may investigate alternative sources or arrangements which may meet the design objectives and balance fitness for purpose and long-term maintenance requirements.

Other items which have a high embodied footprint include the stainless steel bins; street light poles and furniture.

9.3.1 Overall Recommendations

Recommendations to achieve the performance requirements for the external works and landscaping are outlined in Table 21. Refer to APPENDIX B: Material Sources for sources of recommended materials and discouraged materials.

9.4 Avoid

The following materials/designs should be avoided when possible:

- Virgin concrete for pavers and basecourse.
- Virgin materials for street furniture and equipment.
- Stainless steel for bollards, bins and bike racks.
- Hardwood / Cast aluminium for street furniture.

Table 21: One Planet Design Pathway: External Works

Sub-element	Low Footprint Materials
Pavers & basecourse	▪ Consider specifying Zeobond recycled content concrete pavers ▪ Specify 100% recycled DGB basecourse materials ▪ Consider use of recycled content concrete with fibermesh and coloured finish in place of concrete and pavers
Bollards, Bins, Bike Racks	▪ Consider use of recycled plastic bollards in place of stainless steel
Street Furniture	▪ Consider using recycled plastic furniture in place of hardwood / cast aluminium
Kerb and gutters	▪ Consider using Enviro-kerb and grates in place of concrete kerb and guttering ▪ If concrete request 100% fly-ash replacement or recycled concrete

10 Summary

This summary paper provides users with a background on the concept and application of ecological footprint to physical assets. The impact aspects considered and their boundary (as required by standards) and also gives some insight into design approach to minimise total ecological footprint of materials.

Ultimately, it is essential to use an analytical approach to evaluate the whole of life impact of a building, its fitout and operational requirements in order to establish the most ecological and economically productive approach.

The Footprint Calculators are designed to support project teams with this objective and have a large number of materials alternatives as outlined above embedded to reduce the time and complexity of these types of multi-dimensional analyses.

Refer to www.footprintcompany.com.au for more information.

10.1 Limits and Warrantees

The Footprint Company maintains an active research process on materials and arrangements and makes every effort to ensure that material provided reflects current industry standards. Users of this report must make their own investigations as to the fitness for purpose of any arrangement or material outline and TFC take no responsibility for Users actions in this regard.

APPENDIX A: Audit Submission Checklist

Each element must comply with the maximum footprint target and the following deliverables must be submitted. A final schedule of built quantities must be produced as well as a fitting schedule for the site energy. In general, if a more environmentally friendly product/material is used, evidence must be produced (i.e. specifications from manufacturer, certificates of recycled material, green tag compliance).

Appendix Table 1: Compliance Table

Element	Maximum Footprint Target (gm2/m2)		Reports and Submissions must provide and comply with:	Document Received	Mandatory Requirement Achieved
	Refurbishment	**New Build**		☐	☐
All			Final schedule of built quantities. Evidence of recycled material or environmentally friendly choices from manufacture (product documentation to prove compliance with regulatory body).	☐	☐
Structure and Roof	0	130-200	Report the quantity of materials (m^2) and manufacturer specifications of: • Structural / non-structural concrete • Formwork • Reinforcements or cables • Steel • Roof (membrane, lining, glaze, frame, slab etc) • Other	☐	☐
Façade	0	30-50	Report the quantity (m^2) of materials and manufacturer specifications of: • Glazing • Solid Walls • Sunshade / Balustrade elements • Perimeter / Retaining Walls • Other	☐	☐
Internal Walls	12-19	30-50	Report the quantity (m^2) of materials and manufacturer specifications of all internal walls and finishes.	☐	☐

Internal Ceilings	3-5	4-6	Report the quantity (m^2) of materials and manufacturer specifications of all internal ceilings and ceiling finishes.	☐	☐
Floor finishes	3-4	12-18	Report the quantity (m^2) of materials and manufacturer specifications of: • Soft floor finishes • Hard / resilient floor finishes • Timber / fibre floor finishes	☐	☐
Furniture	10-15	30-50	Report the quantity of materials and manufacturer specifications of: • Chairs • Workstations • Tables • Cabinets	☐	☐
Equipment and other items	19-29	30-50	Report the quantity of materials and manufacturer specifications of all equipment and other appliances. Report the total cost ($) spent on: • Consumables • Paper and print services • Food and drink • Cleaning and waste services • Other	☐	☐
Doors	1	2-4	Report the quantity (m^2) of materials and manufacturer specifications of all internal and external doors.	☐	☐
Services	0	130-190	Report the type of service and total cost ($): • Mechanical services • Electrical services • Hydraulic services • Vertical services • Fire services	☐	☐
External Works	0	1	Report the total cost of ($), quantity ($m^2$) of materials and manufacturer specifications of: • Landscaping • Paving • Fencing	☐	☐

Other	0	0-1	Report the total cost ($) of: • Landscaping works • Excavation works • Remedial works • Demolition • Development management • Design service • Project management • Contingency • Design fees • Preliminaries, profits and supervision	□	□

APPENDIX B: Material Sources and Discouraged Materials

Appendix Table 2: Structure Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Core walls	Dincell: www.dincelconstructionsystem.com Kingspan: www.kingspaninsulation.com.au Armstrong's Wallflex www.armstrong-aust.com.au	• Material intensive designs.
Formwork	Lysaght's "Bondek": www.lysaght.com Deslauriers: www.deslinc.com Geoplast (IT): www.geoplast.it	• Timber formwork.
Structural concrete	ResourceCo: www.resourceco.com.au	• Unstressed concrete.
Non-structural concrete	VisQueen EcoMembrane: www.visqueenbuilding.com Ecoground: www.ground-control.com.au	• Virgin materials.
Reinforcement bar & mesh	Propex: www.fibermesh.com One Steel's Eco-Reo™: www.reinforcing.com.au	• Steel mesh.
Structural Steel	OneSteel: www.onesteel.com.au	• Virgin steel.
Purlins & Girts etc	Lysaght's Zed and Cee: www.lysaght.com	• Steel intensive design.
Bulk Excavation	Dincell: www.dincelconstructionsystem.com	
Plastic column forms	Deslauriers: www.deslinc.com Geoplast (IT): www.geoplast.it	• Concrete column forms.
Kerb & gutter	Pipeline and Drainage Systems' "Enviro-kerb": www.pds-plc.com	• Virgin materials.
Grates, drains & rails	Stormtech: www.stormtech.com.au Pipeline Drainage Systems: www.pds-plc.com Replas: www.replas.com.au	• Cast-iron and stainless steel.
Sub-soil drainage	Atlantis' geotextile and flo-cells: www.atlantiscorp.com.au	• Virgin materials.

Appendix Table 3: Roof Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Purlins & Girts etc	Lysaght's Zed and Cee: www.lysaght.com	• Steel intensive designs.
Roof Sheeting	Lysaght: www.lysaght.com	• Virgin materials. • Stainless steel, copper and zinc cladding.
Composite panels	Kingspan: www.kingspanpanels.com.au	• Panels with an internal ceiling.
Roof drainage	Stormtech: www.stormtech.com.au Pipeline Drainage Systems: www.pds-plc.com Replas: www.replas.com.au	• Stainless steel.
Roof access ways & plant decking	Perma Composites: http://www.permacomposites.com Replas: www.replas.com.au	• Aluminium and stainless steel access ways, handrails and stairs.
Roof lights	Danpalon: www.danpalon.com.au	

Appendix Table 4: Facade and External Wall Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Cladding	Nu-Wall: www.nu-wall.co.nz Cedar Sales: www.cedarsales.com.au Urbanline Architectural: www.urbanline.com.au	• Virgin aluminium. • Stainless steel, copper and zinc cladding.
Sarking & Insulation	Bradford: www.bradfordinsulation.com.au Fibreco: www.fibreco.com.au Knauf's Earthwool ®: www.knaufinsulation.com.au Tontine's Pacific NonWovens: www.tontineinsulation.com.au Proactive Technology Australia's Polastic: www.proactivetechnology.com.au	• Fibreglass or rockwool insulation.
Wall framing & channel	BlueScope: www.bluescope.com.au Lysaght's Zed and Cee: www.lysaght.com	• Virgin aluminium.
Flashing & Capping	Lysaght: www.lysaght.com	• Virgin steel.
Sunscreens	Permacomposities: www.permacomposites.com Kawneer: www.kawneer.com	• Virgin materials.
Blockwork	Motarless Masonry Technology: www.mortarless.com.au Boral: www.boral.com.au Island Block: www.islandblock.com.au Dincell: www.dincelconstructionsystem.com One Steel's Eco-Reo™: www.reinforcing.com.au	• Virgin materials for cement and reinforcements.

Appendix Table 5: Internal Wall Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Sarking & Insulation	Bradford: www.bradfordinsulation.com.au Fibreco: www.fibreco.com.au Knauf's Earthwool ®: www.knaufinsulation.com.au Tontine's Pacific NonWovens: www.tontineinsulation.com.au Proactive Technology Australia's Polastic: www.proactivetechnology.com.au	• Fibreglass or rockwool insulation.
Wall framing & channel	BlueScope: www.bluescope.com.au Lysaght's Zed and Cee: www.lysaght.com	• Thick gauge steel. • Blockwork.
Plasterboard	Knauf Plasterboard: www.knaufplasterboard.com.au Boral Enviro plasterboard: www.boral.com.au USG Borals's Powerscape: www.powerscape.com Gyprock's Environmental range: www.gyprock.com.au	• Virgin materials.
Solid partitions	Oretech Industries, Durra: www.ortech.com.au CSR: www.csr.com.au Boral: www.boral.com.au	• Blockwork (especially blockwork with motar)
Timber	Bamboo and Timber: www.bambooandtimber.com.au Replas: www.replas.com.au	• Virgin timber. • MDF and plywood.

Appendix Table 6: Internal Finishes and Fitment Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Ceilings	SupaWood's SuperSlat Maxi: www.supawood.com.au Armstrong's Dune: www.armstrong-aust.com.au USG Borals's Powerscape: www.powerscape.com/ USG Boral's Radar™: www.usgboral.com OWA's OWAconstruct®: www.owa.de/en	• Virgin timber. • Virgin framing and plasterboard.
Resilient Flooring	Consentio's Eco: www.ecobycosentino.com Parchem: www.parchem.com.au Armstrong: www.armstrong-aust.com.au Australian Floorworks' EcoGround ™: www.ground-control.com.au Geo Flooring: www.geoflooring.com.au Tarkett's iQ Eminent: www.tarkett.com.au Wicanders Cork Flooring: www.wicanders.com/en/	• Vitrified tiles. • Glazed ceramic tiles. • Marble paving.
Resilient Finishes	Tarkett: www.tarkett.com.au Crossville: www.crossvilleinc.com	• Vitrified tiles. • Virgin glass or porcelain tiles.
Fitments and Cabinets	Herman Miller Australia: www.hermanmiller.com.au RJ Workspace: www.rj.com.au Schiavello: www.schiavello.com Furniture Concepts: http://esvc000230.wic048u.server-web.com/index.html Posh: www.posh.com.hk/en Baresque: www.baresque.com.au Laminex: www.laminex.com.au	• Virgin timber. • Material intensive designs.

Appendix Table 7: Service Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Insulation	Fletcher Insulation: www.insulation.com.au Bradford: www.bradfordinsulation.com.au Fibreco: www.fibreco.com.au Knauf's Earthwool ®: www.knaufinsulation.com.au Tontine's Pacific NonWovens: www.tontineinsulation.com.au Proactive Technology Australia's Polastic: www.proactivetechnology.com.au	• Virgin materials.
Pipework	Recycled Pipe Manufactures (RPM Pipe): www.rpmpipe.com.au	• Copper or galvanised pipework.
Kerb and gutters	Pipeline and Drainage Systems' "Enviro-kerb": www.pds-plc.com Stormtech: www.stormtech.com.au Pipeline Drainage Systems: www.pds-plc.com Replas: www.replas.com.au	• Virgin concrete kerb and guttering.

Appendix Table 8: External Works Sources and Discouraged Materials

Sub-element	Possible Sources	Discouraged Materials
Pavers & basecourse	Zeobond Group's E-Crete: www.zeobond.com Island Block's Pavers for the Future: www.islandblock.com.au Boral: www.boral .com.au	• Virgin concrete pavers.
Bollards, Bins, Bike Racks	Replas: www.replas.com.au	• Stainless steel.
Street Furniture	Innowood: www.innowood.com.au	• Hardwood. • Cast aluminium.
Kerb and gutters	Pipeline and Drainage Systems' "Enviro-kerb": www.pds-plc.com Stormtech: www.stormtech.com.au Replas: www.replas.com.au	• Virgin concrete kerb guttering.