6. Protect the environment with climate action / ~~Lead in mitigation and resilience efforts against the climate emergency and environmental crises~~

6.1 Commit to net zero whole-life emissions to contribute to climate change mitigation

State of health

Climate change will impact human life and health in nearly every way imaginable; from access to water, impact on agriculture and food supply, to jeopardising the future of our cities and infrastructure. Climate change is termed by the World Health Organization as 'the greatest global health threat of the 21st century'[1] (WHO, n.d). Between 2030 and 2050, climate change is predicted to lead to approximately 250,000 additional deaths each year, caused by malnutrition, malaria, diarrhoea, and heat stress. The economic cost of these health impacts is estimated to be US $2-4 billion per year by 2030[2].

With the building and construction sector responsible for 39% of global carbon emissions,[3] and expectations that the global building stock is expected to double in size by mid-century[4], addressing emissions across the whole lifecycle of a building is urgent. While most emissions occur from the occupational phase of the building lifecycle, referred to as operational emissions, the substantial increase in new buildings will see a dramatic rise in embodied carbon. Embodied carbon is the emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure[5].

Within occupied buildings, cooling is a growing issue that can lead to competing priorities between environment and human health, wellbeing, and development. Cooling technologies, such as refrigeration and air conditioning, emit large quantities of HFCs (hydroflourocarbons), a potent greenhouse gas with '1,000 to 9,000 times greater capacity to warm the atmosphere than carbon dioxide' (Drawdown, 2017)[6]. A United Nations report highlights that "cooling is now responsible for about 10% of global warming and growing rapidly"[7] (United Nations, 2019).

The volume of HFCs in the atmosphere is increasing at 8-15% per year due to population growth and urbanisation, and their use is likely to increase as our climate warms further due to climate change[8]. The importance of sustainable development is unparalleled here, with 2.3 billion people across the world expected to soon purchase an air conditioning unit or fridge, and it is likely that choices will be limited to inefficient and highly emitting appliances[9].

As the vast majority of HFC emissions occur at end of life stage for these technologies (estimated 90%[6]), sustainable removal and waste management of cooling appliances is an essential part of climate change mitigation in the built environment sector. This could prevent the release of HFC emissions equivalent to nearly 58 gigatons of carbon dioxide, which is equal to over 63 years of global aviation emissions[10] (based on 2019 annual data).

Outcomes:

- All new and existing buildings demonstrate improvements in lifecycle energy efficiency, targeting net zero operational carbon emissions in all new buildings by 2030, and net zero embodied carbon in all new buildings by 2050 (including emissions from equivalent greenhouse gases, specifically HFCs).

Strategies across the lifecycle

Strategies for the building sector recommended by the World Green Building Council are aligned to the WorldGBC Advancing Net Zero global project principles[11]:

For operational carbon:

Design:
- Reduce energy demand, by prioritising efficiency and incorporating on-site renewable sources
- Consider sustainable energy concepts both within a building and at scale, for example connection to local energy networks across multiple buildings, such as a campus or city quarter, in order to increase the efficiency of energy assets across buildings
- Plan for the future**:** Set out trajectory of improvements and 'trigger points' in lifetime of investments to maximise likelihood and practicality of energy-efficient renovations

Operation:
- Measure and disclose carbon, with buildings working towards achieving annual operational net zero carbon emissions balance based on metered data
- Reduce energy demand, by prioritising efficiency in use and minimising energy waste
- Incorporate innovative business models that allow energy trading across various buildings to minimise energy waste and achieve highest efficiency
- Generate power from renewables, supplying remaining energy balance through renewables, ideally on-site, followed by off-site, then offsets
- Improve verification and rigour through expansion of sustainability scope and reporting

For embodied carbon:

Design:
- Prevent**:** Question the need to use materials at all, considering alternative strategies for delivering the desired function, such as increasing utilisation of existing assets through renovation or reuse.
  - Passive design strategies, particularly around thermal comfort, can eliminate the need for MEP equipment which will require replacement through lifecycle of a building
- Reduce and optimise: Use low carbon design solutions in terms of upfront emission reductions and as part of a whole life approach. In early stages of design, use lifecycle analysis to target dematerialization, light-weighting of structural elements, switch to lower carbon material sources, and design for waste prevention by building with modular and pre-fabricated components. Such low carbon designs, zero carbon responsibly sourced materials, and low or zero carbon construction techniques will maximum efficiency and minimize waste on site.
  - Selection of products with closed-loop or take-back programs to support a circular economy (see Principle 6.4)
- Plan for the future**:** Consider future use scenarios and end of life, maximising the potential for maintenance, repair and renovation and designing for disassembly and deconstruction to facilitate future reuse.

Operation:
- **Offset:** As a last resort, offset residual embodied carbon emissions either within the project or organisational boundary or through verified offset schemes.

For HFC reduction:

Design:
- Implement cooling technologies with low-GWP refrigerants in all new and renovated constructions
- Improve passive design measures, such as insulation, shading and solar gain prevention and community scale master planning, to avoid or reduce the use of cooling systems (such as air-conditioning)

Design (policy recommendations**):**
- Use policy levers and wider mechanisms to undertake ambitious measures to improve energy efficiency in the cooling sector while phasing out HCFC and phasing down HFC refrigerants

under the Montreal Protocol, such as developing national cooling plans based on domestic circumstances, using energy performance standards (MEPS)

Operation:

- Refrigerant and equipment management: replace HFCs in cooling technologies with low- or zero-global warming potential alternatives, such as propane and ammonium[12]; practice responsible management and servicing of existing equipment and better designs for future equipment to minimise leaks

Benchmarks:

- By 2030, all new buildings, infrastructure and renovations will have at least 40% less embodied carbon with significant upfront carbon reduction, and all new buildings are net zero operational carbon.
- By 2050, new buildings, infrastructure and renovations will have net zero embodied carbon, and all buildings, including existing buildings must be net zero operational carbon

Organisations, cities and regions can commit to climate action through the WorldGBC Net Zero Carbon Building Commitment: https://www.worldgbc.org/thecommitment

More information:

- Australian Sustainable Built Environment Council (ASBEC) 2019 'Every Building Counts: A practical plan for emissions reduction': https://www.everybuildingcounts.com.au/
- Beam Plus New Buildings V2.0 'Materials and Waste, Sustainable Site': https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- BREEAM International New Construction Standard 'Ene 01 Reduction of energy use and carbon emissions' and 'Mat 01 Life cycle impacts': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard 'Asset Energy Performance' and 'Operational Energy Performance': https://www.breeam.com/discover/technical-standards/
- C40 Cities 'Towards a Healthier World: Climate Change, Air Quality and Health' https://www.c40.org/research
- Climate and Clean Air Coalition 'Hydroflourocarbons' https://www.ccacoalition.org/en/slcps/hydrofluorocarbons-hfc
- Cradle to Cradle Certified™ Products Program (Renewable Energy and Carbon Management) https://www.c2ccertified.org/
- DGNB ' No More Excuses' https://www.dgnb.de/en/council/publications/index.php
- DGNB ' The cost trap of refrigerants' https://www.dgnb.de/en/council/publications/index.php
- E.ON 'City Energy Solutions' https://www.eon.com/en/business-customers/city-energy-solutions.html
- Green Building Council of Australia Green Star - Design & As Built 'Energy: https://new.gbca.org.au/green-star/rating-system/design-and-built/
- Jordan GBC 'Developing an energy benchmark for residential buildings in Amman' https://drive.google.com/file/d/1KMD_6Kb2b6Px0ZRhnP6qaQ2UsLpaTmhl/view (Link to be updated)
- Government Architect New South Wales 2018 'Guide to Environmental design in schools': https://apo.org.au/sites/default/files/resource-files/2018-10/apo-nid202276.pdf
- Green Building Council of Australia Green Star – Communities 'Environment: https://new.gbca.org.au/green-star/rating-system/communities/
- IFC's EDGE rating tool: 'Embodied Energy in Materials' https://www.edgebuildings.com/edge-embodied-energy-in-materials-methodology/
- Sutherland, L and Santini, M. RAP Online. 'Filling the policy gap: Minimum energy performance standards for European buildings' https://www.raponline.org/knowledge-center/filling-the-policy-gap-minimum-energy-performance-standards-for-european-buildings/
- USGBC LEED v4.1 BD+C rating system, 'Building lifecycle impact reduction' https://www.usgbc.org/credits/new-construction-schools-new-construction-retail-new-construction-data-centers-new-constru-6?return=/credits/New%20Construction/v4.1
- WorldGBC, 2019: Advancing Net Zero Status Report 2019
- WorldGBC, 2019: Bringing Embodied Carbon Upfront

- WorldGBC, 2017: From Thousands to Billions
- WorldGBC: The Net Zero Carbon Buildings Commitment
- World Health Organization. (2011). Health in the green economy : health co-benefits of climate change mitigation - housing sector. World Health Organization. https://apps.who.int/iris/handle/10665/44609

6.2 Design for resilience in preparation for the climate crisis and extreme weather events

State of health

Every year natural disasters kill around 90,000 people and affect close to 160 million people worldwide[13]. Over the past decade, disasters have been responsible for 0.1% of deaths globally, but have severely impacted the health and wellbeing of millions more across the world, often in the most vulnerable nations[14]. Natural disasters displace more people than conflict and violence[15]. Data shows that flooding caused most disasters between 1994 and 2013, accounting for 43% of all recorded events and affecting nearly 2.5 billion people.[16].

Today, more people are at risk than 50 years ago, and construction in flood plains, earthquakes zones and other high-risk areas has increased the likelihood that a routine natural hazard will become a major catastrophe. Additionally, climate change is understood to lead to increased frequency and severity of extreme weather events. The Intergovernmental Panel on Climate Change Fifth Assessment Report (2014) showed that changes in extreme weather and climate events have been observed since about 1950, and attribution studies demonstrate evidence of human contribution through anthropogenic climate change in worsening these events in likelihood and/or severity[17].

One of the most devastating socio-economic outcomes of environment disasters is the damage wreaked upon infrastructure, vital services, resources, and particularly housing and livelihood of local populations. Drought, fire, and famine are also direct results of the climate crisis, and indirectly linked to the building sector due to sectoral contribution to global emissions, which will have severe impacts on human health and quality of life.

Although disaster-resistant communities are challenging to implement, particularly in locations where multiple environmental threats are present, conscious design of a built environment with climate resilience strategies and adaptation to changing situations can offer relief against worst-case scenarios and provide possible long term benefits to these vital socio-economic determinants of health.

Outcomes

The design and operation of buildings and urban areas should incorporate strategies to enhance community resilience to the climate crisis. Strategies must not exacerbate societal inequalities and should account for the needs of vulnerable populations locally.

Strategies across the lifecycle

Design:

- Resilient design strategies, considered for mitigation and adaptation to evolving environmental, social, and economic circumstances
- Environmental assessments at building planning or master planning stage, specialised for situational risks, e.g. flood risk assessment
- Design for reduced dependence on complex building controls and systems, providing manual overrides in case of malfunction or temporary power outages
- Plan resilient systems, including independent power reserves or non-centralised power generation in areas at risk of natural disaster and national grid failures
- Specify products and materials that will not give off gas or leak hazardous substances in the event of natural disaster, including avoidance of cooling systems that would leak highly polluting refrigerants in case of breakage
- Utilise vernacular design practices that were prevalent before the advent of air conditioning and central heating. Combine these design strategies with modern materials to optimise resilient design to maximise human health and comfort in situation of systems failures.

Operation:

- Carry out water conservation practices and rely on annually replenished water resources, including, potentially, harvested rainwater, as the primary or back-up water supply

- Practice community resilience and prepared response to natural disasters

Benchmarks:

- UNDRR; 'Sendai Framework for disaster risk reduction': https://www.undrr.org/implementing-sendai-framework/what-sf

More information:

- Australian Sustainable Built Environment Council (ASBEC) 2019 'Every Building Counts: A practical plan for emissions reduction': https://www.everybuildingcounts.com.au/
- Beam Plus New Buildings V2.0 'Sustainable Site': https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- BREEAM International New Construction Standard 'Hea 07 Hazards', 'Mat 05 Designing for durability and resilience', 'Wst 05 Adaptation to climate change' and 'Pol 03 Surface water run-off': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard 'Wat 01 Water monitoring'… [and all subsequent credits until] Wat 14 Water strategy' and 'Rsl 02 Surface water run-off impact mitigation': https://www.breeam.com/discover/technical-standards/
- DGNB ' No More Excuses' https://www.dgnb.de/en/council/publications/index.php
- DGNB ' The cost trap of refrigerants' https://www.dgnb.de/en/council/publications/index.php
- Global Commission on Adaptation's resources (flagship report here and background papers here)
- Government Architect New South Wales 2018 'Guide to Environmental design in schools': https://apo.org.au/sites/default/files/resource-files/2018-10/apo-nid202276.pdf
- Green Building Council of Australia Green Star – Communities 'Environment': https://new.gbca.org.au/green-star/rating-system/communities/
- Green Building Council of Australia Green Star - Design & As Built 'Emissions': https://new.gbca.org.au/green-star/rating-system/design-and-built/
- National Center for Atmospheric Research, USA & IAG 2019. Severe Weather in a Changing Climate: https://www.iag.com.au/sites/default/files/documents/Severe-weather-in-a-changing-climate-report-151119.pdf
- Ranđelović, D & Vasov, et al. 2018. Determination of climate characteristics as a dominant parametar in building design - case study the city of Niš. Resilient Design Institute 'Resilience design strategies': https://www.resilientdesign.org/resilient-design-strategies/
- United Nations. Disaster Preparedness for Effective Response. Guidance and Indicator Package for Implementing Priority Five of the Hyogo Framework. https://www.unisdr.org/files/2909_Disasterpreparednessforeffectiveresponse.pdf
- UNECE publication on Guidelines for the formalization of informal constructions: https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/Technical_guidelines_informal_settlements.EN.pdf
- World Health Organization. (2011). Health in the green economy : health co-benefits of climate change mitigation - housing sector. World Health Organization. https://apps.who.int/iris/handle/10665/44609
- Wu, W. 2020. Natural Hazards. 'Disaster Resilient Communities: An examination of development differences' https://link.springer.com/article/10.1007/s11069-020-03865-5

6.3 Use water efficiently, working to avoid local shortage crises

State of health

Nearly 1.8 billion people in seventeen countries, or a quarter of the world's population, appear to be veering towards a water crisis with the potential of severe shortages in the next few years. Of the 17 nations, 12 are in the Middle East and North Africa[18]. The ongoing rise in global population will continue to place pressure on this finite resource.

Water is used at all stages of a building's lifecycle, from the extraction of raw materials, in manufacturing, during construction, and in the operational phase in buildings of all types. Water is a resource often used in the demolition process, which can include retrofit and de/reconstruction. Highest water use is typically during the in-use phase of buildings and is consequently regulated by building standards in many countries[19].

Water in developed countries is pumped, purified, treated, and heated before it reaches building occupants. This process greatly increases the amount of energy that we use. Domestic hot water usage alone is responsible for 35 million tonnes of greenhouse gas emissions in the UK, representing around 5% of national energy use[20]. When we are wasting water, we are also wasting the energy that is used in preparing it for use.

The public water supply represents 21% of the total water use in the EU – with buildings accounting for most of the usage, many initiatives are currently being implemented at local or national levels to reduce water consumption in buildings[21].

Outcomes

Reduce demand, enhance water efficiency, and ensure sustainable drainage and water management through the design, construction, and operation of built environment to reduce stress on water bodies and related ecosystems. Explore utilisation of other sources of water, such as treated greywater, at site and community level where feasible.

Strategies across the lifecycle

Design:

- Re-use and recycle fresh water on-site, utilising grey and blackwater systems where feasible.
- Explore sustainable drainage opportunities, such as permeable hard surfacing, to facilitate responsible water management and reduce water waste.

Construction:

- Commit to water reduction in materials sourcing and construction stages of lifecycle

Operation:

- Carry out on-site water collection and conservation practices and rely on annually replenished water resources, including harvested rainwater as the primary or back-up water supply.
- Include low-flow features within operational buildings, for example water-less human waste disposal and wastewater systems
- Install water leakage detection systems
- Manage on-site water in a responsible manner, with aim of increasing water infiltration into soil and return to groundwater.
- Organisational advocacy around water efficiency; including water offsets, divestment from organisations that support fossil fuel pipelines across water sources, positive personal behaviour change

Benchmarks:

- BBP. '2017 Real Estate Environmental Benchmarks' https://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/REEB%20Benchmarking%202017_0.pdf

- CIRIA 'Key performance indicators for water use in offices' https://www.ciria.org/Resources/Free_publications/KPI_water_offices.aspx
- Water Key Performance Benchmarks and Indicators for Offices and Hotels. https://waterwise.org.uk/wp-content/uploads/2019/09/CIRIA-2006_Water-Key-Performance-Indicators-and-Benchmarks-for-Offices-and-Hotels.pdf

More information:

- Beam Plus New Buildings V2.0 'Water Use': https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- Build Magazine Research: 'Benchmarking water use in commercial buildings' https://www.buildmagazine.org.nz/assets/PDF/Build118-80-Research-Benchmarking-Water-Use.pdf?
- BREEAM International New Construction Standard 'Wat 01 Water consumption', 'Wat 02 Water monitoring', 'Wat 03 Water leak detection and prevention', 'Wat 04 Water efficient equipment', 'Mat 01 Life cycle impacts' and 'Pol 03 Surface water run-off': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard 'Wat 10 Reducing utility-supplied water consumption', 'Wat 12 Water recycling', 'Rsl 01 Flood risk assessment'… [and all subsequent credits until] 'Rsl 08 Social risks and opportunities', 'Pol 01 Minimising watercourse pollution', 'Pol 02 Chemical storage', 'Pol 07 Inspection of watercourse pollution prevention features' and 'Pol 10 Response to pollution incidents': https://www.breeam.com/discover/technical-standards/
- Cradle to Cradle Certified™ Products Program (Water Stewardship) https://www.c2ccertified.org/
- Construction Products Association, 2015. '*Water efficiency, the contribution of construction products'* https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf
- DGNB ' No More Excuses' https://www.dgnb.de/en/council/publications/index.php
- DGNB ' The cost trap of refrigerants' https://www.dgnb.de/en/council/publications/index.php
- Green Building Council of Australia Green Star - Design & As Built 'Water: https://new.gbca.org.au/green-star/rating-system/design-and-built/
- Green Building Council of Australia Green Star – Communities 'Environment: https://new.gbca.org.au/green-star/rating-system/communities/
- Vasilevska, M & Vasilevska, L: Modern stormwater management approaches in urban regeneration. In: Conference Proceedings of 6th International Conference Contemporary achievements in civil engineering: http://www.gf.uns.ac.rs/~zbornik/doc/NS2018.52.pdf
- Water Savings Solutions Pack: http://www.investinginwater.org/

6.4 Ensure safe, healthy and circular use of materials across the building lifecycle

State of health

Hazardous chemicals can be found everywhere. Modern life has brought hazardous chemicals into our homes and lives through everyday products such as clothing, electronics, and food packaging, and can increase the risk of serious illness. Exposure to toxic or polluting materials is an environmental and public health concern across all stages of the built environment lifecycle, from the production of materials to buildings in occupation and beyond.

The relationship between building materials and health in the built environment is multi-faceted; four core concepts to improve human health and quality of life are outlined below.

<u>Safe production of materials:</u>
Workers involved in generating materials across the supply chain needed for construction are at risk of diverse health issues, one example being the production of bricks. Brick kilns, 90% of which are in Asia, are recognised as one of the largest stationary sources of black carbon which, along with iron and steel production, contributes 20% of total global black carbon emissions[1]. The consequential air pollution is damaging to human health on both local and global scales, as discussed in Principle 1.1. A reduction in wasted materials, both through higher site efficiencies and construction practices and the reuse of existing materials as part of a circular economy, would subsequently reduce the pollution from production.

<u>Circular material use:</u>
The concept of circular material use, and ‘cradle to cradle’ principles, is recognised as sustainability best practice globally for the built environment, considering both materials within building interiors, as well as heavy materials utilised in construction. The Ellen Macarthur Foundation considers the transition to a circular economy as the required ‘fundamental shift in the global approach to cutting emissions’, and states the implementation of circular principles in five core areas worldwide could eliminate emissions on a scale equivalent to those generated by all transport globally[22]. Heavy industries (cement, steel, aluminium) represent three of the five core areas focused on in this research, and are substantial contributors to the embodied emissions of building and infrastructure projects, thus emphasising the major role the building and construction industry must play.

Materials found within healthy, sustainable buildings should be operating as part of a circular economy of material re-use. Materials must mitigate risk of poor indoor environmental quality through the release of airborne pollutants, such as Volatile Organic Compounds. These materials are termed ‘low-emissive’. Circular material use calls for re-use and recycling of existing resources, however, hazardous chemicals that currently exist within the built environment must be extracted through retrofit and deconstruction work, allowing reuse of non-contaminated materials only.

<u>Non-hazardous chemicals:</u>
Man-made toxic chemicals are common ingredients in many everyday products[23], and studies are demonstrating serious long-term impacts on human health due to this continued exposure. For example, scientists have linked the fact that men in the Western world produce half as much sperm as they did 40 years ago to exposure to toxic chemicals[24], and that exposure to toxic chemicals can increase the risk of breast cancer in women[25]. Other studies link exposure to toxic chemicals to attributable IQ loss and intellectual disability in children[26].

Many of the hazardous substances in widespread use are replaceable with safer alternatives. For many building products, hazards in product ingredients are unknown or protected by trade secrets. Seeking greater disclosure of building material ingredients as well as finding safer alternatives are ways the building and construction industry can support the transition to safer chemicals being used and developed.

<u>Designing out waste:</u>
For many cities the disposal and treatment of waste is a growing burden that is increasingly difficult to tackle. From 2000-2012, waste generated in cities approximately doubled, increasing from 680 million tonnes to 1.3 billion tonnes per year. This figure is expected to nearly double again to 2.2 billion

tonnes by 2025[27] as a result of increasing population, urbanisation, and changing consumption patterns.

The waste problem is most severe in urbanising regions and developing countries, where collection and disposal services do not exist or cannot cope with increasing amounts of waste. As a result, waste is either disposed in open and uncontrolled dumpsites, openly burned, or leaks into the land, waterways and oceans. This represents the third largest man-made source of methane[28]. Unmanaged waste may also become a breeding ground for microbes and toxins that contaminate the air, soil, and water[29]. Waste is also a severe risk-factor to marine ecosystems and natural life, particularly plastic pollution of ocean environments[30].

These practices have deleterious impacts on public health, the environment, and the wellbeing of waste workers and nearby residents. Our buildings and communities have a central role in waste reduction, both as the locations in which we live, work and use the majority of our products and resources, but also through the construction industry's sustainable management and use of materials.

Outcomes:

- Building projects consciously avoid the use of hazardous materials and chemicals during construction projects (including retrofit and deconstruction), facilitating the extraction from existing materials and projects to avoid contamination and further circulation in industry. All projects support the built environment sector's transition to a circular economy with minimal waste leakage into the natural environment.

Strategies across the lifecycle

<u>Materials</u>

Design:

- Design for adaptation and flexibility in design and operational use of buildings, increasing lifespan of use and reduce the need for demolition and rebuilding
- Minimise use of resources using LCA (to optimise balance between materials and energy use, dematerialization, waste generation etc.)
- Choosing products wisely based on chemical content/makeup/constitution, prioritising low-emissive materials for environments occupied by people and transition away from hazardous chemical use, and utilise recovered materials to implement a circular economy of material use

Construction:

- Avoid hazardous substances, and safely remove if feasible, to facilitate recycling and circular re-use of materials
- Close the loop : design out waste, create circular products, and prefer refurbished, remanufactured, and recycled products in purchasing.

Operation:

- Material use reporting: transparent monitoring and publication of resource use, targeting and encouraging circularity in site operations

<u>Waste</u>

Design:

- Prevent waste from building design by using modular systems, components, eliminating finishes, and supporting manufacturers that participate in circular economy and zero waste design goals for products
- Ensure projects have multiple waste streams (including food waste) with source separation to support occupant behaviour change and reduce greenhouse gas emissions associated with operational waste.

Construction:

- Support the reduction of construction and demolition waste by designing for material recovery, promoting higher-grade recovery applications where possible to facilitate longer lifespan of material re-use

Operation:

- Promotion of composting (food waste) and recycling on-site in buildings, from construction to operational stages of building lifecycle
- Organic waste diversion to minimize food and landscape waste to landfills can reduce methane generation and avoid unnecessary expansion of landfill to accommodate excess waste
- Prevent open waste burning: Promoting alternatives to open burning to reduce black carbon emissions and to prevent the release of cancer-causing compounds and other toxic substances.
- Litter reduction programs to prevent leakage into the environment

Benchmarks:

- Whole building Life Cycle Assessments undertaken at design stage, benchmarked in accordance with national averages, or by comparing an innovative, low-carbon design against a similar building using traditional design and materials.
- Environmental Product Declarations (EPDs) and product chemical transparency labelling schemes for specific products
- Hazardous chemical lists, such as REACH Restricted Substances List (EU Regulation) and additional market resources

More information:

- Australian Sustainable Built Environment Council (ASBEC) ‘Every Building Counts: A practical plan for emissions reduction’: https://www.everybuildingcounts.com.au/
- Beam Plus New Buildings V2.0 ‘Materials and Waste, Energy Use, Integrated Design and Construction Management’: https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- BREEAM International New Construction Standard ‘Energy’, ‘Materials’ and ‘Waste’ categories: https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard ‘Energy’ and ‘Resources’ categories: https://www.breeam.com/discover/technical-standards/
- Cradle to Cradle Certified™ Products Program (Renewable Energy
- C40 Cities. ‘Municipality-led circular economy case studies’ https://c40-production-images.s3.amazonaws.com/researches/images/75_CE_case_studies_interactive.original.pdf?1554823891
- ChemSec ‘The Bigger Picture: Assessing economic aspects of chemical substitution’ https://chemsec.org/publication/authorisation-process,chemicals-business,reach/the-bigger-picture-assessing-economic-aspects-of-chemicals-substitution-2016/
- ChemSec ‘The Missing Piece. Chemicals in circular economy’ https://chemsec.org/app/uploads/2019/03/The-missing-piece_190313.pdf
- ChemSec ‘SIN List: Substitute it Now’ (Hazardous chemical list) http://sinlist.chemsec.org/
- Cradle to Cradle Certified™ Products Program (Renewable Energy and Carbon Management) https://www.c2ccertified.org/
- DGNB ‘ No More Excuses’ https://www.dgnb.de/en/council/publications/index.php
- DGNB ‘ The cost trap of refrigerants’ https://www.dgnb.de/en/council/publications/index.php
- The Ellen Macarthur Foundation. ‘Completing the picture: how the circular economy tackles climate change’ https://www.ellenmacarthurfoundation.org/publications/completing-the-picture-climate-change
- The Ellen Macarthur Foundation. ‘Towards a circular economy: Business rationale for an accelerated transition’ https://www.ellenmacarthurfoundation.org/publications/towards-a-circular-economy-business-rationale-for-an-accelerated-transition
- Elizabeth Wilhide. ‘Materials : A Directory for Home Design’
- EPD (Environmental Product Declarations). The International EPD System: https://www.environdec.com/
- European Chemicals Agency ‘Information on Chemicals’ https://echa.europa.eu/information-on-chemicals
- Green Building Council of Australia Green Star – Communities ‘Environment: https://new.gbca.org.au/green-star/rating-system/communities/

- Green Building Council of Australia Green Star - Design & As Built ‘Energy, Materials’: https://new.gbca.org.au/green-star/rating-system/design-and-built/
- Jordan GBC ‘Developing an energy benchmark for residential buildings in Amman’ https://drive.google.com/file/d/1KMD_6Kb2b6Px0ZRhnP6qaQ2UsLpaTmhI/view (Link to be updated)
- International Living Future Institute: Declare for Products https://living-future.org/declare-/
- International Living Future Institute: Living Building Challenge (https://living-future.org/lbc/), Living Product Challenge (https://living-future.org/lpc/), Zero Carbon (https://living-future.org/zero-carbon/) and Zero Energy (https://living-future.org/zero-energy/)
- Mindful Materials, a material declaration platform: http://www.mindfulmaterials.com/
- UL: ‘UL GREENGUARD Certification Program’ https://www.ul.com/resources/ul-greenguard-certification-program
- UL: ‘Product Lens Certification’ https://www.ul.com/offerings/ul-product-lens-certification
- USGBC’s LEED certification- ‘Building lifecycle impact reduction’ credit: https://www.usgbc.org/credits/new-construction-schools-new-construction-retail-new-construction-data-centers-new-constru-6

References

[1] World Health Organisation. http://www.who.int/globalchange/global-campaign/cop21/en/
[2] World Health Organisation. Climate Change and Health. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health
[3] UN Environment 'Global Status Report 2017' https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf
[4] UNA-UK 'Climate 2020' https://www.climate2020.org.uk/towards-zero-carbon-building/#:~:text=As%20the%20world's%20population%20increases,double%20in%20size%20by%202060.
[5] WorldGBC 'Bringing embodied carbon upfront' https://www.worldgbc.org/embodied-carbon
[6] Drawdown, 'Refrigerant Management' https://drawdown.org/solutions/refrigerant-management
[7] United Nations, 2019. 'Keeping cool in the face of climate change' https://news.un.org/en/story/2019/06/1041201
[8] Climate and Clean Air Coalition. HFC Initiative Factsheet. http://www.ccacoalition.org/ru/resources/hfc-initiative-factsheet
[9] Sustainable Energy for All. Chilling Prospects: Providing Sustainable Cooling for All. https://www.seforall.org/sites/default/files/SEforALL_CoolingForAll-Report.pdf
[10] ATAG 'Facts and Figures; https://www.atag.org/facts-figures.html#:~:text=Worldwide%2C%20flights%20produced%20915%20million%20tonnes%20of%20CO2%20in%202019.
[11] World Green Building Council. Advancing Net Zero. https://www.worldgbc.org/advancing-net-zero/what-net-zero
[12] Drawdown, 'Refrigerant Management' https://drawdown.org/solutions/refrigerant-management
[13] World Health Organisation. Environmental health in emergencies. https://www.who.int/environmental_health_emergencies/natural_events/en/
[14] Our World in Data. Natural Disasters https://ourworldindata.org/natural-disasters
[15] United Nations Office for Disaster Risk Reduction. https://www.undrr.org/
[16] Prevention Web. The human cost of natural disasters: a global perspective. https://www.preventionweb.net/publications/view/42895
[17] Met Office. How is climate linked to extreme weather? https://www.metoffice.gov.uk/weather/climate/climate-and-extreme-weather
[18] Bloomberg, 2019. https://www.bloomberg.com/graphics/2019-countries-facing-water-crisis/
[19] Construction Products Association, 2015. 'Water efficiency, the contribution of construction products' https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf
[20] Environment Agency, 2008. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291728/scho0708bofv-e-e.pdf
[21] European Commission, 2011. 'Water Performance of Buildings' https://ec.europa.eu/environment/consultations/pdf/background_water_efficiency.pdf
[22] The Ellen Macarthur Foundation. 2019. 'Completing the picture: how the circular economy tackles climate change' https://www.ellenmacarthurfoundation.org/publications/completing-the-picture-climate-change
[23] ChemSec. 2019. 'The Missing Piece. Chemicals in circular economy' https://chemsec.org/app/uploads/2019/03/The-missing-piece_190313.pdf
[24] S Dindyal. 2003. 'The sperm count has been decreasing steadily for many years in Western industrialised countries: Is there an endocrine basis for this decrease?' The Internet Journal of Urology. http://ispub.com/IJU/2/1/7519
[25] Rodgers, K, et al. 2018 'Environmental chemicals and breast cancer: An updated review of epidemiological literature informed by biological mechanisms.' Environmental Research Journal. https://www.sciencedirect.com/science/article/pii/S0013935117307971
[26] Gaylord, A, et al. 2020 'Trends in neurodevelopmental disability burden due to early life chemical exposure in the USA from 2001 to 2016: A population-based disease burden and cost analysis'. Molecular and Cellular Endocrinology Journal. https://www.sciencedirect.com/science/article/abs/pii/S0303720719303685?via%3Dihub
[27] Climate and Clean Air Coalition 'Waste' https://www.ccacoalition.org/en/initiatives/waste
[28] Climate and Clean Air Coalition 'Landfill Gas Capture and Use https://www.ccacoalition.org/en/activity/landfill-gas-capture-and-use
[29] Climate and Clean Air Coalition 'Landfill Gas Capture and Use https://www.ccacoalition.org/en/activity/landfill-gas-capture-and-use
[30] WWF, 2018. 'Plastics: Why we must act now' https://www.wwf.org.uk/updates/plastics-why-we-must-act-now?pc=ATC001002&ds_rl=1263542&pc=ASF001002&ds_rl=1263542&gclid=EAIaIQobChMIsMv4rPj-6gIVA-ztCh06fQC4EAAYBCAAEgLCKvD_BwE&gclsrc=aw.ds