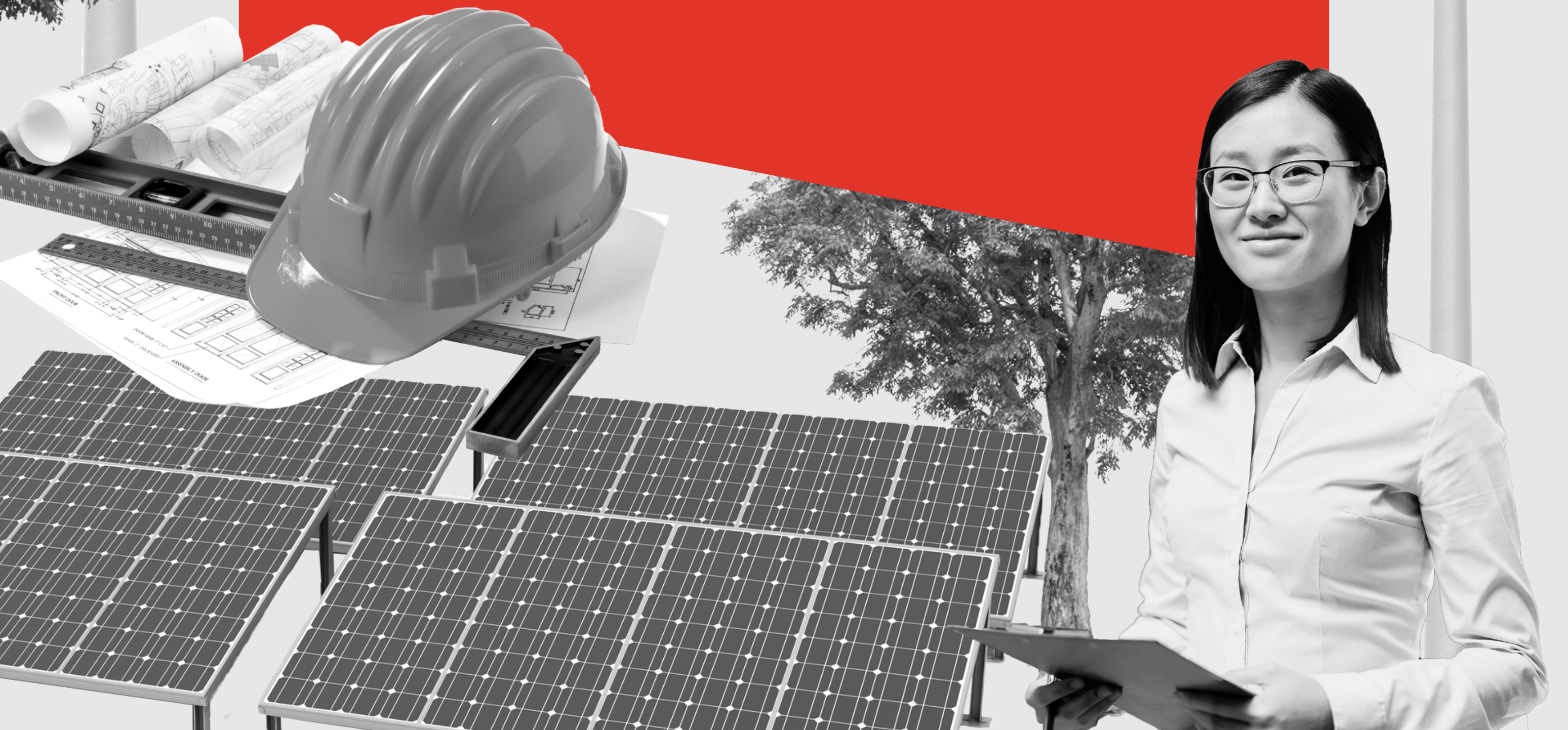
ENGINEERS
AUSTRALIA

Implementing Sustainability:

Principles and Practice



Acknowledgements

Engineers Australia (EA) National Congress, in 2013, unanimously supported a proposal to make EA's approach to sustainability more contemporary.

New Sustainability and Climate Change Policies were produced in 2015. This document provides guidelines on how to develop more fully the principles of sustainability and to enable them to be implemented in practice.

Key authors of parts A and B include David Rice, Graham Davies, Chris Fitzhardinge, Lorie Jones and a number of other contributors. Four workshops, attended by over 100 EA members from a wide range of disciplines, along with Past EA Presidents David Hood, Marlene Kanga and David Cruickshanks- Boyd provided further input and support.

Part C was prepared by Blue Environment (Strategic Environmental Consultants) for EA's College of Environmental Engineering. It was published as Towards Sustainable Engineering in 2015. It has been incorporated in this document with only the original Introduction changed.

A draft of the whole document was provided to all EA College Chairs and as much of their feedback as practicable has been included in this final document.

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Foreword

Engineering will play a vitally important role in shaping our future world for the better.

Engineers Australia (EA) believes that sustainable engineering will be crucial for future generations to enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation. This is reflected in EA's Sustainability Policy.

These Guidelines have been prepared to assist implementation of the Policy. It is intended to become the first reference point for all practicing engineers when presented with the opportunity to plan, design and build a new product or project, or improve an existing one. Understanding the principles of sustainability is considered to be one of the core competencies of professional engineers.

John McIntosh

Engineers Australia National President

7 September 2017

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Summary

Engineers, through our Code of Ethics, have a responsibility to benefit the community by creating sustainable solutions. But this goes beyond the engineer's professional responsibilities.

Beneficiaries from sustainability can include politicians, companies, accountants, employers, employees, communities, indeed most people and most life forms.

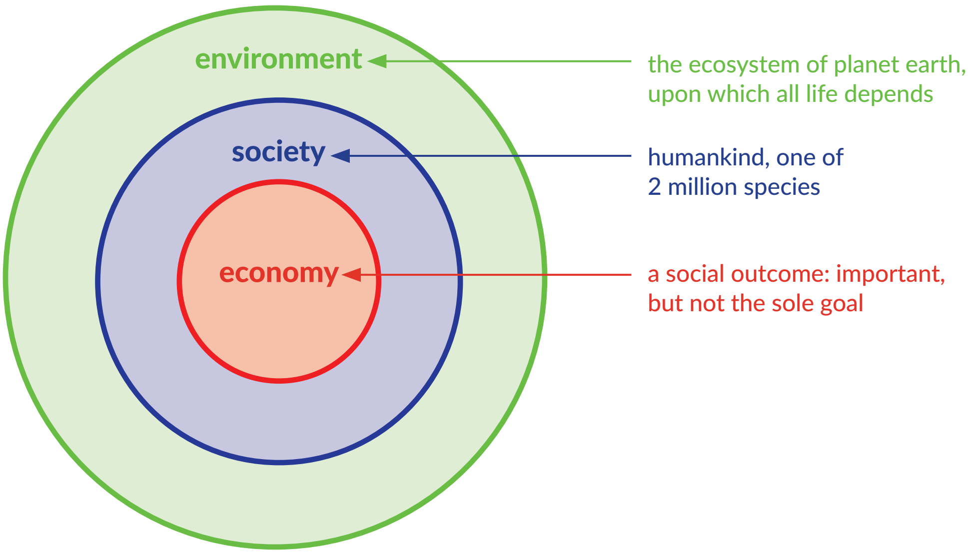
Engineers have contributed greatly to society's current lifestyle, but by many measures the natural environment is in decline. This is despite efforts such as the United Nations goals of Sustainable Development. For example:

- Over the past few hundred years, it is estimated that humans have been responsible for up to a thousand times more extinctions than the natural rate.
- Global warming has already reached 0.9°C, is on track to reach 1.5°C even if we stop all further CO2 equivalent emissions today, and is likely to reach 4°C by 2100, based on current predictions.

The environment has not just intrinsic value, but an economic value significantly larger than GDP.

Continued degradation of the environment is unsustainable, but what does this mean to members of Engineers Australia? The EA Sustainability Policy states that, 'For our members, sustainability means that future generations will enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation'.

It is vital to understand the relationship between those environmental, social and economic conditions—to recognise that we live in and are totally dependent on the environment—and that these conditions form the interdependent system shown below:



Achieving better social and environmental conditions implies remediation and offsets, because it is usually not possible to have a project with no negative impacts. To deal with negative impacts we need a process for assessing projects from a whole of life perspective against their objectives, including considering alternative solutions. Where negative impacts are inevitable then remediation and offsets should be incorporated.

This process must involve stakeholders and the community.

This process must recognise that negative externalities should be internalized within the project.

And this process needs to consider the whole of the life of the project, not just its early years.

The aspiration is that, through this process, all projects can be made positive: economically, socially and environmentally. At present, this is unlikely and we need to recognise this reality, which we can do using rating systems. We can use formal/quantitative ratings, especially for big projects, and simple/qualitative ratings for small projects or while developing big projects.

Sustainability is related to risk management, innovation and resilience; indeed, the sustainability process is a powerful form of risk management. Because we are exceeding the world's capacity for renewal, we are drawing heavily on the planet's capacity for resilience. This increases the risk for our children and their children, which makes implementing sustainability increasingly important.

The principles above apply generally.

Practice Notes that apply mainly to Australia follow. They provide a lot of detail about sustainability in planning, project delivery, management, stewardship and case studies. Descriptions of many of the formal Australian rating tools are included.

This document is in three parts:

Part A is an introduction

Part B covers the principles of sustainability: general concepts that can be used in every day situations anywhere. They may be considered as motivators.

Part C consists of practice notes: information about individual projects and sustainability standards, with references that apply mainly to Australia. They may be considered as enablers.

Part A: Introduction

This document is produced primarily as Guidelines for members of Engineers Australia to use in their professional practice. It may also be used by other professionals and for teaching.

Engineers play a fundamental role in maintaining and improving quality of life. We help provide infrastructure for our society's basic needs: buildings in which we live, work, and play, and many of the things we buy to enjoy. However, this impacts on our environment, locally and globally. Through our Code of Ethics we have a responsibility to benefit the community and to create sustainable solutions.

Engineers Australia (EA) has produced this document to assist engineers in meeting the sustainability requirements of the Code of Ethics. It is for engineers of all disciplines, and for training student engineers. It gives engineers the means to demonstrate that they have been duly diligent in the performance of their profession.

Beneficiaries from sustainability include:

1. Politicians, because the sustainability process reduces risk and increases the chances of re-election.
2. Companies, because it is likely to improve their social license.
3. Accountants, because there is more likelihood of the right project being scoped.
4. Employers, because fostering sustainability increases the likelihood of being an employer of choice.
5. Employees, because sustainability increases the likelihood of job satisfaction.
6. Engineers, because seeking sustainability meets an ethical responsibility.
7. Our children and their children, because sustainability seeks environmental, social and economic improvements.
8. The other 2 million species, because sustainability is also about improving their conditions.

It is important to note the following when considering the relationship between Australian engineers and sustainability:

- The EA Code of Ethics requires members to 'use our knowledge and skills for the benefit of the community to create engineering solutions for a sustainable future'. A copy of the Code is in Appendix 1.
- EA has adopted a Sustainability Policy and a Climate Change Policy (see Appendix 2 and Appendix 3).
- The World Federation of Engineering Organizations[1] (WFEO) has a Code of Practice that includes contributing to healthy surroundings in both the built and natural environment'. EA is a member of WFEO.
- We need these Guidelines to implement sustainability in our work as professional engineers, to expand on the Code of Ethics and Policies so we can understand sustainability in enough detail to explain it to our stakeholders, clients and the community, and to implement it in our day-to-day work.
- This builds on the 1992 EA 'Environmental Principles for Engineers' which gave an insight into the environment, community, economics and ethics.
- Engineers have contributed greatly to our current lifestyle; for example safe transport, reliable electricity, clean water, hygienic sewerage and fast telecommunications. However, many engineering endeavors have also, directly or indirectly, contributed to environmental degradation. This document will help engineers contribute to a sustainable future.
- Sustainability responsibility applies to everyone, particularly professionals, including all engineering disciplines at all levels, for all types of work. However, different levels of sustainability responsibility apply to different levels of overall responsibility. For example, a junior engineer will be expected to raise sustainability questions with their senior engineer, and accept guidance in answering those questions. A senior engineer will be expected to actively promote sustainability, including community and stakeholder involvement, with project owners. EA can provide guidance (sustainability@engineersaustralia.org.au) where problems arise about the degree of responsibility.
- It is sometimes said that if Australian engineering bears the burden of sustainability requirements, we risk international competitiveness. However, some domestic infrastructure projects[2] do not compete internationally. Industries such as manufacturing and mining often do compete, but they should be sustainable, otherwise their negative impacts will be directly detrimental to Australia. Plus, it is beneficial for Australia to promote a 'clean and responsible' engineering image.

1 http://www.wfeo.org/ and search for Code of Practice for Sustainable Development

2 Some infrastructure does not directly compete internationally, for example domestic water supply, sewerage, or public transport. Other infrastructure, such as freight and port facilities used for exporting goods does compete. And Australia as a whole competes for international tourists and overseas talent by having better environmental, social and economic conditions (sustainability).

Part B: Principles of Sustainability

B1. Current state of the planet

Problem definition is a fundamental part of engineering. It is essential to know the current state of affairs, which in turn influences our perspective. Then we need to know how to achieve sustainability and how to measure it.

B1.1 What is the Problem?

Human development, while creating much good, has also caused damage. By many measures, the natural environment is in decline. This is despite many efforts to stop this, such as the United Nations goals of Sustainable Development. For example:

- Biodiversity: Over the past few hundred years, it is estimated that humans have been responsible for up to a thousand times more extinctions than the natural rate[3].
- Deforestation: more than 80% of the Earth's natural forests have already been destroyed[4]
- Global warming: Global warming has already reached 0.9°C[5], is on track to reach 1.5°C[6] even if we stop all further CO^2 equivalent emissions today, and is likely to reach 4°C by 2100, based on current predictions.
- Ocean Pollution: 8 000 000 tonnes of plastic waste ends up in our oceans every year[7]. Anthropogenic debris was found[8] in at least 25% of fish marketed for human consumption.
- Fish Stocks: around 85% of global fish stocks are over-exploited, depleted, fully exploited, or in recovery from exploitation. Catches in the tropics are expected to decline by a further 40% by 2050[9].

People's management of global assets is also a problem, for example:

- **Social equity:** the richest 1% of the world's population control up to 40% of the world's assets[10], while the poorest 50% owns just 1%.
- **Economy:** the common measure of economic 'progress' is Gross Domestic Product (GDP). GDP records activities such as the manufacture of land mines and repairs to vehicles and people after traffic crashes as positive, yet it excludes negatives such as environmental degradation[11] or social displacement, choosing to label such costs as 'externalities'.

Clearly none of this is sustainable. Prudent risk management indicates that we need to respond to these challenges. These are problems of awareness and perspective. Typically engineers are very aware of aspects such as deadlines, design standards, budgets and safety. The sustainability impacts of our actions now need to sit alongside these as key aspects of what we do.

3 www.greenfacts.org > Biodiversity > 4. What pace is biodiversity lost?
4 http://www.nationalgeographic.com/eye/deforestation/effect.html
5 Global mean temperature change since 1880; Dr Karl Braganza, Australian Bureau of Meteorology, EA Climate and Sustainability Leadership, Melbourne, 17 May 2016
6 Around 0.6°C to 0.8°C further rise is already locked in; Ian Dunlop, EA Climate and Sustainability Leadership, Melbourne, 17 May 2016
7 http://news.nationalgeographic.com/news/2015/02/150212-ocean-debris-plastic-garbage-patches-science/
8 Nature, Scientific Reports, September 2015. Samples of 25% of fish sold for human consumption in a market in USA contained anthropogenic debris, mainly fibers from textiles; 28% from a market in Indonesia contained anthropogenic debris, all plastic. Anthropogenic debris was also found in 33% of shellfish. https://www.nature.com/articles/srep14340.pdf
9 www.bbc.com > smart planet > sustainability > earth > how the world's oceans could be running out of fish
10 https://sustainabledevelopment.un.org TST Issues Brief: Promoting Equity including Social Equity
11 It may include some environmental impacts, for instance in countries where there is a carbon price, but rarely costs all environmental impacts.

B1.2 The Sustainability Perspective

Many people in society value economic activity highly. Global GDP amounted to $75 trillion in 2011[12]. What is rarely appreciated is the size of ecosystem services: the 'free' services provided by the natural environment that benefit humans, such as water filtration, seafood, erosion control and pollution removal. Costanza[13] estimates these to be worth $125 trillion per year[14], or around 1.7 times the GDP. This estimate is based on a relatively simple method of measuring areas of aquatic and terrestrial biomes multiplied by the value of service per unit area. A more complex method based on dynamic feedback of ecosystem services into human activities, including the economy, estimates that ecosystem services are worth about 4.5 times the GDP globally[15].

The problem is that we are losing these services rapidly. Costanza estimates that there has been a loss between 1997 and 2011 of around $20 trillion in the value of ecosystem services.

The key message is that the environment has not just intrinsic value, but an economic value larger than GDP and GDP is only a measure of economic activity, not necessarily of prosperity or value. As Margaret Thatcher[16] said, we need economic growth, but growth that does not plunder the planet for tomorrow.

Another way of looking at this is that we are using at least 1.5 times the Earth's capacity to regenerate. That is, it takes the Earth 18 months to regenerate what we use in 12 months[17]. This is an average figure. If everyone lived the lifestyle of the average American or Australian we would need five Earths. The impact varies across different parts of the Earth's ecosystem. It has already exceeded three of what are known as 'planetary boundaries'. These are boundaries within which environmental scientists believe are 'safe
operating spaces for humanity', as shown below:

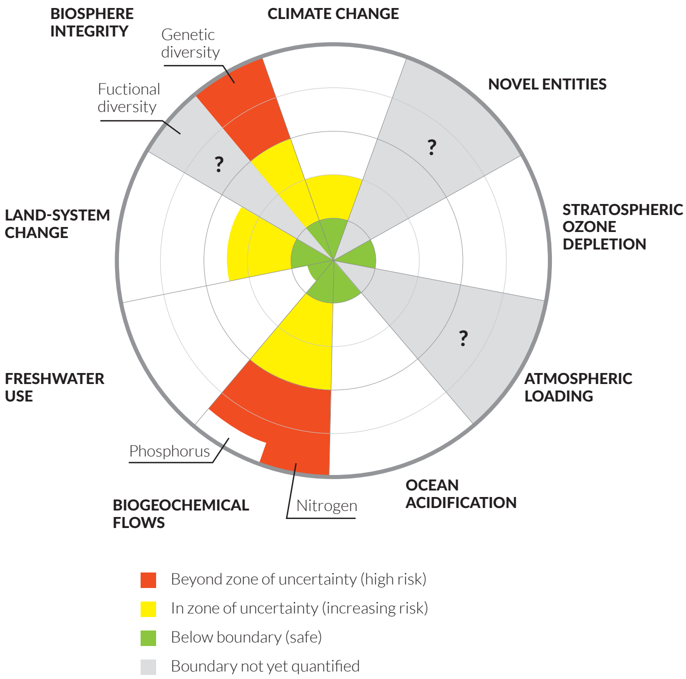


Figure 1: the nine planetary boundaries[18]

Fortunately, we have managed to pull back on one of the planetary boundaries that appeared to be heading towards high risk: namely stratospheric ozone depletion. This was achieved through the Montreal Protocol. We now need to work on the other boundaries, especially genetic diversity, and phosphorous and nitrogen loading. These should be local as well as global perspectives, and local is where Engineers Australia members can make a significant difference through the myriad of projects on which we have influence.

12 Measured in $US2007

13 Changes in the Global Value of Ecosystem Services; Robert Costanza, Rudolf de Groot, Paul Sutton, Sander van der Ploeg, Sharoyn J Anderson, Ida Kubiszeweski, Stephen Farber and R Kerry Turner; Global Environmental Change 26 (2014). Global Environmental Change is a peer-reviewed international journal (www.journals.elsevier.com)

14 Also for 2011, measured in $US2007

15 Global Unified Metamodel of the Biosphere (GUMBO)

16 November 1989 address to United Nations General Assembly (Global Environment)

17 Global Footprint Network, 2016, www.footprintnetwork.org

18 From *Planetary boundaries: Guiding human development on a changing planet* by Will Steffen et al. Science 13 Feb 2015: Vol. 347, Issue 6223, 1259855. DOI: 10.1126/science.1259855. Reprinted with permission from AAAS.

B2.
What is sustainability for EA members?

This section provides guidance on what is meant by sustainability at the engineering project level.

B2.1 Definition

A definition of sustainability is important because we need to agree on what 'sustainability' is before we can implement it. The EA Sustainability Policy (second paragraph) states, 'For our members, sustainability means that future generations will enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation'.

B2.2 More understanding

The EA definition includes environmental, social and economic aspects. It is vital to understand the relationship between these aspects, because they are interdependent. This is reflected by the statement in the Policy that emphasises the need to recognise 'that a healthy economy is underpinned by a healthy environment and respect for all life on earth'.

This interdependence is presented in Figure 2 below.

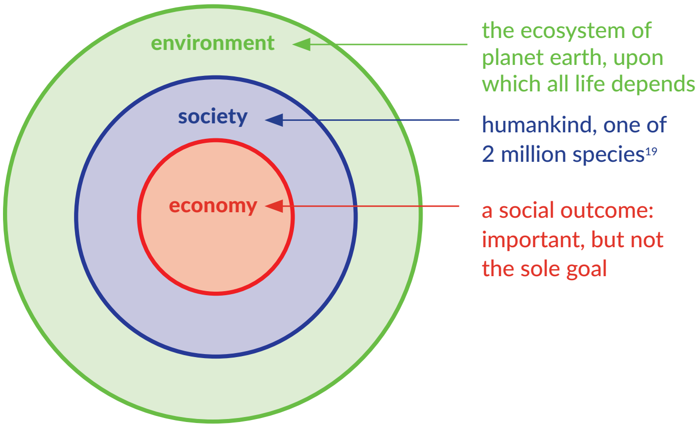


Figure 2: Nested Circles Mind Map

This mind map shows a systems approach in which the environment of the planet is finite, where people share this finite system with a huge number of other species and the economy is a sub-set of the human social system. This systems approach is expanded in Appendix 4.

This is where we live

As Paul Gilding[19] puts it, 'Most people still don't think they live in "the environment" but rather see that as being "somewhere else", so they connect to environmental protection in an abstract way. … logically people get the basic science of where humans fit into the ecosystem … this is more a subconscious response'. The mind map reminds us of the fundamental relationship between the environmental, social and economic aspects. This is more interdependence than balance.

Balance can be taken as trading off one aspect for another, often trading off environmental negatives for economic positives. But we know that this is not sustainable in the long-term. This is not to downplay the importance of economic gains; we need a strong economy if we are to afford social and environmental improvements. It is to say that the aspiration must be for the economic, social and environmental impacts of an action to be entirely positive. As EA Sustainability Policy Principle 4 states: 'Think holistically and innovatively, and account for the externalities and whole of life impacts, such that there is a net sustainability benefit'.

B3.
How can we achieve it?

The definition of sustainability requires 'that future generations will enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation'. This implies that 'remediation' and 'offsets' are needed. This is because it is usually not possible to have an engineering project with absolutely no negative impacts. For example, building a road will usually increase noise, require clearing of vegetation, take houses, or have some other negative impact. A common approach in engineering is to:

- Firstly, review the action to see if its objectives can be met in another way (e.g. by travel demand management rather than road construction) so that the negative impacts of construction are avoided.
- Secondly, see if the action can be modified to avoid the negative impacts (e.g. divert the road around the houses).
- Thirdly, provide remediation (e.g. build a noise wall) to reduce negative impacts.
- Once these three requirements are explored, the fourth requirement is to develop 'offsets' (e.g. provide equivalent vegetation elsewhere that is of similar ecological value to the area cleared and greater in size, so that a net environmental gain is made).

19 Approximately 2 million known species plus about 5 to 8 million species estimated still to be discovered. https://www.sciencedaily.com/releases/2011/08/110823180459.htm releases/2011/08/110823180459.htm

20 Gilding, 2011, The Great Disruption – How the Climate Crisis Will Transform the Global Economy, Paul Gilding, Bloomsbury Publishing, London.

Finally, if the combination of review, modification, remediation and offsets cannot produce a sustainable project, then it will be useful to go back to the objectives, to see whether another type of project can better meet those objectives. This may include reviewing the objectives themselves.

This process must involve stakeholders and the general community, especially to test the acceptance of remediation efforts and offsets, and to uncover all the issues associated with a project. It is part of the Sustainability Policy 'Context' section, which says that 'Engineers Australia and its members commit to ensuring all relevant stakeholders are consulted, and that open and regular reporting of progress towards delivering sustainability outcomes forms a fundamental component of engineering practice'.

The process also includes considering the whole life cycle of the project, from concept development through planning, design, construction, operation and recycling. Think 'cradle to cradle'.

The aspiration is that, through this process, all actions can be made positive: environmentally, socially and economically. But it is likely that many actions will not be able to attain 'equal to or better than' impacts in all areas and so be truly sustainable. Some actions will get close—they will be slightly unsustainable. Other actions will be more unsustainable. We need to recognise this reality by measuring it.

B4.
How can we measure it?

We need some form of assessment system to show whether an action is close to sustainability, or a long way off. This gives credibility to the term 'sustainability'.

To do this we need to measure the net environmental, social and economic outcomes. A variety of tools are available, including:

- long-term/life cycle assessments,
- formal/quantitative assessments, and
- simple/qualitative assessments, including regeneration.

B4.1 Quantitative (Formal) Rating

Many formal rating systems exist. The Practice Notes in Part C include information on ten formal rating systems that should be used where appropriate. For example Green Star[20] may be chosen for building design and construction, NABERS[21] for existing buildings, IS[22] for infrastructure projects, or EnviroDevelopment[23] for urban developments. Consider whether they cover environmental, social and economic aspects, and whether they consider alternatives and long-term/life cycles. EA members need to check any formal system against these Principles, to put them into context. Many of these existing systems use trained assessors—they are quantitative, therefore detailed, and require significant resources to apply. This is appropriate for major projects, but we also need something less onerous for minor projects and when doing basic work on major projects.

B4.2 Qualitative (Simple) Ratings

Two types of qualitative assessment are recommended.

The first is a quick check (long term environmental, social and economic improvement), especially for small projects. Keep the mind map in mind. A quick check is also valuable during the day-to-day process of developing larger projects. This will greatly enhance the chances of larger projects getting high sustainability ratings. The intention is that quick checks will also raise awareness among other professionals, stakeholders and the general community. Frequent quick checks against our sustainability definition and mind map by a large number of people may turn out to be as effective in implementing sustainability as applying complex ratings to a few large projects.

The quick check needs the assessor to consider whether the overall environmental, social and economic impacts appear positive. In most projects there will almost certainly be some negative impacts (for example, inconvenience during construction of a new facility), but 'overall' means that these relatively minor negatives are more than offset by the greater benefit when the facility is operating. Negatives in one area (environmental, social or economic) must be traded off against the greater benefits in that area, but negatives in one area should not be traded against benefits in another area. In particular, environmental or social negatives must not be traded for economic positives, as has often been the case in the past.

The overall environmental impact may be checked by considering whether the environmental negatives are likely to be outweighed by environmental positives. For example, to build a new clean energy facility may require clearing of vegetation, but if this clearing can be offset by a greater area of protected vegetation elsewhere, then the clearing impact may be considered at least neutral, and, hopefully, environmentally positive. This, combined with the significant environmental positive that would be expected by obtaining clean energy, would quickly indicate an environmental positive overall.

20 Green Star is the Green Building Council of Australia's rating system.
21 NABERS is the National Australian Built Environment Rating System, managed by the NSW Office of Environment and Heritage.
22 IS is the Infrastructure Sustainability Rating Tool, developed by the Australian Green Infrastructure Council, now known as the Infrastructure Sustainability Council of Australia.
23 EnviroDevelopment is the Urban Development Institute's tool for assessing environmentally sustainable developments.

Similarly, the overall social impact may be checked by considering if the social negatives are clearly outweighed by social positives. For example, a new town bypass may result in some disadvantage to a few people living near the bypass, but could be perceived as an advantage to a large number of people in the town. If effective measures are taken to reduce the negatives, such as community involvement in deciding remediation measures, and the number of people benefitting substantially outnumbers those experiencing the negatives, then this may be seen as socially beneficial overall.

The overall economic impact may be assessed by a Benefit Cost Ratio[24] or some other method of showing that the economic benefits outweigh the costs. Because of uncertainties in estimating future benefits and costs, it is desirable for the benefits to significantly outweigh the costs. It may be that early in the project development a full economic analysis is not available, but results for other similar projects can indicate likely results.

Most projects have more environmental, social and economic impacts than the examples above, but the examples illustrate the general approach. Quick assessments can also be refined as the project develops and more information becomes available.

The second type of qualitative assessment is structured around 'Plain English' descriptions[25]. Suggested plain English descriptions are shown in Figure 3 below.

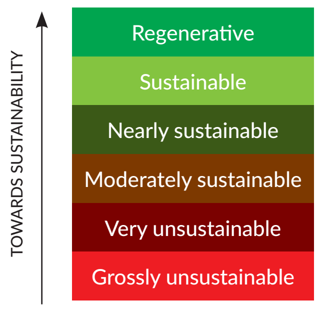


Figure 3: 'plain English' descriptions

The 'Regenerative' assessment recognises that the present human footprint is 1.5 times the ecological capacity of the earth, and that additional effort is required to address this major risk. This means not just a positive outcome (just a bit more than 1.0 times) but at least 1.5 times.

Assessments are made according to Figure 4 below.

TOWARDS SUSTAINABILITY

	Economic	Social	Environ-mental	Longevity	Alternative	(total) RATING
Regenerative	>1.5 times	>1.5 times	>1.5 times			No. of times
Sustainable	★	★	★	★	★	★★★★★
Nearly sustainable	total 4 to almost 5 stars					★★★★★ ★★★★ to
Moderately sustainable	total 4 to almost 4 stars					★★★★ ★★ to
Very unsustainable	total 1 to almost 2 stars					★★ ★ to
Grossly unsustainable	total less than 1 star					★ or less

Figure 4: 'plain English' ratings

Regenerative assessments should be aimed at those boundaries that have already been exceeded, as shown in Figure 3: namely genetic diversity, and nitrogen and phosphorous in the biosphere. Targeting these areas for regeneration is sensible risk management, as is targeting the areas of increasing risk—namely climate and land use changes.

The economic, social and environmental assessments can be made as for the quick qualitative assessment above.

'Longevity' refers to the likelihood of the project remaining economically, socially and environmentally benign for 100+ years, or the allowance made for recycling in earlier years. Many new products, such as mobile phones or cars, are most unlikely to have a 100+ year life, so recycling needs to be factored in. Some projects, such as a new major bridge, port or land subdivision, are likely to have very long lives, and their situation in 100+ years should be considered. Obviously it is not possible to know what the situation will be in 100+ years, but it is possible to have an informed discussion about the likely situation based on trends being experienced today, such as climate change, sea level rise, population growth, energy/water/food security and increased globalisation.

'Alternative' relates to whether there is an alternative project reasonably available[26] that is better than the one being assessed; alternative projects may be more environmentally, socially and economically sound. This is key—if there is a better option then it should be pursued. This sounds obvious, but it is surprising how often this is not done, especially if a better project involves a quite different type of solution, for example: traffic demand management as an alternative to building a new road, or energy demand management instead of a new power station.

24 A Benefit Cost Ratio (BCR) is the total economic benefits of a project relative to the total costs including construction, operation and maintenance; both discounted over time to a common year, often the year of opening the project. Typical discount rates usually mean that the benefits and costs at around 40 years after opening are so small as to be insignificant.
25 Based on those used by the Sustainable Transport Coalition of Western Australia www.stcwa.org.au
26 Available at the time of doing the assessment

B5.
Relation to Risk Management

Sustainability is a powerful form of risk management. This is a reason for adopting sustainability as a mainstream process in addition to our ethical responsibilities.

The relation of sustainability to innovation, risk management and resilience is shown in Figure 5 below.

DRIVER	INITIAL RESPONSE	PROCESS	OUTCOME	
Economic, social or environmental changes	Innovation Established methods	Risk management Sustainability process	Desired	Undesired
			Resilience Legacy Sustainability i.e. environmental social and economic positives	Weakness environmental, social and economic, negatives

In this diagram sustainability is both a process and an outcome and the sustainability process is a powerful form of risk management

Figure 5: the relation of sustainability to innovation, risk management and resilience

The sustainability process includes strategic planning and community engagement. It is about producing positive outcomes in the short and long term. And to maintain those positive outcomes under changing circumstances we need resilience. Resilience comes from having variety and ample resources (spare capacity) to respond to unknown future changes. For example, if a transport system relies heavily on hydrocarbon fuels, low occupancy cars are a risk. If it is to become resilient to, say, future oil shortages then we need more local employment, and we need to encourage walking, cycling and public transport. Alternatively, if in future we were to encounter, for example, a dangerous new virus, then public transport would be problematic, and we would need more car, walking and cycling facilities.

The degree to which we provide that variety and ample capacity can be informed by risk management. We already have conventional risk management (e.g. fire breaks, industrial safety or liability insurance). We can enhance our risk management via the sustainability process, to reduce the risk of economic, social or environmental negatives now and in the long-term future.

A good candidate for risk analysis is energy. Currently, Australia imports more than 50% of its oil through the South China Sea and exports enormous quantities of gas, leaving local supplies at risk. This poses risks to energy security and reliability. These risks can be mitigated by making the energy supply more sustainable[27] and local, through renewable energy, energy efficiency[28] and demand management. This includes considering 'whole of life', to avoid intended side effects such as Jevon's Paradox (where efficiency is offset by increased consumption) or embodied energy becoming greater than the direct energy saved. Electricity consumes close to 50% of Australia's energy utilisation, and this is likely to increase as fossil fuels are progressively phased out. Energy is a key driver of the economy.

We need innovation to cope with changes, and we need risk management to critically assess those innovations. For example, the introduction of new fuels such as hydrogen requires that the risks and economics be carefully evaluated by trials before large-scale use. Such risk is encompassed in the precautionary principles endorsed by EA.

We see general links between sustainability, innovation, risk management and resilience. The details will depend on the nature of the specific risk. The greater the potential risk, the greater the warrant for 'spare' capacity—'spare' in the sense that it may never be used, but if it is needed it is there to provide resilience in a catastrophe. Spare capacity may be created by the innovative design of infrastructure, such as the use of multi-storey car parks as refuges during flood events.

Because we are exceeding the world's capacity for renewal, we are increasing the risks substantially for our children and their children, which makes the promotion of sustainability essential.

27 Applying the five criteria shown in Figure 4
28 See Engineers Australia 'Energy Position Statement, 2016' at https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/energy_position_statement_0_0.pdf

Part C: Practice Notes

C1. Introduction

These practice notes update Engineers Australia's 1997 Towards Sustainable Engineering Practice—Engineering Frameworks for Sustainability. They are intended to provide engineers with guidance and detailed information on sustainability, and suggestions as to how sustainability may be implemented in their professional activities.

This update includes checking web based references. They have been updated to September 2017, but may change again as web sites are updated. If so, try searching the new sites for similar information.

C2. Planning

C2.1 Investigation and analysis

The initial stages of a project or development of a product will involve preliminary analysis and scoping. This should involve a needs assessment, making sure that the project scope is appropriate by answering questions such as:

- Why undertake this project or develop this product?
- What are the preferred outcomes?
- Which elements of the project or product are really needed?
- Where is the best place for this project?
- What is the urgency (when is this required)?
- Whom is this project going to impact or benefit?
- What are the benefits of the proposed product?
- What are the impacts of the product manufacturing process?
- Can the product be manufactured using less raw materials or materials with recycled content? Is its operation resource and energy efficient?
- How will the product be managed at the end of its useful life? Can it be wholly or partially reused or recycled?

The outcomes of the project should also be assessed, including the project scale, product life expectations, consumer needs and the future capability of the project. Simulation of various design options is a useful tool in the early stages of a project. Consultation with various stakeholders will need to occur, including potential investors, government agencies such as local council and licensing bodies, local communities and users/customers. The current government framework and support mechanisms (i.e. tax incentives, rebates and pricing structures) should be assessed to determine the policy climate for a successful project.

The assessment should include discussions on how the same outcome could be achieved through a different method. Is it possible to make a change to something existing rather than produce something new? Is this the right project and what alternatives are available? The current proposal may include a preferred technology, but are there other options which have been fully examined for feasibility?

C2.2 Location

Appropriate location and siting of projects is important, because more than 1,700 species and ecological communities are known to be threatened and at risk of extinction in Australia. Biodiversity is declining in many areas because of threats from degradation and fragmentation of habitats, invasive species, unsustainable use of natural resources, changes to water flows and climate change.

Regulatory authorities legislate through planning controls to ensure appropriate site assessments occur. The type and degree of assessment will depend on the location and current environmental status of that location. In some states this also includes assessment of cultural significance or Aboriginal heritage.

Choosing the right location for an engineering project should involve assessment of all feasible options, considering the needs of the project itself, the location and type of neighbouring facilities, access to infrastructure and compatibility with surrounding land uses. Usually a number of possible sites will be identified via a preliminary assessment, followed by a detailed assessment of those sites shortlisted. A sustainability assessment should consider the following questions:

- Why are these possibly the right sites? What alternatives are available and at what cost/risk?
- What are the surrounding land uses—residential, commercial or industrial? Is this site zoned for the proposed use, or will licenses/planning approvals be required?
- Where are the local neighbours situated in relation to

the proposed activities? Is this positive or negative in relation to the project?

- Is necessary infrastructure (water, energy, access) available at the site and suitable for the project?
- What are the environmental site conditions (topography, weather/climate, sea level, hydrology, ecology) and how will they be impacted (improved or degraded) by the project?
- Is one location more likely to be impacted by climate change or other natural disasters (cyclone, earthquake, flood, drought, etc.) than others?
- How does the orientation or location of various site activities influence the choice of a site? Will an alteration to our project layout influence the desirability of a site (e.g. relocation of odorous activities away from residential neighbours)?
- Is there any site history to consider (contamination, cultural heritage or indigenous sites)?
- Are there flow-on transport effects from using a particular location (e.g. additional market distribution impacts)?

A more detailed assessment will include risk assessment, stakeholder and community consultation and government approvals. These are detailed in the following sections.

C2.3 Impact and risk assessment

A detailed risk assessment should be undertaken to determine whether the project's final outcomes justify the risks. Risk assessment should be undertaken using a systematic approach such as ISO 31000 Risk Management—Principles and Guidelines or a similar methodology. The basic process of risk assessment is shown in Table 1.

For sustainability, risk assessment should consider:

- **Environmental** changes that may result from the project or product
  - A variety of data gathering and environmental assessments may be required. Depending on the project location and relevant legislation, this may involve the preparation of an environmental impact assessment or environmental effects statement.
  - Further detail of the types of investigations that would be conducted during this assessment is documented in Table 2. An examination of the environmental issues for the various alternatives should include the option of taking no action.
- **Economic** impacts and financial viability of the project or product
  - A cost benefit analysis should consider financial risks and benefits, including consideration of the consumer base, value to the employment market, regional economic development and potential changes to living standards.
  - Examination of proposed funding arrangements may consider user pays options and the proposed return on public or private funds.
  - Full cost accounting should incorporate all costs and consider costs over the full life cycle of the project or product (including the true value of using virgin raw materials or non-renewable resources and product stewardship obligations at end-of-life of a product).
- **Social** impacts and community needs
  - Project or product objectives and operations should be ethical, and stakeholder and community liaison undertaken with integrity and good will.
  - Social impact assessments should include examination of cultural heritage and indigenous issues, the safety and wellbeing of employees and risks to local community.
  - Safety of employees and the general public can be assessed via hazard and operability (HAZOP) studies and must be managed in accordance with legislative requirements.
  - A project or product's sustainability will be improved by the promotion of improved social cohesion, integration with surrounding land uses and coordination of transport options.

Table 1: Risk assessment process

Stage	Determinations
Establish context	Area of assessment: environmental, social, financial Scope of assessment: internal/external factors, strategic operational
Identify hazards	Potential impacts and why these are negative or positive What sequence of events needs to occur Consideration of potential disasters
Consequence	Who will be impacted How will the impacts be realised (injuries, damage)
Probability of the risk occurring	How often can this sequence of events occur
Analyse and prioritise risks	Which risks should be addressed first Establish a timetable of when risks should be controlled
Treat the risks	Mitigate the consequences or reduce the probability Redesign the project to reduce negative risks
Monitor and review	Regular or planned reviews of assessments should be conducted for ongoing projects Review when new data becomes available particularly where estimates or judgements have been made

Table 2:
Environmental and social hazard identification

Element	Assessment
GIS mapping	Mapping of the site, neighbouring facilities and key features to determine vulnerable receptors.
Background data	Collation of existing environmental data (e.g. soils, groundwater, watercourses, air quality, noise, odour), supplemented by additional sampling to establish a baseline.
Historical review	Review of previous land uses and historical activities, examination of indigenous or cultural significance in the region.
Biodiversity	Evaluation of flora, fauna and biodiversity currently on site. Determination of impacts with local ecology particularly threatened or endangered species. The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 enables the Australian Government to join with the states and territories in providing a national scheme of environment and heritage protection and biodiversity conservation.
Water	Examination of projected water use, availability of suitable water quality and quantity from all sources—potable, groundwater, rainwater, stormwater, wastewater.
Stormwater	Determination of stormwater flow projections via an examination of hydrogeology and climatic conditions, and a comparison with proposed activities. Review of potential for the stormwater changes to cause sediment, pollution or litter issues, erosion or riparian zone damage to local water courses, and changes to environmental flows.
Land and groundwater	Assessment of potential impacts to land and groundwater due to proposed activities. This could be via underground sources (tanks or pipes) or via filtration from above ground sources (spills, drains, etc.). Information can be obtained from the National Centre for Groundwater Research and Training (groundwater.com.au/useful_resources), which develops information sheets, some with technical detail on their research projects being undertaken in this area. The National Atlas of Groundwater Dependent Ecosystems (Bureau of Meteorology bom.gov.au/water/groundwater/gde/index.shtml) presents the current knowledge of groundwater-dependent ecosystems across Australia. It displays ecological and hydrogeological information on known groundwater-dependent ecosystems and ecosystems that potentially use groundwater. The Atlas is a tool to help consider ecosystem groundwater requirements in natural resource management, including water planning and environmental impact assessment.
Emissions	Examination of emissions to air and noise. Review of the key environmental protection equipment to be installed for changes in emissions. Review of local air-shed and consideration of cumulative effects with neighbouring industrial emissions and how this will affect the project's 'license to operate' from the local community. Data of most urban regions in Australia can be obtained from the National Pollutant Inventory (npi.gov.au). Where there are noise issues this is typically managed by the state-based authorities or local council in some jurisdictions, depending on the source of noise. NSW EPA's Noise guide for local government guidelines (www.epa.nsw.gov.au/noise/nglg.htm) includes noise management principles describing how current planning instruments and policies can prevent noise problems. It suggests a range of engineering strategies that can be used to control noise at the source, in the transmission path or at the receiver.

Energy	Assessment of energy demand for peak and standard operating activities. This should include determination of suitable energy sources based on quality and quantity. Consideration should be given to all energy requirements, including machinery, transport, lighting and heating, ventilation and air-conditioning (HVAC).
Climate change adaptation	Assessment of climate change risk and potential of adaptation techniques for risk reduction. Possible risks to consider (depending on location and regional climatic conditions) include rising temperatures; extreme heat and fire days; changed rainfall patterns causing droughts, flood and storms; changes in sea level; and storm surges along tidal rivers. These risks may impact on buildings, infrastructure, asset maintenance, transport systems and community spaces. Key data on climate change can be obtained from the Bureau of Meteorology (Bureau of Meteorology, Climate change and variability, 2014 bom.gov.au/climate/change). Some states, such as Tasmania, have additional localised data (e.g. Tasmanian Government, Adapting to Climate Change, 2014 dpac.tas.gov.au and search for 'Climate Change'); this includes data formatted into trend maps based on temperature, rainfall, evaporation and cloud amount. Geoscience Australia (Geoscience Australia, OzCoasts—Australian Online Coastal Information, 2014 ozcoasts.gov.au/coastal/index.jsp) also has data for the coastal areas of Australia with respect to shoreline erosion, coastal impacts and sea level rise.
Waste	Consider options for avoiding and minimising waste, as well as reuse, recycling and (lastly) disposal options. Estimate projected types and amounts of waste generated. Examination of waste processes should include storage, transport and the feasibility of disposal locations for all wastes produced, including hazardous waste. The National Waste Policy (Australian Government, National Waste Policy http://www.environment.gov.au/search/site/national%20waste%20policy) outlines Australia's waste management and resource recovery direction to 2020. The policy covers wastes in the municipal, commercial, industrial, construction and demolition sectors, and covers gaseous, liquid and solid wastes. More detailed information on regional and local waste avoidance and resource recovery opportunities is available from state/territory departments and local councils. Note: in some jurisdictions there is a regulatory requirement for a waste management plan to be completed as part of the planning approval process for a new development.
Life cycle assessment (LCA)	Identification and quantification of environmental and social impacts during the total life cycle of the project or product. This includes the embodied energy and water, the environmental and social costs of harvesting raw materials, transport, manufacturing, use and disposal of the product. Conducting LCA early in a project, during the planning phase, can provide engineers with a basis to re-design a product if an outcome is not favourable.
Environmental risk mitigation options	Review of potential mitigation options, which will reduce environmental impacts of the project or product for both the preferred and alternative options.

Following the identification and analysis of the various risks to the project, the risks should be documented in priority order for further examination. Changes to the project plan should be made to avoid those risks deemed unacceptable and allow for mitigation of consequences, or the project should be probability investigated to reduce the probability of negative impacts.

Additional resources:

The Australian Life Cycle Assessment Society has established a library of links to various publications in the LCA domain. The library covers many topics from industries, including agriculture, energy, water, waste, etc. and includes case studies and guidelines available via PDF or for purchase. There are also guidelines, principles and methodologies for the collection of life cycle data, along with protocols for LCA processes for different sectors. Further information can be found at alcas.asn.au

Climate Change Adaptation Checklists

The following guidelines and checklists explain the background to climate change, providing advice on how to prepare and develop adaptation strategies.

1. The Infrastructure Sustainability Council of Australia has outlined a range of adaptation measures and aligned them with industry examples from transport and built infrastructure, energy transmission and water management. A rating chart designed to rate a project or business performance in climate change adaptation is also provided.
   isca.org.au/images/pdf/cca_guideline_v2.1.pdf

2. Australian Industry Group's Climate change adaptation checklist has examples of impacts and opportunities for adaptation. The checklist is aimed at the manufacturing industry, and provides a methodology for assessing climate change risks to manufacturing businesses, assisting in identifying adaptation options. It also refers to case studies conducted using the checklist methodology.
   https://www.aigroup.com.au/search/?filter=&q=climate+change+adaptation

3. The NSW Government's Guide to Climate Change Risk Assessment is aimed at local government assets, but the methodology suggested is based on standard risk management approaches and can be adapted to any business. The guide uses a combination of international and local references, making the guide usable across Australia.
   environment.nsw.gov.au and search for 'Guide to Climate Change Risk Assessment'

C2.4 Stakeholder and community consultation

Planning for new projects or products should ensure that the project meets society needs at a cost and risk acceptable to the community.

Consideration should be given to extensive engagement with relevant stakeholders and the local community early in the planning process in order to raise awareness, capitalise on local knowledge and build consensus for mutually agreed outcomes.

Note that there may also be a need for engineers to raise the client awareness of the benefits of incorporating sustainability into their product or project.

During planning for consultation, the following questions should be considered:

- Who should be consulted?
  e.g. planning bodies, government authorities, emergency services, community groups, employees, product consumers, project users
- What consultation method should be used?
  e.g. public meetings, focus groups, surveys, direct communication
- How can stakeholders and community members respond?
  e.g. surveys, written submissions, dedicated phone line/email, face-to-face
- When and how often should consultation be carried out?
  e.g. planning phase, draft designs/reports, regular/ongoing communication with community reference group
- What outcomes are sought?
  e.g. improvements to project or product design, planning support, social 'licence to operate'.

The International Association for Public Participation has developed a spectrum (Figure 1), which outlines different levels of public engagement.

C2.5 Approvals

Planning for a new product, project or upgrade must address the relevant statutory requirements; these will differ according to the type and location of the proposal. Some necessary approvals may include the following:

- Local
  - development approvals
  - planning consents or permits
  - building permits
  - waste management plans.
- State/regional
  - development approvals prior to construction
  - ongoing permits or licensing from the environment authority
  - water use licenses, depending on the water source
  - wastewater discharge approvals
  - approvals from work safety authority
  - safety assessment for certain types of hazardous facilities.
- National
  - permits if activities affect species in Commonwealth areas
  - approvals for activities conducted off-shore
  - assessments through the Environment Protection and Biodiversity Conservation Act 1999 for matters of environmental significance, which may include:
    - world heritage properties
    - national heritage places
    - wetlands of international importance (listed under the Ramsar Convention)
    - listed threatened species and ecological communities
    - migratory species protected under international Commonwealth marine areas
    - the Great Barrier Reef Marine Park
    - nuclear actions (including uranium mines)
    - a water resource, in relation to coal seam gas development and large coal mining development.

Often the information gathered during earlier planning stages will need to be provided to the relevant planning authorities for assessment, and should include justification that all possible impacts have been reduced to as low as is practicable.

Increasing level of public impact

	INFORM	CONSULT
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.
Promise to the public	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how public input influenced the decision.
Example tools	Fact sheets Websites Open houses	Public comment Focus groups Surveys Public meetings

Figure i): Public participation spectrum
Source: International Association for Public Participation, iap2.org

INVOLVE	COLLABORATE	EMPOWER
To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
We will work with you to ensure that your concerns and issues are directly reflected in the alternatives developed & provide feedback on how public input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Workshops Deliberate polling	Citizen advisory committees Consensus-building Participatory decision-making	Citizen juries Ballots

C3. Design

Good design is a key input to sustainable practice for many engineering activities. Attention to sustainable outcomes during the design stage can prevent problems occurring later by:

- making a project or product more efficient and extending its useful life
- conserving raw materials, energy and water and producing more with less
- reducing the use of toxic materials and eliminating the resulting toxic wastes
- making operations and services safer and more 'user-friendly'
- simplifying and reducing the cost of product stewardship obligations at the end-of-life of a product, and
- fostering communities.

Sustainable design goes beyond compliance with legislation: it considers options that have a positive impact, such as 'closing the loop' of material flows (so that raw materials used in product manufacture can be recycled and re-manufactured) and establishing industrial ecology systems (where manufacturers can utilise neighbouring companies' waste as raw materials). Sustainable design approaches can be varied and will depend on project specifics, but the major themes are discussed in the following sections.

C3.1 Eco-design

Eco-design incorporates design features that reduce the environmental impacts over the full life cycle of a product or project. It considers the various stages of material procurement, manufacture, use, disposal, recycling and reuse. Protection of local ecosystems and measures to reduce the impact on the environment, including natural, cultural, heritage and indigenous assets, is imperative in the design.

The design should take into consideration:

- longevity—make it repairable, durable, recyclable and adaptable for alternative use (including re-use and re-manufacture)
- ease of deconstruction for future modifications or decommissioning
- utilisation of existing buildings, equipment and infrastructure in new developments
- the types of materials or equipment used, including efficiency of resource use, reduced material use and use of materials with recycled content
- the potential to reduce demand for scarce resources, including water, rare minerals and fossil-fuel intensive resources
- the avoidance of chemical use (particularly in accordance with international protocols)
- systems for carbon uptake and possible solutions to minimise greenhouse gas emissions
- a usable layout with key infrastructure in appropriate locations
- the needs of regular and once-off users (e.g. visitors)
- appropriate access and traffic management to increase walking/cycling options, create urban villages and foster communities, and
- ongoing operational needs (including energy demand, ease of maintenance, user needs).

C3.1.1 Passive design

Passive design makes best use of local site conditions to reduce energy use and greenhouse emissions. This can involve orientating a building to maximise natural sources for heating and cooling, or designing building envelopes to minimise the demand for additional heating or cooling. Passive building design gives consideration to:

- lighting, window choice, glazing, orientation and shading
- heating, cooling, air flow and air-conditioning
- equipment and amenities with eco-ratings
- choice of building materials and insulation, and
- energy sources (e.g. solar, wind, other renewable).

The Australian Government provides advice on passive design through the Your Home program. The website (www.yourhome.gov.au/passive-design) provides information sheets and case studies detailing materials, energy, water and other approaches in developing sustainable homes across building types and climate zones. Although it is focussed on home design, the principles apply equally to other building types.

The Australian Government's ESD design guide for office and public buildings (Australian Government 2007, (www.environment.gov.au and search for 'design guide office and buildings') introduces ecological sustainability issues and how the built environment affects them. It details initiatives that can minimise the environmental and social impacts of buildings and outlines tools that can assist (specifically ABGR, NABERS and Green Star, discussed further in Section 3.2). It also includes eleven detailed case studies.

The Facility Management Association of Australia has a variety of guides, articles and conference papers available through their 'Knowledge base Home' archive. One example is … Facilities by the Facility Management Association of Australia, https://www.fma.com.au/ and search for 'Good Practice e-Guide Multi-Unit Residential 2012', which provides an overview of facilities management in multi-unit residential buildings. It has a particular focus on common areas and shared services, and includes information on designing for sustainability, waste and utilities management.

C3.1.2 Building automation and information models

Buildings are becoming smarter and more automated, which can have improved sustainability outcomes, but this often cannot be achieved without due consideration at the design stage. Retrofitting can be a significant and costly challenge. The establishment of automated control systems can apply to lighting, heating/cooling, lifts, windows and their coverings, as well as many other electrical systems. Building automation can reduce the amount of resources required during the operation of a building, but will increase the materials required during construction (extra cabling, switches, etc.). Adequate metering systems will need to be incorporated to ensure tenants, owners and developers can manage their own parts of the systems.

Building Information Modelling (BIM) is a digital representation of the physical and functional characteristics of a facility. Various software options are available to assist in decisions during the life cycle of the facility. The software will schematically include the various requirements from a variety of disciplines (architects, landscape design, surveyors, civil, structural and building services) at various stages of a project, such as initial design, retrofit or reconstruction. This allows clashes in design to be avoided, provides a better understanding of material needs, and ensures areas of operational weakness (e.g. valves) can be found quickly when needed.

Good BIM software programs allow the user to include additional information such as costs, timelines, manufacturers' details, energy and water use, and maintenance requirements. BIM programs are very difficult to implement retrospectively to an existing building. As BIM programs are a fairly new tool used in construction, there is no current standard approach to BIM software, which causes difficulty when requiring cohesiveness with the data requirements of a variety of disciplines.

Additional resource:

The US National Building Information Model Standard Project Committee has developed the National BIM Standard (www.nationalbimstandard.org) and search for 'NBIMS-US™ V3'.

C3.2 Design rating tools

Rating tools have been developed for different categories that allow for a determination to be made on the potential environmental impact of a project's site selection, design, construction, maintenance, etc. Most of these tools should be used during the design phase to test out the proposed project configurations and various alternatives. Others may be used during operation as part of a review stage to track and improve sustainability. Some Australian tools are discussed below.

C3.2.1 Green Star

Local councils and building authorities are now requiring that certain buildings be assessed using the Green Building Council of Australia's Green Star tool (www.gbca.org.au/green-star) as part of the planning and/or building application process. The Green Star rating tool assesses building or community projects against a number of different categories which help assess the environmental impact of a project's site selection, design, construction, maintenance, etc. The categories include management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions and innovation. Green Star also has new tools for As Built and Performance (i.e. once a building is completed and operational), which are similar to those provided by NABERS.

C3.2.2 NABERS

The National Australian Built Environment Rating System, or NABERS (NSW Government 2014, www.nabers.gov.au), is a national rating system that measures the actual (annual) environmental performance of Australian buildings, tenancies and houses. NABERS has tools for offices, hotels, shopping centres, data centres and homes, which can be completed by an accredited assessor or for free as a self-assessment. Accredited NABERS ratings are now being used when advertising for tenants or sale and measure:

- energy efficiency
- water usage
- waste management
- indoor environment quality, and
- the impact on the environment.

C3.2.3 ABGR

The Australian Building Greenhouse Rating Scheme (ABGR, www.abgr.com.au) is administered nationally by a group of sustainable energy agencies. ABGR has broad industry support and is being used for energy rating, target development and design requirements. The ABGR scheme rates buildings from one to five stars, with five stars representing exceptional greenhouse performance. ABGR can be used to rate the base building (central services), individual tenancies or a whole building. ABGR is also used within the Green Star and NABERs rating programs for the energy/greenhouse component.

C3.2.4 NatHERS

The Nationwide House Energy Rating Scheme (NatHERS, nathers.gov.au/) sets national standards for software used to rate the thermal performance capabilities of Australian houses. NatHERS software can be used to assess individual houses, townhouses and apartments. Houses assessed using NatHERS are given a rating estimating the potential heating and cooling needs for the house. NatHERS provides three software options (Accurate, BERS Professional and FirstRate) to demonstrate compliance with the minimum energy efficiency standards for new buildings outlined in the Building Code of Australia.

C3.2.5 Calculating Cool

Sustainability Victoria's Calculating Cool—HVAC Online Rating Tool (www.calculatingcool.com.au/#/about) helps benchmark the performance of an HVAC system against best practice. It was developed in Victoria, but can be used nationwide. The tool uses energy consumption data and system attributes to rate the energy efficiency of an HVAC system. It may be possible to generate a partial rating with incomplete input data, however, the user is encouraged to store the unique reference code automatically generated by Calculating Cool to retrieve the building profile and complete data entry to generate the full rating.

C3.2.6 BASIX

The NSW Government's Building Sustainability Index (BASIX) establishes minimum standards for all new dwellings, and alterations and additions to existing dwellings throughout the state (www.basix.nsw.gov.au/basixcms/). BASIX is applied through a NSW planning regulation that sets percentage reduction targets for greenhouse gas emissions and water use for dwellings of a similar size in the same geographical location.

BASIX covers the building envelope thermal performance and a wide range of household energy uses by fixed equipment such as heating and cooling appliances, lighting and hot water. BASIX is a web-based tool that is available for use by anyone, although users must register and log in.

C3.2.7 IS rating scheme

Certain industry associations also develop and promote rating tools to be used within that industry. These include the Infrastructure Sustainability Council of Australia's IS rating scheme for infrastructure (https://isca.org.au/). IS ratings evaluate sustainability across the design, construction and operation of infrastructure (transport, water utilities, communication networks and energy utilities).

C3.2.8 WERS

The Australian Window Association's Window Energy Rating Scheme (WERS) ranks windows for their energy performance in typical housing anywhere in Australia, and advises on the suitability of windows for particular climate zones (www.wers.net/wers-home). WERS also compares the performance of window films, which provide some shading and insulation. Ratings are performed by accredited organisations of the Australian Fenestration Rating Council against the WERS and Australian Standards in window construction.

C3.2.9 Energy Star

The Energy Star rating system was created by the US Environmental Protection Agency and has been adopted by several countries around the world, including Australia (www.energyrating.gov.au/about/other-programs/energy-star/). The Energy Star mark is awarded to the top 25% most energy efficient products, including heat pump/air conditioners, solar water heating systems, washing machines, dishwashers, televisions and a range of other domestic and office appliances.

C3.2.10 Green Vehicle Guide

The Green Vehicle Guide ratings scheme is based on testing the air pollution and greenhouse gas emissions of vehicles and determining an overall rating. These ratings, together with information on the fuel consumption and category of vehicle, are provided at **www.greenvehicleguide.gov.au**, and allow comparison between vehicles to inform vehicle purchasing decisions.

C3.3 Sustainable procurement

Sustainable procurement aims to reduce the adverse environmental, social and economic impacts of purchased products and services, and can include considerations such as ethical sourcing, waste disposal and the cost of operation and maintenance over the life of the goods. Projects should use materials from renewable sources in order to reduce depletion of natural finite or past-peak resources.

Sustainable procurement involves working with the supply chain to facilitate purchasing decisions that provide net environmental benefit, allowing for the purchase of materials and equipment that:

- is from sustainable sources
- is free from participation in slave labour, child exploitation or other labour systems reliant on social disadvantage
- has a low eco-footprint
- includes a high recycled content
- is safe and toxin free
- is locally produced, and
- has a low embodied environmental value.

Information should be sought from suppliers to make informed decisions. Choosing the right product should also include consideration of the impacts arising from transport and distribution. This may involve the development of a procurement policy, with supply contracts established with preferred suppliers.

Good Environmental Choice Australia (GECA, www.geca.org.au) operates an independent multi-sector ecolabelling program. GECA is a non-profit organisation and is a member of the Global Ecolabelling Network. It has a certification program where standards are developed following the ISO 14020 Environmental labels and declarations guidelines (general principles for global best practice in ecolabelling). GECA's scheme enables consumers to choose (via free access to an internet database) from thousands of certified products and services which have a lower impact on the environment and human health, and address important social considerations. The Australian Government commissioned the development of the Sustainable Procurement Guide (Australian Government 2013, **http://www.environment.gov.au/resource/sustainable-procurement-guide**) to assist purchasers to include sustainability considerations in all stages of the procurement process, from identifying the business need to disposing of goods.

C3.3.1 Embodied environmental value

Buildings should be designed and materials selected to balance embodied environmental value with factors such as the climate, availability of materials and transport costs. Embodied environmental value typically considers the total energy and water required for the extraction, processing, manufacture and delivery of building materials to the building site.

Energy derived from fossil fuels produces carbon dioxide (CO2) and contributes to greenhouse gas emissions. As this is the typical source of Australian energy, embodied energy is an indicator of the overall environmental impact of building materials and systems. Unlike life cycle assessment, which evaluates all of the impacts over the whole life of a material or element, embodied environmental value only considers the front-end aspect of the impact of a building material. It does not include the operation or disposal of materials.

Lightweight building materials often have lower embodied energy than heavyweight materials, but in some situations lightweight construction may result in higher ongoing energy use. For example, where heating or cooling requirements are high, this may raise the overall energy use of the building. Conversely, for buildings with high heating or cooling requirements but a large diurnal (day/night) temperature range, heavyweight construction (typically with high embodied energy) and the inclusion of high levels of insulation can offset the energy use required for the building.

When selecting building materials, the embodied energy should be considered with respect to:

- the durability of building materials
- how easily materials are separated
- the use of locally sourced materials
- the use of recycled materials
- the specified standard sizes of materials
- the aim to avoide waste, and
- the selection materials that are manufactured using renewable energy sources.

Some organic products can have a high embodied water content. Where use of organic products is relevant, preference should be given to products grown using water conservation measures (such as the use of drip irrigation, stormwater or recycled water).

C3.3.2 Materials

Choice and use of suitable materials is an important sustainability decision. Materials should be appropriate for their use and have low sustainability impacts. Some raw materials are finite and demand has put their ongoing supply at current levels in doubt; their supply has peaked and future availability is uncertain. This is important for a range of resources, including oil and certain rare earth minerals used within the electronics industry, as natural resources are depleted and are becoming scarce.

The use of hazardous materials should be avoided or reduced in accordance with the standard risk management framework. Where specific chemicals must be used, their transport, classification and labelling is highly regulated. Whether the chemical is hazardous to persons, the environment or physical structures, the management processes are similar.

Most states operate under Safe Work Australia's Globally Harmonised System of Classification and Labelling of Chemicals (www.safeworkaustralia.gov.au/sites/swa/whs-information/hazardous-chemicals) providing consistency across Australian states. The seventh edition of the National Transport Commission's Australian Dangerous Goods Code (www.safeworkaustralia.gov.au/sites/swa/ whs-information/hazardous-chemicals and search for 'Dangerous Goods') has been implemented in all jurisdictions in Australia and lists provisions applicable to the transport of dangerous goods, including:

- classification
- packaging and performance testing
- use of bulk containers, freight containers and unit loads
- marking and placarding
- vehicle requirements

- segregation and stowage
- transfer of bulk dangerous goods
- documentation
- safety equipment, and
- procedures during transport emergencies.

The transport of dangerous goods within Australia is controlled on a national level and the actual use of such goods within a workplace is controlled by state-based legislation. Guidance on the substitution or reduction in the use of dangerous goods is provided by each state authority. HAZOP and similar types of technical assessments will be required to be completed by designers and engineers to determine compliance with health and safety requirements.

Additional resource:
State based chemical handling requirements can be found at:

- www.safework.sa.gov.au/show_page.jsp?id=112285#.U889EGAU-vE http://www.deir.qld.gov.au/workplace/hazards/hazchem/index.htm#.U889YmAU-vE
- https://www.worksafe.vic.gov.au/search?query=chemical+handling+requirements
- www.worksafe.vic.gov.au/safety-and-prevention/health-and-safety-topics/hazardous-substances
- http://www.commerce.wa.gov.au/search/site/chemical%2520handling%2520

The use of certain chemicals has been regulated at a national level due to Australia becoming a signatory to a variety of international protocols or conventions facilitated by the United Nations Environment Programme. These include:

- The Stockholm Convention, which outlines the protection of humans and the environment from persistent organic pollutants by elimination of the use of these chemicals (http://www.environment.gov.au/topics/environment-protection/chemicals-management/pops)
- The Rotterdam Convention, which specifies the need for prior informed consent for the trade in certain hazardous chemicals and pesticides (http://www.daff.gov.au/agriculture-food/ag-vet-chemicals/ stockholm-rotterdam)
- The Montreal Protocol, which outlines the phase-out of the consumption of chlorofluorocarbons. Australia will largely phase out consumption of hydrochlorofluorocarbons by 2016, four years ahead of the schedule required by the Protocol (http://www.environment.gov.au/protection/ozone/ montreal-protocol)
- The Basel Convention, for controlling the transboundary movement of hazardous wastes and their disposal (http://www.environment.gov.au/topics/environment-protection/hazardous-waste/conventions).

C3.4 Resource efficiency

Efficient use of resources allows maximum value to be made of raw materials and reduces waste costs and impacts. Resource efficiency can be built into the total life cycle of a project or product, including design, operation and end-of-life considerations.

Industry associations often provide assistance to member businesses to conduct assessments and determine potential resource efficiencies. The Australian Industry Group has partnered with Sustainability Victoria and Zero Waste SA to establish the Resource Efficiency Assist program. This program provides access to assessments, classes, workshops and tools for resource efficiency (http://www.resourceefficiency.aigroup.com.au/ toolsandresources). The tools available include online videos and fact sheets for a variety of industry types with regards to energy, waste and water.

C3.4.1 Energy

The efficient use of energy provides significant sustainability outcomes and can reduce costs, greenhouse gas emissions and health impacts. Some government authorities set energy emission limits for particular industries. Minimising energy and emissions may avoid the need for regulatory approval or reporting.

Designing for appropriate energy use can include consideration of equipment efficiencies or the use of renewable energy sources. Equipment should be chosen for high efficiency to keep energy use at a minimum. An assessment of the amount, timing and type of energy used is important in identifying practical opportunities for improved efficiency and reduced costs. Such opportunities may include turning off equipment when not in use, the operation of non-essential equipment when off-peak charges apply, or changing energy use patterns.

The fuel source and ability to store energy for later use is also an opportunity to improve energy efficiencies. This may include consideration of on-site co-generation or tri-generation facilities, using production wastes or imported fuels to generate electricity and heat. Both electricity and heat may be used on-site to form an integrated part of an industrial ecology system.

There are many sources of advice with regards to the energy efficiency of machinery and equipment. Sustainability Victoria has produced Energy Efficiency Best Practice Guides (Sustainability Victoria, various dates, http://www.sustainability.vic.gov.au/search-results?q=energy+efficiency+machinery). Although these guidelines provide technical detail for the industries listed below, the generic process used for identifying efficiencies could also be adapted to other industries or machinery types, including:

- data centres and IT facilities
- industrial refrigeration
- compressed air systems
- lighting
- pumping systems, and
- steam, hot water and process heating systems.

The NSW Government developed the Measurement and Verification Operational Guide (NSW Government 2012, http://www.environment.nsw.gov.au/resources/energyefficiencyindustry/120990bestpractice.pdf) to help auditors, energy efficiency project managers, government program managers and policy makers to translate theory into practice. While the guide was developed to support the measurement of energy savings from projects receiving government assistance, it can also be used as a resource for other projects. Specific guidebooks have also been produced for:

- boilers, steam and compressed air applications
- commercial and industrial refrigeration applications
- commercial heating, ventilation and cooling applications
- lighting applications
- motor, pump and fan applications
- renewable and cogeneration applications, and
- whole building applications.

C3.4.2 Water

The importance of conserving scarce water resources is generally recognised across Australia, particularly in regions with low rainfall or those reliant on groundwater sources. Planning for water sensitive cities considers the interaction of the urban hydrological cycle in ways that:

- provide water security through efficient use of different water resources
- enhance and protect the health of watercourses and wetlands
- reduce and manage flood risk, and
- provide liveable public spaces that harvest and clean water.

Research on ways to achieve this is undertaken by (among others) the CRC for Water Sensitive Cities; more information can be found at www.watersensitivecities.org.au

In recent years a number of water authorities have required industrial customers to plan for and introduce water conservation measures. Most industries are aware of the potential of using non-potable water (e.g. stormwater, rainwater, recycled water, treated wastewater) for many industrial applications. Industrial wastewater systems should be designed to reduce salts and other contaminants, allowing for the alternative use of wastewater; this may include on-site reuse or off-site use in industrial ecology networks. Wastewater should not be discharged without prior treatment and should adhere to best practice standards and regulatory requirements to ensure that volume, contaminants, temperature and other water quality parameters are met.

Australia's National Water Quality Management Strategy (Australian Government, various dates, www.environment.gov.au/topics/water/water-quality/national-water-quality-management-strategy) sets water quality targets or guidelines which are usually adopted into legislation or water discharge licences at a state level. These guidelines cover a number of issues including:

- quality benchmarks
- groundwater protection
- diffuse and point source management
- sewerage systems
- effluent management (for particular industries), and
- water recycling.

The use of wastewater is not as prevalent in the residential market, partly due to regulatory inhibitors but also due to community concern with regards to potential or perceived health impacts. The use of household grey water is slowly increasing, as individuals make changes to existing homes. Many new housing developments have installed 'third pipe' systems where recycled water is plumbed directly into gardens or homes.

The *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks* (Australian Government, various dates, http://www.environment.gov.au/search/site/Australian%20Guidelines%20for%20Water%20Recycling%3A%20Managing%20Health%20and%20Environmental%20Risks) provides a generic framework for the management of recycled water quality and use that applies to all combinations of recycled water and end uses. It also provides specific guidance on the use of treated sewage and greywater for purposes other than drinking and environmental flows. Rather than rely on end-of-pipe testing, the government framework recommends using a risk management approach to ensure human and environmental risks are mitigated. Aspects not covered by this framework are the use of recycling to reduce the amount of wastewater and stormwater discharged into environments such as oceans and rivers, and the subject of water allocations (including environmental flows).

Rainwater can be captured in a stormwater collection system and be incorporated into best practice landscape design. Layout and plant choice should consider water efficiency and require very little irrigation. The *Australian Guidelines for Urban Stormwater Management* (Australian Government 2000, http://www.environment.gov.au/system/files/resources/30f22565-8ec8-4308-80a2-a6e4554a55cd/files/urban-stormwater-management-paper10.pdf) has practical advice on the quality of run-off and water sensitive design. Many states are controlling stormwater and improving discharges via town planning provisions; for example, it is now compulsory under the Sustainable Neighbourhoods Clause 56 of the Victoria Planning Provisions to design and manage urban stormwater management systems for all new residential subdivisions to meet current best practice objectives. As new subdivisions are completed, stormwater management and quality will improve. Best practice objectives have been documented in the CSIRO Urban Stormwater—Best Practice Environmental Management Guidelines (CSIRO 1999, http://www.publish.csiro.au/search?qUrban+Stormwater–Best+Practice+Environmental+ Management +Guidelines+&stype=b), which resulted from collaboration between state government agencies, local government and leading research institutions. The guidelines have been designed to address the planning, design or management of urban land uses or stormwater drainage systems and provide guidance in ten key areas:

- environmental performance objectives
- stormwater management planning
- land use planning
- water sensitive urban design
- construction site management
- business surveys
- education and awareness
- enforcement
- structural treatment measures, and
- flow management.

Sustainable rural water use has been the target of a number of programs at national and state level. These programs encourage more efficient irrigation systems and technologies that reduce water loss, deliver long-term social and economic benefits, and return a share of water savings to rivers, wetlands and floodplains. Examples include converting open channels to pipes, and converting flood irrigation to centre pivot/lateral move in-field irrigation systems.

C3.4.3 Waste

The waste management hierarchy sets out a hierarchy of activities (Figure ii) in preferential order for environmental improvement. This hierarchy is incorporated in most state waste policies, although the details may differ slightly in each state.

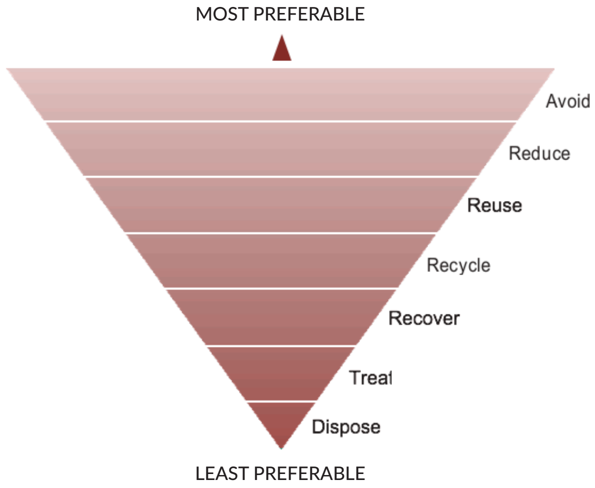


Figure ii): Waste management hierarchy

The waste hierarchy aims to reduce the generation of waste and make better use of resources. Relevant activities, in order of preference, include:

- **Avoidance**—design processes to avoid the production of waste
- **Reduction**—minimise the generation of waste, reduce the use of hazardous materials
- **Reuse**—identify opportunities for on-site use, for reuse of materials for a productive purpose, to extend the life of materials through multiple or alternate uses
- **Recycle**—process to use recycling product or by-product, separate materials at source to reduce contamination of recovered resources
- **Recovery** of energy—use waste as a fuel or energy source
- **Treatment**—treat waste to stabilise or reduce hazard, prevent or minimise environmental risks before disposal, and
- **Disposal**—deposit to landfill, option of last resort.

Recycling systems are in place for a range of commercial and industrial materials in Australia such as asphalt, concrete, paint, timber, electronic waste, cardboard, plastics, tyres and many others. Information on the availability of local recycling systems can be obtained from local councils or regional waste and recycling organisations.

Additional resource:

State-based authorities with responsibility for waste and recycling exist in some states; among other things, they facilitate development of commercial and industrial recycling. Further information can be found at:

www.zerowaste.sa.gov.au/
www.sustainability.vic.gov.au/en
www.wasteauthority.wa.gov.au/

C3.4.4 Emission modelling

Good design in a project will assess the potential air and water emissions from all plant and equipment. The assessment will usually include modelling of the impacts, with a variety of scenarios examined in the models. Changes to parameters such as temperature, volume and speed may alter the dispersal of a pollutant in the atmosphere or water course and therefore the impacts on neighbours or surrounding sensitive land uses.

C3.5 Process optimisation

Designing a project should consider the variety of processes involved and how they can be optimised for best output, minimal costs and increased efficiency. Traditionally this has been part of good engineering practice, but has increased in importance due to the potential for sustainability gains. There is a range of modelling and simulation software which can be used to help assess the performance of project systems and processes.

Most technological equipment and industrial plants have a combination of automation and manual operation. Maintaining an effective balance enables process flexibility while ensuring safety, environmental and production controls are in place. The development of appropriate management systems (plant layout, procedures/processes, tools and training) enables manufacturers to be flexible and to efficiently meet customer and market needs.

When conducting assessments to improve management systems there should be consideration of improvements in process optimisation, such as:

- heat recovery, heat banks and process heat integration
- co- and tri-generation
- suitable process flow transport options
- kinetic energy advantages
- thermodynamic considerations, and
- waste to heat or energy options.

C3.6 Climate change adaptation

Some of Australia's most important assets are located in areas at risk of climate change impacts, such as:

- sea level rise, tidal flows to estuarine areas, inundation of low-lying areas
- change in rainfall patterns (increases in some areas and drought in others)
- extreme weather events—floods, storms, cyclones, heat
- increased potential for bushfires
- increased potential for injury or death due to extreme heat days and changes in disease transport
- exposure of infrastructure assets to changes in temperature, and
- changes to environmental and natural ecosystems.

The effects of climate change are being felt across Australia and are likely to increase in the future, with little likelihood of reversal in the medium term. It falls to us to manage climate change risks through implementation of adaptation measures. This will impact on engineering design in a number of ways, including where to locate infrastructure, increased health and safety issues, levels of infrastructure redundancy and consideration of disaster and emergency planning.

The Australian Government's 2013 *Climate Adaptation Outlook: A proposed national adaptation assessment framework* (http://www.environment.gov.au/climate-change/adaptation/publications/climate-adaptation-outlook) notes that engineers must design railway lines, power transmission systems and other structures to cope with the extremes of heat. The report also highlights where and when decision-making needs to consider climate change, including:

- where to build—appropriate location of facilities in areas of possible sea or river inundation
- designing buildings and assets—due to extremes in weather houses, bridges, railways, urban drainage, ports, energy and water infrastructure will need to be more resilient, including strengthening underground assets due to cracking and drying of soils, flood impacts, increased/decreased atmospheric water vapour
- designing infrastructure and assets—allowing for change in water flows, increased number of high volume and high speed flood days, tidal and high sea level impacts in coastal and estuarine areas
- planning and building governance—more adaptive to building design and siting frameworks which allow buildings to manage future risks
- designing to facilitate appropriate emergency management (particularly during days of extreme heat, fire, floods) where there is potential for regional

infrastructure failures such as power, water and transport

- assessment of potential health impacts due to increasing numbers of extreme heat days and changes to diseases (such as vector-borne and water-borne diseases)
- management of potable and irrigation water sources—urban environment may be at risk of water authority infrastructure impacts, regional water risks due to changes in environmental flows in rivers and lack of rainwater, and
- consideration of economic impacts and investment risks due to inappropriate siting of key community facilities and industry.

C3.7 Sustainable communities

Urban design should support the development of resilient sustainable communities, incorporating methods for healthy living with a balance between public and private spaces. Project design should concur with local community goals and include controls to avoid or manage potential impacts (noise, odour, traffic, dust, etc.) on neighbouring communities. The design should include community input gained during a consultation phase.

Creating Places for People: An urban design protocol for Australian cities (Australian Government 2011, https://urbandesign.org.au/?s=Creating+Places+for+People) is a collaborative commitment to best practice urban design in Australia. The protocol is the result of collaboration between peak community and industry organisations and all levels of Australian government. It establishes 12 principles for quality urban places and shows how to use the current tools to plan and achieve good urban design. The main principles of the protocol aim to create productive and liveable spaces through effective leadership and the integration of design excellence.

Designs should consider opportunities for job creation or growth and the potential impact on local or wider economic development. New economic opportunities are being driven by sustainability concerns and can lead to improved quality of life. There are various government support or funding programs available for new businesses showing green credentials or conducting research in these areas.

C3.7.1 Neighbourhood planning

Local governments are often responsible for implementing sustainability in their community, with involvement in the development of new suburbs to meet urban growth needs, approval processes for new construction and the maintenance of existing community infrastructure. As such, local councils have a pivotal role in regulation, education and environmental management. They are well placed to lead by example, and inform and encourage local businesses and communities to take up environmental improvement programs and initiatives.

Many councils are pursuing initiatives to reduce the environmental footprint of their own actions, using methods such as stormwater improvements, waste education, and biodiversity protection initiatives.

The International Council for Local Environmental Initiatives (ICLEI) is an international body which promotes local action for sustainability, and has council members across 86 countries. ICLEI sources and shares information on local sustainable development through annual newsletters, regional updates on activities, case studies, training guides and fact sheets. Topics range from financing energy efficiency projects, solid waste management and the use of municipal economic instruments to improve environmental performance. http://oceania.iclei.org

All Australian states have local council associations which provide sustainability (predominantly environmental) information and resources to their member councils. The associations often work across a variety of regions for projects that can share outcomes and findings for other regions and include the:

- Local Government Association of Queensland http://www.lgaq.asn.au/web/guest/public-home?p_p_auth=d2b49ZZN&p_p_id=77&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&p_p_col_count=1&_77_struts_action=%2Fjournal_content_search%2Fsearch
- Local Government Association of the Northern Territory www.lgant.asn.au
- WA Local Government Association http://www.walga.asn.au/Policy-Advice-and-Advocacy/Environment/Environmental-Planning-Tool.aspx
- ACT Government www.act.gov.au/browse/topics/environment
- Municipal Association of Victoria www.mav.asn.au/
- Local Government NSW www.lgnsw.org.au/policy/environment
- Local Government Association Tasmania http://www.lgat.tas.gov.au
- Local Government Association of South Australia http://www.lga.sa.gov.au/ search?t=siteSearch&searchMode=results&searchCurrentSiteOnly=true&searchString environment
- Australian Local Government Association www.alga.asn.au/?ID=73&Menu=44,60

C3.7.2 Sustainable transport

Key themes in sustainable transport seek to:

- *enable equity of access (including for businesses, regional, disabled and disadvantaged residents)*
- *make cities more efficient and liveable (reducing urban sprawl)*
- *integrate transport planning, development and operation*
- *design and operating environmentally sensitive transport systems*
- *implement travel demand management (discouraging car use, encouraging car share arrangements)*
- *encourage walking, cycling and use of public transport*
- *ensure safety and reliability, and*
- *improve operating efficiency (including energy efficiency).*

Transport is a major contributor to greenhouse gas emissions in Australia. However, due to the significant existing infrastructure and the increasing costs of change, improvements in transport systems have so far been incremental. Sustainability improvements have largely focused on urban road network management (e.g. automated control systems for traffic light sequencing) to improve traffic flow and reduce emissions and travel times, with additional attention on personal travel safety and reducing the impact of road infrastructure on natural ecosystems.

Australian engineers have limited ability to alter the design of our future car fleet, as vehicle construction in Australia is being discontinued (although some trucks are still produced in Australia). All road vehicles in Australia must comply with the Australian Design Rules (ADR, www.infrastructure.gov.au/roads/motor/design/index.aspx) the requirements of which are harmonised with international requirements. The ADR sets limits for vehicle emissions and noise, and specifies fuel consumption labelling. Fuel quality is managed under the Fuel Quality Standards Act 2000 (www.infrastructure.gov.au/roads/environment/index.aspx). For the purchasing of vehicles the Australian Government has developed the Green Vehicle Guide (http://www.greenvehicleguide. gov.au) to identify and compare the emissions of many vehicles available on the market.

With the exception of some major interstate roadways, most road and transport infrastructure in Australia is planned and maintained at state and local government level. An example is in Victoria, where VicRoads is the state-based agency. This agency also has input into some public transport (i.e. tram and bus systems) and bicycle networks where they integrate with the road system. VicRoads (https://www.vicroads.vic.gov.au/planning-and-projects/environment) has policies and practical programs on sustainability, climate change and environment protection during road construction. Various metrics are used by agencies to assess the impact or improvements made when new transport systems are implemented. Often the distance travelled per person for the amount of energy spent is used as a comparative metric for efficiency of travel modes.

Other large transport infrastructure (such as ports and railways) may be managed and/or constructed by both public and private consortiums. Establishment of sustainability requirements early in a project are important in setting the expected standard of operation during the construction phase.

Additional resource:

The Australian Road Research Board provides research, consulting and information services to the road and transport industry. Information is available via their website (www.arrb.com.au/), although some is only available to the client for whom the research was undertaken. They have performed many research projects related to sustainability including:

- infrastructure science (use and design of materials, pavements, concrete)
- infrastructure management (design of roads, cities)
- safe systems, and
- congestion, freight and productivity.

C4.
Project Delivery

Engineers are involved in many types of projects, such as civil construction, electronics design, equipment manufacture or wastewater treatment plant operation. While the method of delivering each type of project differs, common opportunities for improving sustainability are discussed in the following sections.

C4.1 Environmental protection

As outlined in Section C3, it is preferable to incorporate environmental protection into the design stage and focus on cleaner production methods. Table 3 focuses on end-of-pipe processes and treatments which may be required during project delivery.

Table 3:
Enviromental protection

Element	Protection actions
Water	• Reduce reliance on potable water supplies by matching the quality of water required with the use. Use groundwater, rainwater or stormwater in suitable applications. • Undertake wastewater treatment on site, treat for reuse or recycling opportunities and avoid disposal. If possible identify off-site users and match the quality of water needs. Reclaim materials lost in wastewater for reuse and to increase water quality. • Utilise efficient plumbing fixtures and equipment, change pressure, reduce landscape irrigation, investigate manufacturing changes and retrofit with efficient equipment during times of refurbishment. • Manage incoming and outgoing stormwater. Options include slowing velocity, managing contaminants, identifying reuse options while ensuring a balance in environmental flows, maintaining vegetation buffers for natural drainage systems, use of wetlands to reduce contaminants in waterways.
Land and groundwater	• Maintain current ecology and vegetation, and improve where possible. Create vegetation protection zones with fencing/barriers and ensure activities are not going to impinge on these areas. • Conduct activities with attention to erosion and sediment control by decreasing angles of batters, stabilising soils and installing sediment control mechanisms. • Manage production activities so that soils and geology are not contaminated. This is important when reclaiming land from a previous industrial use and will need to be conducted in accordance with legislation. • Ensure compliance with the relevant groundwater sections of the National Water Quality Management Strategy (http://www.environment.gov.au/water/policy-programs/nwqms/index.html) and state-based legislation.
Climate change adaptation	• Install appropriate mitigation methods as highlighted in the risk assessment and design phases. • Ensure programs have contingencies for extreme heat, flood, cyclone, etc.

Materials	• Follow the organisational green procurement policy documented in the planning phase to manage resource use. • Develop and follow a waste management plan, which includes a regular review of wastes to identify improvements in accordance with the waste hierarchy. Identify wastes that can be reused or recycled on site. • Ensure that the storage of materials (particularly stockpiles, chemicals, fuels and waste) is secure and will not impact on community health or the environment.
Air	• Reduce emissions (chemicals and odour) from production activities by effective engineering design. Where emissions are unavoidable, installation of emission control technologies such as biofilters, scrubbers, cyclones, after-burners, etc. will be required. • Reduce emissions by using fuel-efficient vehicles with lower emissions, as well as changing fuel type and driver behaviour. Behaviour management is supported by the effective design of suburbs, with walk/cycle/public transport options available.
Noise	• Noise and dust are significant amenity issues, particularly when residential and industrial areas are co-located either due to historic land use or poor planning decisions. Controls include baffles, suppression, screening or the relocation of activities.
Energy	• Energy management includes effective operation of the installed equipment. This should involve operation at optimal conditions (a full production run, turn off when not in use, correct operating temperatures and pressures). • Utilise efficient plumbing fixtures and equipment, change pressures, investigate manufacturing changes and retrofit with efficient equipment during times of refurbishment. • Request renewable energy sources from energy suppliers. Investigate the option of co-/tri-generation and on-site energy production options.

There are significant sustainability issues that can arise during the development and construction phases of large infrastructure projects; additional planning for environmental protection will therefore be required. Issues such as noise, odour, stormwater, waste, litter, traffic, dust and other community impacts are often more of a risk in larger projects and need additional management.

The Australian Government has developed a Construction and Development Waste Guide (https://www.environment.gov.au/system/files/resources/b0ac5ce4-4253-4d2b-b001-0becf84b52b8/files/case-studies.pdf) to promote recycling and reuse across the supply chain.

Legislative environmental advice is available from state-based environmental authorities and addresses issues such as the management of waste, pollution controls, noise controls, etc. Examples of guides include the following:

- Environmental guidelines for major construction sites (EPA Victoria 1996, publication 480, www.epa.vic.gov.au/our-work/publications/publication/1996/february/480)
- Stormwater pollution prevention: Code of Practice for the building and construction industry (EPA SA 1999, http://www.epa.sa.gov.au/environmental_info/water_quality/programs/stormwater/pollution_prevention_for_building_and_construction_activities), and
- ‘Healthy Waterways and Stromwater Strategies, Melbourne Water, 2013 (https://www.melbournewater.com.au/aboutus/reportsandpublications/key-strategies/pages/healthy-waterways-and-stormwater-strategies.aspx).

C4.2 Social considerations

When effective design in the initial stages has occurred, management of social issues during the operational phase should be simpler. Activities to address social sustainability include:

- Maintaining aesthetics and visual amenity to demonstrate respect for the local community.
- Engaging in ongoing consultation with the community—use of newsletters, newspaper articles, signage, flyers and committee meetings are all appropriate methods.
- Preparing and following appropriate management plans for indigenous and cultural heritage.
- Preparing and following an appropriate occupational health and safety (OHS) management system and ensuring compliance with OHS legislation. Establishing detailed site operating procedures, ensuring that employees have access to them and follow them. Ensuring appropriate supervision, first aid, personal protective equipment and security.
- Identifying staff with particular knowledge to act as sustainability champions in the workplace.
- Conducting induction and regular training programs for employees.
- Identifying opportunities for ongoing engagement with the local community and employees, e.g. through employing local staff, workplace diversity, charitable work, volunteer opportunities, staff recognition programs, regular management communication, industry education, employee awareness and engagement, training and leadership programs.
- Developing procedures for complaints handling and record keeping of outcomes.
- Installing signage for community to contact site management regarding concerns.

C4.3 Economic considerations

Use of local suppliers and employees will contribute to regional economic growth and improved sustainability outcomes. Generally accepted accounting procedures should be used as a basis for financial management, with additional consideration of environmental accounting and life cycle accounting where relevant. Appropriate performance indicators and a structure for regular monitoring and reporting should be established. In many cases the cost of environmental impacts are not accounted for in standard accounting practices. For example, the effects of air pollution from manufacturing activities may impose health costs on the wider public; equally, the high use of fossil fuels in the economically advanced world can contribute to the severity of natural disasters, such as cyclones in developing countries. Economic externalities like these may need to be considered in cost-benefit analyses carried out during project planning and feasibility assessments.

C5. Management

An operation that is run well is likely to improve sustainability. It will strive for high efficiency in all its activities, including energy and material use, and will have a streamlined management system.

C5.1 Operational efficiency

Operational efficiency can be achieved via optimal equipment operation, regular maintenance schedules and effective management programs. This will help to reduce operational and capital expenditure and increase outputs, with the additional benefits of reduced use of resources, increased safety due to simpler work procedures and improved matching of staff skills with organisational needs.

Ways of improving efficiency include:

- the centralisation or automation of working processes
- the elimination of faults or errors (to improve quality of output)
- the improved training of employees
- strict controls on suppliers and subcontractors
- improved equipment or better utilisation of current equipment
- upgrades to production processes and methodologies, and
- increased consumer/community loyalty and engagement.

Various programs have been developed to improve and manage operational efficiency. Some of these management techniques include lean manufacturing, quality management, value mapping and productive maintenance. Essentially, these programs increase value and decrease waste, as shown in Table 4.

Table 4: Efficiency management

Increasing value	Decreasing waste
Rapid changeover between product outputs	Reduction in set-up errors
Improving production flow	Elimination of trial runs
Increasing production output per shift	Improved quality, reduced errors and defects
Just in time production	Products are 'fresher' to market
Reduced stock storage levels, improved inventory	Reduce time-wasting, materials in handling and waiting
Standard components and tools	Manage plant and equipment to reduce damage
Scheduling of tasks, changeovers and maintenance	Reduce over-production, produce to customer needs

C5.2 Management systems

A management system is a methodology that can be applied to a variety of processes, including quality control, lean integration, financial information and environmental management. International standards exist for a number of these, e.g. ISO14001 Environmental Management Systems—Specification with guidance for use and ISO9000 Quality Management. Many large organisations integrate the environment, health, safety and quality into the same management system.

Managing issues in a systematic way can help to:

- increase efficiency, produce consistent products/ outcomes
- reduce waste (materials, time, money)
- improve agility or flexibility of the workforce and outcomes
- provide reliable data for decision-making
- improve governance by the management team
- reduce legislative non-compliance risk
- drive continuous improvement by feeding learnings back into the process
- engage employees who promote innovative ideas
- reduce insurance costs, and
- improve community recognition and public reporting.

A management system should be prepared for use during the delivery phase and endorsed by management and the executive team. Management systems encompass:

- documented roles and responsibilities
- processes to maintain currency of compliance documents
- procedures
  - standard operating procedures
  - maintenance
  - contingencies
  - complaints management
  - emergency/crisis
- framework for induction and on-going training
- framework for monitoring and auditing, and
- standardised templates, forms, documents.

A particularly effective form of contract management is 'alliance contracting'. This is especially effective for large civil projects. It requires and develops trust between the project owner, designer and constructor; it can lead to innovations with environmental, social and economic benefits. In alliance contracting common goals for the owner, designer and contractor to achieve are agreed upon. The owner, designer and contractor's staff all work in a common office, so innovative ideas can more easily be developed and mutually agreed upon. Incentives include the sharing of any cost savings and greater job satisfaction for those working on the project.

C5.3 Monitoring

Monitoring will be required regularly throughout the operation; it may be targeted due to an immediate issue, or scheduled in accordance with the management system. Examples include:

- environmental monitoring—checking that the project is not impacting on the local environment via scientific sampling programs (emissions, stormwater and effluent discharges)
- monitoring of waste production and confirmation of data accuracy
- equipment monitoring and maintenance programs
- visual inspections and workplace surveillance for compliance with procedures
- reviews of community or customer complaints—reviewing data and conducting a comparison with production data to determine patterns or repeating issues, and
- conducting consumer, community or employee surveys.

When scientific sampling programs are in place, certified methodologies must be followed with regards to the sampling type and analysis undertaken. In Australia, laboratories are certified via the National Association of Testing Authorities (NATA) to ensure that tests are carried out by qualified personnel. Sampling methodologies will depend on the medium being sampled (soil, air, water, waste, effluent) and the analysis to be conducted (chemical, biological, etc.).

Data obtained during monitoring should be reviewed regularly and changes should be made when procedures are not working or are ineffective. Data may need to be provided to regulatory bodies to show compliance with licences, permits or standards.

C5.4 Audit and compliance

Auditing should be conducted by suitably qualified personnel either in-house or via an independent external party. The audit process should be thorough and should investigate through an examination of relevant documents, inspections/observations of procedures, confirmation of compliance and interviews. Depending on the scope of the audit, the outcomes will provide judgement on the adequacy of controls, confirm compliance with documented management systems and evaluate management and governance systems. It is important to conduct a regular auditing program; the timing and detail may depend on the level of risk identified in the planning stage. Higher risk issues will need more regular and detailed audits. Audit processes are outlined in Table 5.

Table 5: Auditing stages

Stage	Processes
Endorsement	Gain support from senior management/executive team
Scope	Establish the scope of the audit • sources, equipment • geographical boundaries (which sites are included) • environmental (energy, water, waste etc.) • compliance with permits, licences and legislation
Collation	Gather all relevant data • background information (guidelines, licences, previous audits) • resource, energy and water use • actual costs, costs vs production output • waste production—types, costs and volumes • review design vs actual efficiencies • conduct inspections • interview relevant personnel
Review	Assessment • state where and how the energy/water is used • conduct mass balance to determine losses and efficiency • highlight areas of excessive use or costs • determine payback costs for proposed improvements
Report	Document the findings of the audit and the recommendations
Implementation of changes	Changes can include • hardware/equipment changes • process or procedural changes • maintenance change • alteration to inputs including fuels • improvement to waste management
Review of changes	Ensure that changes are operational and efficient
Review of system	A review of the entire management system should also occur but on a less regular basis

Additional resource:

'The Business of Sustainability Decision Support Tool' has been produced by Consult Australia. It is a preliminary auditing tool to assess the progress of a business towards sustainability. It gives advice on how to assess the following:

1. Sustainable governance, reporting and accounting
2. Internal engagement and staff culture
3. Collaboration and engagement, and
4. Technological improvements to offices and infrastructure.

It is not a rating tool, but provides advice with questions for consideration when a business wants to improve its sustainability, and helps a business identify gaps in its sustainability practice.

http://thebusinessofsustainability.com.au/decision-support-tool-2/

C5.5 Sustainability reporting

C5.5.1 Organisational reporting

Many organisations produce environmental reports which are released in the public domain, and many of the larger multinational organisations are merging annual financial reports under the three banners of environmental, social and economic impacts in order to generate full sustainability reporting. Guidance with regards to the environmental section is provided in sections of ISO14000 Environmental management systems.

Sustainability reports should be produced for a defined audience (internal, external, certain groups) and via an appropriate methodology to suit that audience. Most sustainability reports include the following sections:

- company information—location details, history, products
- details of sustainability programs—efficiency schemes, community projects
- results of monitoring—annualised data, often aggregated by region or type of production
- summary of audit findings
- objectives or goals for future years, and
- legislative requirements and compliance (any fines, breaches).

The key to a good sustainability report is to set and measure against key performance indicators (KPIs). KPIs should be set for a variety of metrics in the three sustainability domains: environment, economic and social. Typical examples include water and energy use, financial profit and OHS compliance. KPIs should be regularly reported to enable change of practice when goals are not being met.

Data collection, modelling and the development of suitable text for a report can be a time-consuming activity and as such needs to be suitably resourced. Often this is via internal environmental staff, with support from human resources and production management staff to review and provide a quality assessment of drafting.

There are many independent organisations which provide verification and certification of sustainability reports; some of these are listed in Table 6. External certification does provide transparency in assessment of the sustainability of a business.

Table 6: Sustainability reporting

Certification group	Website
Global Reporting Initiative	www.globalreporting.org/Pages/default.aspx
Dow Jones Sustainability Index	www.sustainability-indices.com/
Ethisphere	www.ethisphere.com/worlds-most-ethical/
Global 100	www.global100.org/about/
GHG Protocol	www.ghgprotocol.org/about-ghgp
Carbon Disclosure Project—Global 500 Climate Performance Leadership	https://www.cdp.net/en
London Stock Exchange FTSE4Good Rating Indices	http://www.ftse.com/products/search/home?searchtext=FTSE-4Good&type=&page=0&searchtitle=false

C5.5.2 Government reporting

Government agencies are producing more reports with respect to the environment and sustainability; these can provide metrics which inform reporting by private organisations. These reports include:

- State of the Environment reports

The Conversations with the Future 2013 (Australian Government 2013, **https://www.coolaustralia.org/sustainable-australia-report-2013/**) Measuring Sustainability program has developed sustainability indicators for social/human capital, natural capital and economic capital. The program offers a comprehensive and integrated approach to measuring and monitoring sustainability in Australia. It provides information on current and emerging economic, environmental and social issues (and the linkages between them) to support decision-making and planning at national and community levels.

- research studies from organisations such as CSIRO
- climate change reports from the Bureau of Meteorology, and
- reports required by government regulation on matters such as the National Pollutant Inventory (**www.npi.gov.au/reporting**) and National Greenhouse and Energy Reporting Scheme (**www. environment.gov.au/climate-change/greenhouse-gas-measurement/nger**).

C6. Stewardship

C6.1 Product end of life

Typically when products reach their end-of-life they are disposed of as waste. Improved sustainability focuses on closing the loop and forming continuous cycles of use and reuse. The easiest method of reuse is on-site and immediate, using the one product many times. Alternative methods involve off-site recycling and re-manufacturing processes.

A more commercial scale is industrial ecology, which is based on industrial systems mimicking ecological systems, where waste from one process becomes the raw material for another. This has environmental and social benefits (e.g. reduced resource use, reduced waste impacts) as well as financial benefits (e.g. reduced waste costs, revenue from sale of raw materials).

Traditionally, product manufacturers have taken little responsibility for the management or disposal of their products at end-of-life. This is now changing, with the introduction of extended producer responsibility and product stewardship programs. These programs extend Australia-wide and may be legislated or voluntary industry schemes. The scope of each product stewardship scheme will differ, but generally entails take-back and recycling programs funded and managed by an industry body representing the manufacturers of that product. Schemes are currently in place in Australia for agricultural chemical containers, televisions, computers, used oil and packaging (**http://www.environment.gov.au/protection/national-waste-policy/product-stewardship/legislation**); additional industry schemes are under development for paint, tyres, refrigerators and air-conditioners, mercury-containing lamps and handheld batteries.

C6.2 Deconstruction and remediation

Deconstruction will be aided by initial project planning, which incorporates the use of modular materials that are reusable or readily recycled. The demolition process then becomes one of deconstruction, allowing more sustainable use and reuse of equipment and materials at the end of life of a project.

Upon demolition or deconstruction, equipment and materials should be cleaned or decontaminated prior to removal off-site. Materials should be segregated at the source to reduce mixed or contaminated material streams that limit recycling opportunities. Any material residues must be disposed of in accordance with legislative requirements, e.g. wash-waters and contaminated materials may be classified by state regulations as hazardous waste and require specific tracking, transport by accredited transporters, disposal to licensed facilities and recording obligations. Demolition or deconstruction should consider potential community and environmental impacts (noise, dust, litter, odour, etc.) and manage these in accordance with regulations and organisational management systems.

C6.3 Remediation and future land use

State-based authorities legislate for contaminated land management based on national guidelines. Most legislation is focussed on remediation to the standard in the national guidelines (to meet a proposed land use) rather than remediation beyond the standard (for any future land use or return to a greenfield site). Some state-based EPAs provide controls through permits or licensing systems to industries which have a high risk of land contamination; for example landfills, fuel/petrol manufacturing and storage. These types of sites will require managed remediation plans.

Clean-up of a contaminated industrial site will need to be conducted in accordance with regulatory conditions (e.g. licence, permit). The results of land and groundwater assessments may be needed to establish possibilities for future land use. Assessments may also need to be ongoing and as such will need to be considered in a monitoring and rehabilitation plan.

Guidelines are available with respect to particular clean up techniques, but the choice of technique is a technical decision made based on the type and extent of contamination, along with the proposed land use, location and cost implications. An example of state-based guidelines is NSW EPA's Best Practice Note: Landfarming (NSW EPA 2014, **www.epa.nsw.gov.au/clm/140323landfarmbpn.html**). This practice note outlines the expectations for those who undertake soil remediation in NSW using landfarming. It aims to promote best practice and assist practitioners to comply with regulatory requirements, particularly the uncontrolled release of emissions to air, land and water.

Management will develop a rehabilitation plan to ensure a site will meet future needs. This may involve stabilisation and revegetation of areas for public use as an open space. Liaison with local community and planning authorities will be required to determine potential future land uses. The cleaner/greener the land is left the greater are the future land use options and therefore the financial benefits if the land is being sold. Some cases will require a legislative independent audit to verify the suitability of the land for the proposed land use, potentially with conditions controlling the activities or the clean-up to occur.

C7. Case Studies

There is a range of case studies available from existing online sources, including the following:

- Environment Protection Authority Tasmania
  www.epa.tas.gov.au/sustainability/cleanbiz-case-studies
  This site includes nine case studies on resource efficiencies implemented by Tasmanian businesses.
- Environment Protection Authority Victoria
  http://www.epa.vic.gov.au/business-and-industry/lower-your-impact/resource-efficiency/case-studies#casestudies
  This site includes more than 20 resource efficiency case studies which focus on:
  - reduction of trade and prescribed industrial waste
  - reduction in water usage
  - reduction in energy usage
  - illustration of leadership and life cycle approaches.
- NSW Office of Environment and Heritage
  http://www.environment.nsw.gov.au/search?q=case+studies
  These case studies outline increased productivity and reductions in energy, water, waste and raw material use at organisations in the accommodation, aged care, clubs, education, food and beverage, government, manufacturing, printing and services sectors.
- Queensland Department of Environment and Heritage Protection
  www.wetlandinfo.ehp.qld.gov.au/wetlands/resources/case-studies/wetland-management.html
  This site provides access to a number of wetland management case studies conducted through the Queensland Wetland Program.
- Urban Design Protocol (Australian Sustainable Built Environment Council)
  https://www.urbandesign.org.au/casestudies/index.aspx
  These case studies demonstrate the principles of the Urban Design Protocol in practice and include:
  - Darling Quarter: a new mixed use precinct at Darling Harbour (NSW)
  - Parramatta River Urban Design Strategy: a strategy for the regeneration of Sydney's second largest CBD and the Parramatta River foreshore area (NSW)
  - Paddington Reservoir Gardens: a new space for community and cultural activities on the site of a former water reservoir in Sydney's east (NSW)
  - Geelong Youth Activities Area: a public recreational plaza on the waterfront adjacent to the Geelong CBD (Vic)
  - Next Generation Planning Handbook: a new approach to planning the suburbs, towns and cities of southeast Queensland(Qld)
  - Beyond the Pavement: RTA Urban Design Policy, Procedures and Design Principles: sets out the NSW Transport and Maritime Services vision for urban design (NSW).
- WA Waste Authority
  http://www.wasteauthority.wa.gov.au/programs/communication-guidelines/case-studies
  This publication outlines case studies of waste reduction initiatives implemented at 11 schools in Western Australia.
- Zero Waste SA
  www.zerowaste.sa.gov.au/industry/case-studies
  Zero Waste SA's industry program helps companies take a more sustainable approach to their waste management and resource use. This site includes case studies of outcomes at businesses in the not-for-profit, government and education, food and wineries, manufacturing, printing, professional services, tourism and travel, and utilities sectors.

Engineers Australia has also incorporated various case studies into its sustainability assessment training course. While these are not currently online, these may be available upon request.

Abbreviations

ABGR	Australian Building Greenhouse Rating
ADR	Australian Design Rules
BASIX	Building Sustainability Index
BIM	Building information modelling
CO2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EMS	Environmental management system
EPA	Environment Protection Authority
GECA	Good Environmental Choice Australia
HAZOP	Hazard and operability
HVAC	Heating, ventilation and air-conditioning
ICLEI	International Council for Local Environmental Initiatives
IS	Infrastructure sustainability
KPIs	Key performance indicators
LCA	Life cycle assessment
NABERS	National Australian Built Environment Rating System
NATA	National Association of Testing Authorities
NatHERS	Nationwide House Energy Rating Scheme
OHS	Occupational health and safety
TBL	Triple bottom line
WERS	Window Energy Rating Scheme
WFEO	World Federation of Engineering Organizations

Appendix 1: Engineers Australia Code of Ethics

As engineering practitioners, we use our knowledge and skills for the benefit of the community to create engineering solutions for a sustainable future. In doing so, we strive to serve the community ahead of other personal or sectional interests.

Our Code of Ethics defines the values and principles that shape the decisions we make in engineering practice. The related Guidelines on Professional Conduct provide a framework for members of Engineers Australia to use when exercising their judgment in the practice of engineering.

As members of Engineers Australia, we commit to practise in accordance with the Code of Ethics and accept that we will be held accountable for our conduct under Engineers Australia's disciplinary regulations.

In the course of engineering practice we will:

1

Demonstrate integrity

1.1 Act on the basis of a well-informed conscience
1.2 Be honest and trustworthy
1.3 Respect the dignity of all persons

2

Practise competently

2.1 Maintain and develop knowledge and skills
2.2 Represent areas of competence objectively
2.3 Act on the basis of adequate knowledge

3

Excercise leadership

3.1 Uphold the reputation and trustworthiness of the practice of engineering
3.2 Support and encourage diversity
3.3 Communicate honestly and effectively, taking into account the reliance of others on engineering expertise

4

Promote sustainability

4.1 Engage responsibly with the community and other stakeholders
4.2 Practise engineering to foster the health, safety and wellbeing of the community and the environment
4.3 Balance the needs of the present with the needs of future generations

Guidelines on Professional Conduct

The Guidelines on Professional Conduct provide a framework for members of Engineers Australia to use when exercising their judgment in the practice of engineering.

The Guidelines are not intended to be, nor should they be interpreted as, a full or exhaustive list of the situations and circumstances which may comprise compliance and non compliance with the Code of Ethics. If called upon to do so, members are expected to justify any departure from both the provisions and spirit of the Code.

Ethical engineering practice requires judgment, interpretation and balanced decision-making in context.

Engineers Australia recognises that, while our ethical values and principles are enduring, standards of acceptable conduct are not permanently fixed. Community standards and the requirements and aspirations of engineering practice will develop and change over time. Within limits, what constitutes acceptable conduct may also depend on the nature of individual circumstances.

Allegations of non-compliance will be evaluated on a case-by-case basis and administered in accordance with the disciplinary regulations.

1

Demonstrate integrity

1.1 Act on the basis of a well-informed conscience

a) be discerning and do what you think is right
a) act impartially and objectively
a) act appropriately, and in a professional manner, when you perceive something to be wrong
a) give due weight to all legal, contractual and employment obligations

1.2 Be honest and trustworthy

a) accept, as well as give, honest and fair criticism
a) be prepared to explain your work and reasoning
a) give proper credit to those to whom proper credit is due
a) in managing perceived conflicts of interest, ensure that those conflicts are disclosed to relevant parties
a) respect confidentiality obligations, express or implied
a) do not engage in fraudulent, corrupt, or criminal conduct

1.3 Respect the dignity of all persons

a) treat others with courtesy and without discrimination or harassment
a) apply knowledge and skills without bias in respect of race, religion, gender, age, sexual orientation, marital or family status, national origin, or mental or physical handicaps

2

Practise competently

2.1 Maintain and develop knowledge and skills

a) continue to develop relevant knowledge and expertise
a) act in a careful and diligent manner
a) seek peer review
a) support the ongoing development of others

2.2 Represent areas of competence objectively

a) practise within areas of competence
a) neither falsify nor misrepresent qualifications, grades of membership, experience or prior responsibilities

2.3 Act on the basis of adequate knowledge

a) practise in accordance with legal and statutory requirements, and with the commonly accepted standards of the day
a) inform employers or clients if a task requires qualifications and experience outside your areas of competence

3

Excercise leadership

3.1 Uphold the reputation and trustworthiness of the practice of engineering

a) advocate and support the extension of ethical practice

a) engage responsibly in public debate and deliberation

3.2 Support and encourage diversity

a) select, and provide opportunities for, all engineering practitioners on the basis of merit

a) promote diversity in engineering leadership

3.1 Communicate honestly and effectively, taking into account the reliance of others on engineering expertise

a) provide clear and timely communications on issues such as engineering services, costs, outcomes and risks

4

Promote sustainability

4.1 Engage responsibly with the community and other stakeholders

a) be sensitive to public concerns

a) inform employers or clients of the likely consequences of proposed activities on the community and the environment

a) promote the involvement of all stakeholders and the community in decisions and processes that may impact upon them and the environment

4.2 Practise engineering to foster the health, safety and wellbeing of the community and the environment

a) incorporate social, cultural, health, safety, environmental and economic considerations into the engineering task

4.3 Balance the needs of the present with the needs of future generations

a) in identifying sustainable outcomes consider all options in terms of their economic, environmental and social consequences

a) aim to deliver outcomes that do not compromise the ability of future life to enjoy the same or better environment, health, wellbeing and safety as currently enjoyed

Adopted 28 July, 2010

www.engineersaustralia.org.au/ethics

Appendix 2: Engineers Australia Sustainability Policy

Purpose

Engineers Australia and its members are committed to creating and delivering outcomes that will ensure the long-term survival of life on earth in a fair and equitable manner.

For our members, sustainability means that future generations will enjoy environmental, social and economic conditions that are equal to or better than those enjoyed by the present generation.

Our Code of Ethics requires us to develop engineering solutions that repair and regenerate both natural and social capital, while maintaining economic health.

Context

Engineers Australia acknowledges that to achieve sustainability outcomes requires transformative change in business practices, lifestyles, and in the way resource allocation decisions are made.

Fundamental to this change is the recognition that a healthy economy is underpinned by a healthy environment and respect for all life on earth.

Engineers Australia and its members commit to ensuring all relevant stakeholders are consulted, and that open and regular reporting of progress towards delivering sustainability outcomes forms a fundamental component of engineering practice.

Principles

In implementing sustainability across any engineering activity, members of Engineers Australia should:

1. Objectively apply engineering knowledge, skill, and experience to achieve measurable outcomes that enhance both natural and social capital.
2. Maintain an up-to-date knowledge and understanding of sustainability principles and practices relevant to their area of practice.
3. Seek outcomes that deliver fairness and equity within the present generation as well as between present and future generations.
4. Think holistically, and innovatively, and account for externalities and whole of life impacts, such that there is a net sustainability benefit.
5. Be proactive in addressing risks to the environment, society and the economy.
6. Build shared community value, robustness, and resilience.
7. Always practice within the Engineers Australia Code of Ethics.

Guidance

Engineers Australia, as an organisation, considers that sustainability is a key consideration, informed by societal expectations, technical knowledge and expertise, and is to be applied in all areas of its endeavours and strongly promoted to all of its members.

This Sustainability Policy is supported by an Implementation Plan, which articulates specific changes to engineering practice that arise from adoption of this Policy.

Specific sustainability considerations to be applied to engineering practice (policy and projects) include (not in priority order):

1. The use of resources should not exceed the limits of regeneration.
2. The use of non-renewable resources should create enduring asset value (everlasting and/or fully recyclable), and be limited to applications where substitution with renewable resources is not practical.
3. Engineering design, including product design, should be whole system based, with consideration of all impacts from product inception to reuse/repurposing.
4. Product and project design should consider longevity, component re-use, repair and recyclability.
5. Eliminating waste should be a primary design consideration. Unavoidable waste from any one process should be examined for recycling potential as input to another productive process.
6. The rate of release of any substances to the environment should do no net harm, and be limited to the capacity of the environment to absorb or assimilate the substances, and maintain continuity of ecosystem services. In all instances, such releases should be lifecycle-costed and attributed.
7. Proactive and integrated solutions are preferable to reactive, linear, “end of pipe” solutions, such that there is a net sustainability benefit.
8. In circumstances where scientific information is inconclusive, or incomplete, the precautionary principle and risk management practices should be applied to ensure irreversible negative consequences are avoided and not passed as a liability to future generations.

November 2014

Appendix 3: Engineers Australia Climate Change Policy

Purpose

Engineers Australia accepts the comprehensive scientific basis regarding climate change, the influence of anthropogenic global warming, and that climate change can have very serious community consequences.

Engineers are uniquely placed to provide both mitigation and adaptation solutions for this serious global problem, as well as address future advances in climate change science.

This Climate Change Policy Statement has been developed to enable organisational governance on the problem, and provide support for members in the discipline and practice of the engineering profession.

Context

Building upon a long history of Engineers Australia policy development, and as the largest technically informed professional body in Australia, Engineers Australia advocates that Engineers must act proactively to address climate change as an ecological, social and economic risk.

The role of engineers is to lead innovation for, and apply contemporary knowledge towards solutions that add value to ecological, social, and economic wellness.

Engineers Australia is committed to natural resources policy reform to adopt full life-cycle analysis, including the pricing of resource use externalities, to ensure responsible resource allocation decisions.

Engineers Australia considers Australia is particularly vulnerable to climate change impacts arising from an average global temperature rise in excess of two degrees Celsius, relative to the average pre-industrial temperature. These impacts include:

- Increased loss and damage to natural and built environments resulting from greater a frequency and severity of weather events including: higher wind speeds and durations, lightning strikes, intensified precipitation, increased flood peaks and volumes, increased temperature variations and durations resulting in drought, heat wave, more intense wildfires, and cold snap;
- Increased loss and damage to natural and built environments in coastal and riparian environs from: sea level rise, storm surge, wave action, inundation, ground water change and saline intrusion;
- Increased health risks to people, flora and fauna, including from heat, humidity, physical damage and micro-biological change;
- Damage to terrestrial, aquatic and marine ecosystems, particularly coral reef and micro-biological systems;
- Loss of agricultural productivity from changes to rainfall volume and intensity, evaporation, temperature stress, salinity, acidification as well as spatial and temporal seasonal variability; and
- Increased global community instability arising from resource stress.

Engineers should work to eliminate the causal factors contributing to climate change from engineering endeavours, as well as consider contemporary science in adaptation and mitigation initiatives during planning, design, delivery, operation and decommissioning of engineering works and products.

Policy

Engineers Australia's policy position is that the increasing atmospheric greenhouse gas concentrations, including from the combustion of fossil fuels, are contributing to anthropogenic global warming and adverse changes to Earth's climate systems.

Engineers Australia encourages national greenhouse gas emission reduction targets to be pursued to enable transition to renewable and sustainable energy, water, transport, industry and agriculture systems.

Engineers Australia will work to facilitate statutory, regulatory and policy reform such as progressive Renewable Energy Targets, incentives to promote renewable and sustainable energy technologies, energy efficiency standards, transport emission limits, and incentives/disincentives to reduce dependence on fossil fuel sources. It is recognised that this is part of a transitional process.

Engineers Australia reinforces that Engineers are critical to the implementation of long-term strategic policies addressing the inextricable link between energy generation and use, resource consumption and climate impacts.

Engineers Australia's members acknowledge that:

- Engineers have an ethical responsibility for, and play a key role in, limiting atmospheric greenhouse gas concentrations, through transformative change and innovation in engineering education, and practice.
- Engineers are well placed to understand and assess the viability of climate change mitigation and adaptation strategies needed to make the difference and have the practical know-how to implement these strategies.
- Engineers proactively participate together to address the causes and impacts of climate change as a significant ecological, social and economic risk.
- Reduction of the emission of greenhouse gases to the atmosphere associated with engineering activities should be accorded urgent priority in engineering endeavours.
- Engineers should include risk analysis and advice of the likely impacts of climate change in their work.
- Engineers should maintain an awareness of contemporary climate change science and advances thereof, and contribute to the refinement of knowledge and approach, to encourage the best possible engineering outcomes.

November 2014

Appendix 4: Mind Map as a Systems Approach

This appendix shows the expansion of the mind map as a physical systems approach, illustrations of social mindsets (ethics, values and culture), and social organisation (legal, religious and governance) as sophisticated expansions of the simple mind map.

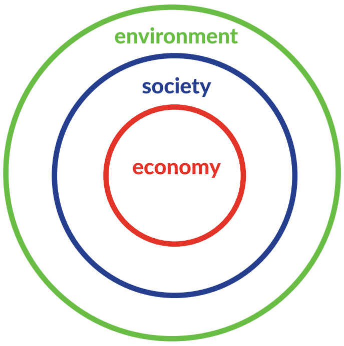


Figure A:
basic system and subsystems

The mind map represents the economic and social aspects as subsystems of the environment of planet Earth. This environment is finite and no subsystem can extend beyond the capacity of the total system.

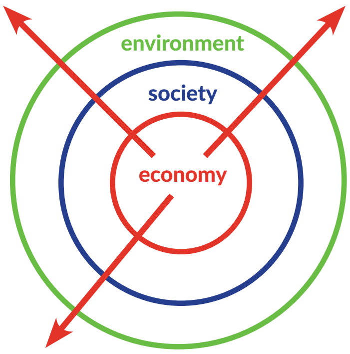


Figure B:
rare—open system

Rarely do economic actions extend beyond the earth's environment.

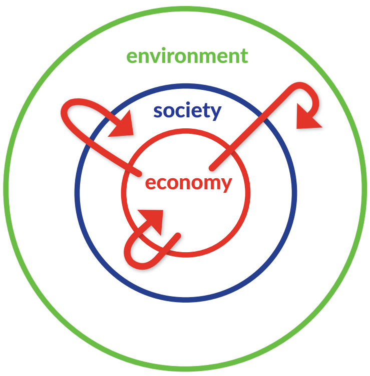
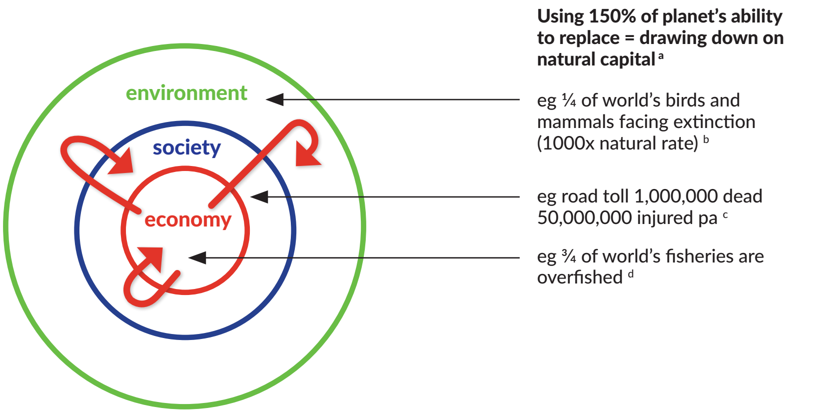


Figure C:
Usual—closed system

This is what usually happens:

the planet tends to act as a closed system. Nearly all the impacts of our economy stay within the earth's environment.

Often economic actions have negative environmental, social and economic consequences. Some of these consequences were unforeseen at the time, or were exacerbated by population growth, with the closed nature of the system not being properly understood. Social actions, such as armed conflict, may also have negative environmental impacts. Some examples follow.



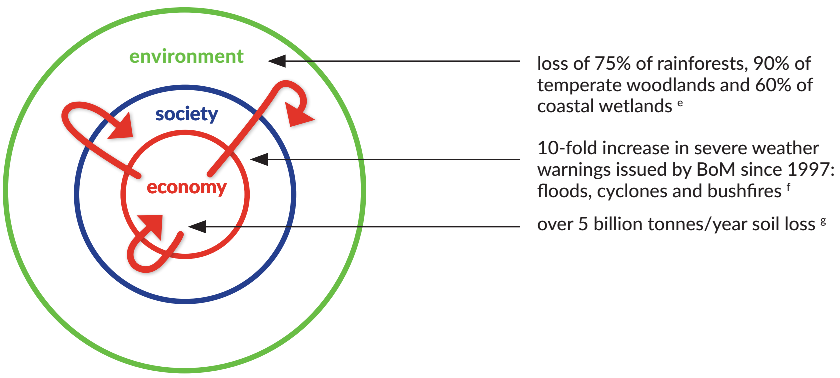
a Global Footprint Network, 2016, www.footprintnetwork.org

b 2012 Halcrow Sustainability Lecture to Institution of Civil Engineers, UK

c Asian Development Bank, www.youtube.com/watch?v=IDuJNwGmzs&feature=player_embedded

d 2012 Halcrow Sustainability Lecture to Institution of Civil Engineers, UK

Figure D:
global examples



e Australian Museum https://www.australianmuseum.net.au/whats-happening-to-australias-biodiversity

f AAP News, June 8 2012

g Australian Agriculture Assessment 2001 report, https://www.environment.gov.au/system/.../australiannaturalresourcesatlasland.doc

Figure E:
national examples

Of course there are also many examples of economic activity having beneficial environmental, social and economic outcomes, but the negative examples above serve to remind us why we need to take a long-term view of impacts.

Another way in which the mind map can be seen as a systems approach is to further consider the environmental, social and economic boundaries.

We have Figure 2 in the Principles to remind us that we live in the environment: fundamental for understanding how to implement sustainability'

But does this go far enough?

We can talk about having a job so we can provide for our family (social), and we can talk about being a productive member of the workforce with sufficient earning capacity to purchase goods (economic)—but we are simply using different words to describe the same thing: having a job.

Similarly, we can talk about the herd instinct in humans that leads people to live in large groups (social), or we can talk about city construction and maintenance (economic), or we can talk about urban agglomerations covering such significant amounts of the earth's surface that they affect climate (environment). But we are essentially talking about the same thing: living in large groups.

In other words, the economic and social systems do not have hard edges, but they flow into each other and into the environment. Not only are they not separate, they are not even clearly delineated. Their boundaries are porous and might be better represented as Figure F:

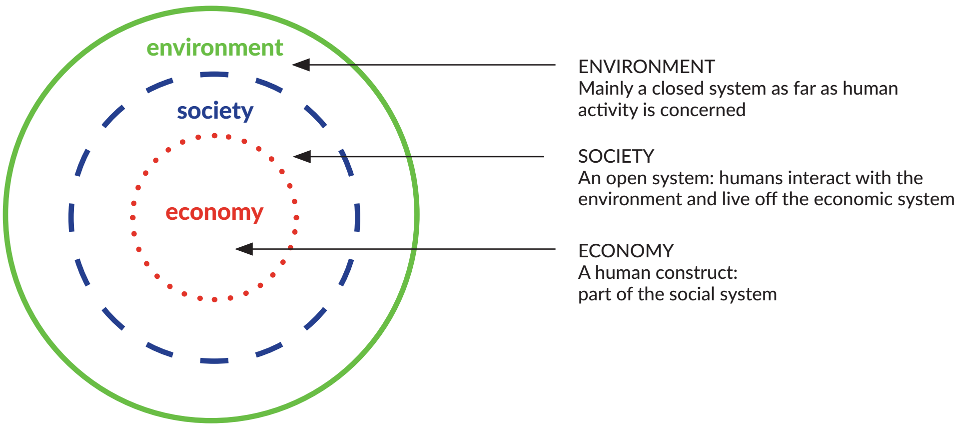


Figure F: open and closed systems

Also the social system can be seen more thoroughly as being made up of various mindsets, such as ethics, culture and values. These also interact with each other, so have porous boundaries, as shown in Figure G.

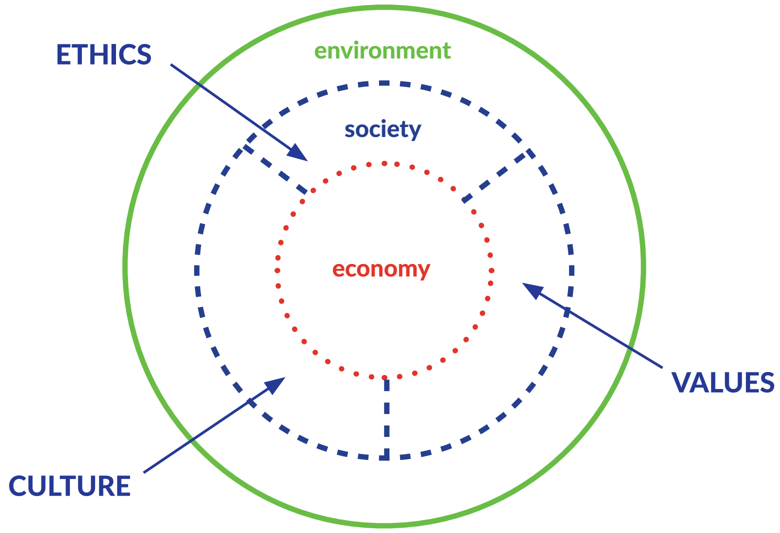


Figure G: social mind sets

And society is organised in different ways, such as through legal, religious and governance structures, which also influence each other, as shown in Figure H below.

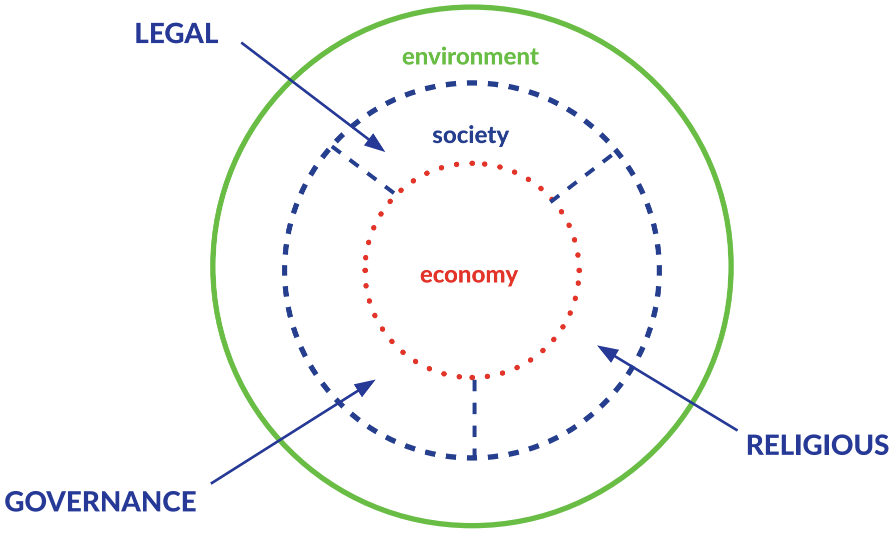


Figure H: social organisation

So, it is important to recognise these permeable boundaries and their interactions. It is especially important to see the economy as part of society—as one of several ways in which humans organise their lives—rather than an end in itself. This may require a cultural shift if we are to become sustainable.

Appendix 5: Further Information FOR PRACTICE NOTES

INTERNAL ORGANISATIONS

Global

Intergovernmental Panel on Climate Change	www.ipcc.ch/	
International Council for Local Environmental Initiatives (ICLEI)	www.iclei.org/ (Local Government for Sustainability)	
International Energy Agency	www.iea.org/	
International Institute for Sustainable Development	www.iisd.org/about/	
Organisation for Economic Co-operation and Development	www.oecd.org/environment/	
United Nations	Sustainable Development programme	http://sustainabledevelopment.un.org
	Environment Programme	www.unep.org
	Basel Convention, movements of hazardous wastes and disposal	www.basel.int/
	The Rotterdam Convention, prior informed consent (PIC) for the international trade of chemicals	www.pic.int/
	Stockholm Convention, persistent organic pollutants (POPs)	http://chm.pops.int/ TheConvention/ Overview/ tabid/3351/Default.aspx
	Framework Convention on Climate Change	http://unfccc.int/
	Global Compact Cities Programme	http://citiesprogramme.com/aboutus
World Bank	www.worldbank.org/ www.openknowledge.worldbank.org/handle/10986/17525	
World Business Council for Sustainable Development	www.wbcsd.org/home.aspx	
World Federation of Engineering Organisations	www.wfeo.org (see 'engineering and the environment')	
Further Information	WWF, *Living Planet Report 2014: Species and spaces, people and places* https://www.wwf.or.jp/activities/data/WWF_LPR_2014.pdf	

Europe

Environmental Protection Agency, Ireland	www.epa.ie/search/results.jsp
European Union	https://europa.eu/european-union/index_en
UK Government Sustainable Development in Government	http://sd.defra.gov.uk/ https://www.gov.uk/government/policies/sustainable-development
UK WRAP (Waste and Resources Action Program)	www.wrap.org.uk/
Zero Waste Scotland	http://www.zerowastescotland.org.uk

Americas

Environment Canada	www.ec.gc.ca/?lang=En
Environmental Protection Agency, USA	www.epa.gov/ www2.epa.gov/science-and-technology/sustainable-practices-science

NATIONAL AUTHORITIES AND AGENCIES

ARRB Group (Australia Road Research Board)	www.ipcc.ch/
Australian Building Codes Board	www.abcb.gov.au/
Australian Government	www.gold.gov.au/ (links to other government and semi-government agencies)
Australian Government	http://www.australia.gov.au/information-and-services/environment
Australian Government—Department of the Environment National Waste Policy	www.environment.gov.au Publications page which can be searched by environment topic: www.environment.gov.au/protection/publications www.environment.gov.au/protection/national-waste-policy waste-policy
Australian Government—Department of Industry	https://industry.gov.au/Search/results.aspx?k=ALL(energy)%20(scope%3A%22Industry%22)
Australian Packaging Covenant	www.packagingcovenant.org.au/
Bureau of Meteorology	www.bom.gov.au/climate/change/
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	www.csiro.au/
Green Power—Accredited Renewable Energy	www.greenpower.gov.au/
National Australian Built Environment Rating System—NABERS	www.nabers.gov.au

National Environment Protection Council	www.scew.gov.au/about-us/nepc
National Pollutant Inventory	www.npi.gov.au
National Transport Commission	www.ntc.gov.au
Your Home: Australia's guide to environmentally sustainable homes	www.yourhome.gov.au
Asset Management Council of Australia	www.amcouncil.com.au/
Australian Council of Recycling	www.acor.org.au/
Australian Contaminated Land Consultants Association	www.aclca.org.au/
Australian Institute for Sustainable Communities	www.canberra.edu.au/research/faculty-research-centres/aisc
Australian Institute of Architects	www.architecture.com.au/ www.environmentdesignguide.com.au/
Australian Institute of Refrigeration, Air conditioning and Heating	www.airah.org.au/
Australian Sustainable Built Environment Council	www.asbec.asn.au/ http://urbandesign.org.au/
Australian Water Association	www.awa.asn.au/
Beyond Zero Emissions	http://bze.org.au/
Cement Concrete and Aggregates Australia	http://www.architectureanddesign.com.au/search?q=sustainability
Cement Industry Federation	www.cement.org.au/
Clean Air Society of Australia and New Zealand	https://www.casanz.org.au
Consult Australia (industry association for consulting companies in the built environment sector)	www.consultaustralia.com.au/ www.thebusinessofsustainability.com.au/
Energy Efficiency Council	www.eec.org.au/
Engineers Australia	www.engineersaustralia.org.au/
Environment Institute of Australia and New	www.eianz.org/
Facilities Management Association of Australia	https://www.fma.com.au
Green Building Council—Green Star Program	http://new.gbca.org.au
Infrastructure Sustainability Council of Australia (previously Australian Green Infrastructure Council)	www.isca.org.au/
Institute of Public Works Engineering Australia	www.ipwea.org/Sustainability/Home
National Centre for Groundwater Research and Training	www.groundwater.com.au/
Planning Institute of Australia	www.planning.org.au
The Property Council of Australia	www.propertyoz.com.au
Urban Development Institute of Australia	www.udia.com.au/about-udia
Waste Management Association of Australia	www.wmaa.asn.au

STATE AUTHORITIES AND AGENCIES

Australian Capital Territory

Climate Change Council	http://www.environment.act.gov.au/cc/climate_change_council
Environment and Planning Directorate	www.environment.act.gov.au www.actpla.act.gov.au/
Environment Protection Authority	www.environment.act.gov.au/environment/ environment_ protection_authority

New South Wales

Climate change	http://climatechange.environment.nsw.gov.au
Environment Protection Agency	www.epa.nsw.gov.au
Office of Environment and Heritage	www.environment.nsw.gov.au/sustainability/index.html
Roads and Maritime Services	www.rms.nsw.gov.au/

Northern Territory

Department of Lands, Planning and the Environment	www.dlp.nt.gov.au/
Department of Primary Industry and Fisheries	www.nt.gov.au/d/index.cfm?header=Climate%20 Change
Environment Protection Authority	www.ntepa.nt.gov.au/

Queensland

Climate Change	www.qld.gov.au/environment/climate/climate- change/
Department of Environment and Heritage Protection	www.ehp.qld.gov.au
Environmental licences and permits	www.business.qld.gov.au/business/running/ environment/licences-permits

South Australia

Department of Environment, Water and Natural Resources	www.environment.sa.gov.au/Home
Environment Protection Authority	www.epa.sa.gov.au/
Zero Waste SA	www.zerowaste.sa.gov.au/

Tasmania

Department of Primary Industries, Parks, Water and Environment	http://dpipwe.tas.gov.au/
Environment Protection Authority Tasmania	www.epa.tas.gov.au
Rethink Waste Tasmania	http://rethinkwaste.com.au/about
Tasmanian Climate Change Office	www.climatechange.tas.gov.au/

Victoria

Climate change	www.climatechange.vic.gov.au
Department of Environment, Land, Water and Planning	www.depi.vic.gov.au/
Environment Protection Authority Victoria	www.epa.vic.gov.au
Sustainability Victoria	www.sustainability.vic.gov.au
VicRoads	www.vicroads.vic.gov.au/Home https://www.vicroads.vic.gov.au/planning-and-projects/environment

Western Australia

Department of Environment Regulation	www.der.wa.gov.au/
Environmental Protection Authority	www.epa.wa.gov.au/
WA Waste Authority	www.wasteauthority.wa.gov.au/

RELEVANT STANDARDS

Standard Number	Title
AS/NZ4360	Risk Management
BS8903: 2010	Principles and Framework for Procuring Sustainably
ISO9000	Quality Management
ISO14001: 1996	Environmental Management Systems: Specification with Guidance for Use
ISO14004: 1996	Environmental Management Systems: Guideline on principles, Systems and Supporting Techniques
ISO14020: 2000	Environmental labels and declarations: General principles
ISO14031: 1999	Environmental management: Environmental performance evaluation
ISO14044: 2006	Environmental Management—Life Cycle Assessment Principles and Guidelines
ISO1996:1982	Acoustics: Description and measurement of environmental noise, Part 1: Basic quantities and procedures Part 2: Acquisition of data pertinent to land use Part 3: Application to noise limits
ISO Guide 64:1997	Guide for the inclusion of environmental aspects in product standards
ISO15686:2000	Buildings and constructed assets: Service life planning, Part 1: General principles Part 3: Performance audits and reviews Part 5: Service life prediction methods
ISO/TC 59/SC 3N	Sustainability in building construction – Terminology (4) – General principles (449) – Assessment of environmental impacts from buildings (467) – Environmental declaration of building products (468)
ISO31000	Risk Management—Principles and Guidelines
ISO50001:2001	Energy Management Systems
ISO55000	Asset Management

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