BDP ENVIRONMENT DESIGN GUIDE

AUGUST 2005 • GEN 68 • SUMMARY

CLIMATE CHANGE AND SUSTAINABILITY

Graeme I Pearman

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

• The climate of the world and Australia has changed and is anticipated to continue to do so through this century.

• Australia and its built environment will be impacted by changes to climatic conditions such as temperature, rainfall, wind

speed, sea-level and in particular by the frequency of extreme events of these conditions.

• Adaptation will be needed to cope with health, water supply and other consequences of climate change through improved

design and/or retrofitting of commercial, industrial and domestic buildings and related infrastructure.

• There will be further pressure on energy supply and the progress towards low carbon dioxide emissions in the energy sector

that will result in greater demand for energy efficiency, alternative energy resources, decentralised power, transport options

and behavioural adjustments that will reflect on the built environment.

• These impacts will be felt through pricing signals, government regulation and community development of a sustainability

ethos.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers

should at least consider the following:

• A risk analysis framework is necessary given that while some outcomes of emerging climate-change science and policy

might be highly probable, other aspects will remain uncertain for some time. Vulnerability can be reduced in terms of the

appropriateness/functionality of building design over reasonable lifetimes by attention to flexibility and adaptability.

• No one can predict exactly how quickly, or with how much impact, the climate change issue is going to unfold, both in terms

of changes to the climate itself or to the energy sector. There exists a substantial risk, however, that there is going to be a

transition, and vulnerabilities will exist for buildings with respect to their security and construction/operational costs unless

precaution is taken in the design and planning stage.

• Town planning and regulation is likely to grow in its demands for both energy and water-resource ef□ciencies.

• Passive design that maximises water and energy ef□ciency should be strategically included in building design.

• The growing ethos of sustainability will likely demand much higher standards in energy and water economy of buildings and

this will □ow through to market in□uences on the cost, maintenance and value of buildings.

Cutting EDGe Strategies

The emphasis of this paper is on the linkages between the building design sector and climate science and not on the technical

options per se. But there appears to be several features that are reiterated in other publications of this series (see below) and through

the greenhouse response strategy documents of the Commonwealth and State Governments. These include:

• Attention to passive reduction of building energy demand through development and building design.

• Exploitation of decentralised power (cogeneration) opportunities.

• Greater use of solar thermal and photovoltaic options where geographically appropriate.

• Greater use of smart devices that avoid intervention by, or provide information to, often ill-informed operators.

• Attention to the extreme-event limits of wind, sea-level, and temperature as de□ned by current guidelines, though these may

be invalidated by climate change.

• Leadership by the design industry in meeting the demands of climate change.

Synergies and References

• The climate change issue is inseparable from Australia's water resource and health issues, its current economic dependence on relatively cheap energy and the export of energy resources or products with high levels of embedded energy. Australia's

primary production strategies are likely to be in□uenced by changing water and climatic conditions.

- BDP Environment Design Guide: GEN 52, GEN 56, DES 27, NOT 9.

The BDP Environment Design Guide is published by The Royal Australian Institute of Architects

CLIMATE CHANGE AND SUSTAINABILITY

Graeme I Pearman

During the 20th century the earth warmed by about 0.6°C, primarily due to the accumulation of greenhouse gases in the atmosphere.

Consequent to this were changes to the characteristics of climatic patterns all over the earth that can be linked de nitely or suggestively

to changes in ecosystems, production systems and human activities. The prognosis is one of further climate change through this century

with impacts on all societal sectors as humans and natural ecosystems adjust to the changes or the consequences of global efforts to mitigate

excessive climate change. Climate change poses threats to economic sectors and enterprises relying on the status quo and thus resistant to

change, and opportunities to those constantly assessing risk and engaging in strategies to maintain adaptability and thus resilience.

Keywords

greenhouse, climate change, adaptation, litigation, sustainability, energy futures, risk assessment, resilience

1.0 INTRODUCTION

This paper presents a current view of the observations and science that underpins concern about the issue of climate change. It does so in an attempt to provide information in a way that links between that science and the needs and issues of the building sector. In that sense it is about better integration of knowledge from different sources in support of decisions and strategies that are more inclusive and likely to deliver sustainable futures. In no way does it purport to be composed by an expert in the needs and challenges of the building sector.

1.1 Climate change has occurred and will continue

The climate of the earth has always varied. Planetary positions, the orientation of the earth, solar emission, volcanic activity and asteroids are all understood to have impacted on climate over thousands to millions of years. Such changes have driven biological evolution, species extinctions, colonisations and natural selection. These mechanisms will lead to further climate change in the future. But the probability of them producing sustained and substantial climatic change this century is very low. In contrast, the rise of greenhouse gases in the atmosphere as a result of human activity (mainly carbon dioxide from the combustion of fossil fuels for energy) caused the planet to warm about 0.6°C during the last century. It is anticipated that warming will continue through this century with a further 2-5°C warming and concomitant changes to the climatic patterns of the world (see for example, Pearman and Hennessy, 2003).

1.2 Knowledge is incomplete

Exactly how much warming there will be is uncertain, first, because we do not know to what extent human intervention will slow the growth of emission of greenhouse gases into the atmosphere. Second, our understanding of the climate system means that we can only estimate the expected warming. Third, warming leads to regional changes due to a complex interaction between the atmosphere, the oceans and the biosphere, so that at any one location it is difficult to anticipate specific changes to the details of daily, monthly and inter-annual climate change. Thus, decisions need to be based on risk assessment that recognises the probability of change and accepts that as scientific understanding develops over coming years and decades we will need to further hone our response to climate change both adaptive (how we manage a changing climatic situation) and mitigative (how we work to minimise emissions).

1.3 Climate change and sustainability

Climate change is the first truly global test of societal resolve to build for a sustainable future. It displays all of the components of an issue requiring a new level of integrative assessment and policy development. It demands a fundamental rethink of the future supply and usage of energy and this has ramifications that are simultaneously economic, social and environmental (Pearman, 2005). The problems we are facing today have very significant implications for future generations.

1.4 Climate change and building

Through the next few decades, the building sector will, as usual, be exposed to constant challenges associated with the emergence of energy technologies, community and client expectation, regulation and population growth. Climate change is but a component of the changing operating environment of the sector, but it illustrates and presents some important strategic issues. On the one hand, climate change itself will bring about new environmental criteria of temperature, sea level, precipitation, winds, etc and especially with respect to extreme events for which the security and functionality of structures needs to present an acceptable risk. On the other hand, as Australia and the world population seeks lower exposure to the risk of climate change a revolution is anticipated in the way we deal with energy supply and demand. The consequence of this will be new demands for energy ef□ciency and sources of energy in both the construction and operation of buildings.

Finally, the emergence of an ethos of ‘sustainability’ is likely to result in community and governance demand for more balance of performance of the sector across environmental, economic and social drivers in meeting the challenges of adapting to change and to mitigation.

2.0 CLIMATE SCIENCE

The United Nations Framework Convention on Climate Change was adopted in 1992 amid growing concerns over the issue of climate change (http://unfccc.int/2860.php). Many nations, including Australia are signatories to that Convention. In order to set in place action to meet the challenges for which the Convention was established, to prevent ‘dangerous anthropogenic interference with the climate system’, the Kyoto Protocol to the Convention came into force with the signing of the Protocol by Russia earlier this year (http://en.wikipedia.org/wiki/Kyoto_Protocol).

Australia is not a signatory to the Protocol, but the Australian Government accepts the findings of the Intergovernmental Panel on Climate Change (see below) and the importance of the climate change issue.

The Federal and State Governments of all Australian jurisdictions have greenhouse strategies or statements in place (e.g. for Queensland, www.epa.qld.gov.au/publications?id=1246), and the NSW, South Australian and Victorian Premiers have commissioned a report on the ratification of the Kyoto Protocol (www.cabinet.nsw.gov.au/pdfs/kyoto.pdf). Discussions are taking place between all State Governments concerning a combined state approach to the issue. It is too early to say where this will lead, how long the Federal Government will hold to its current position, or indeed, if the Protocol mechanism will be succeeded by other mechanisms. It seems certain, however, that legislative action is likely to intensify over coming years and this will lead to potential threats and opportunities for all sectors. The former NSW Premier, Bob Carr, has been particularly active in the climate change issue working with British Prime Minister Tony Blair and others (Blair, 2005). NSW has implemented a Greenhouse Gas Abatement Scheme that commenced on 1 January 2003 which imposes mandatory greenhouse gas benchmarks, on all NSW electricity retailers and certain other parties and the Premier has outlined an ambitious plan to cut the state's emissions by 60 per cent by 2050.

2.1 The Intergovernmental Panel on Climate Change

Recognising that the underpinning science of climate change was still developing, in 1988 the World Meteorological Organisation and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (www.ipcc.ch/index.htm), to bring together scientists (several thousand) from around the world to periodically prepare assessments of the progress of this science. The first assessment of the IPCC was used in discussions leading to the adoption of the United Nations Framework Convention on Climate Change. The purpose is to underpin the international policy activities with the most current and considered knowledge (IPCC, 2001e). These assessments (1990, 1996, 2001; see IPCC, 2001a-d) have also influenced national and regional responses to the issue both governmental and in the private sector. This is likely to continue with the release of the Fourth Assessment

Report in the next two years.

2.2 Key findings of the IPCC Third Assessment Report

The findings of the most recent Third Assessment Report were extensive. I will focus here on just six key findings from the underpinning science (www.ipcc.ch/pub/spm22-01.pdf).

The planet has warmed

In 1985 (WMO, 1986), scientists predicted that given the natural year-to-year variability of climate it would take until about the year 2000 before the general warming from greenhouse gases would appear as a clear signal above that noise. This is what happened. In the 1996 IPCC Second Assessment Report, the question whether global warming had been detected was answered equivocally. But not so in the 2001 Third Assessment Report. The fact that the surface of the planet was seen to have warmed was supported by improved meteorological data, deep ocean measurements, and indicative observations of de-glaciation and vertical changes of temperature through the depth of the atmosphere.

Greenhouse gases continue to increase in the atmosphere

With the exception of methane and some of the chlorofluorocarbons, other greenhouse gases, including the most important, carbon dioxide, have continued to increase in concentration in the atmosphere. This simply reinforces the fact that the cause for concern (these gases affect the energy budget of the planet) has not gone away. Detailed analysis of the rates of accumulation, global spatial and temporal distributions and isotopic composition of the gases form the basis for concluding that these concentration changes are indeed anthropogenically caused.

Models of the climate system are better

There is no way to make meaningful experiments to show how the climate of the earth will change with the addition of greenhouse gases to its atmosphere. We can only be guided by the considerations of computer models of the climate system that represent through equations, all we know about the system, the physics, chemistry, biology and dynamics, in as much detail as possible. We can then solve these equations in super computers to see what the most likely outcomes are from hypothesised changes to atmospheric composition. It is similar to putting a man on the moon and bringing him back. We have to have con□dence that all of the key components are modelled. That con□dence is now signi□cantly greater than ever before based on the capacity of the models to represent in some detail the characteristics of the current climate.

Most of the warming this last century is due to greenhouse gases

Utilising these models, scientists have investigated all of the known possible causes of climate changes through this last century: volcanic activity, variations in energy output of the sun, planetary position and internal dynamics of the atmosphere – ocean system. The conclusion has been reached that most of the changes in

temperature of the last century were caused by changes in greenhouse gases in the atmosphere. This is a most important conclusion, directly linking the climate change to carbon dioxide (primarily) and thus to anthropogenic use of energy resources.

Concentrations will continue to increase through the 21st century

Several factors lead to the conclusion that carbon dioxide concentrations in the atmosphere will continue to increase through much of this century. These include the fact that carbon dioxide has a long effective lifetime in the atmosphere (its concentration would not signi□cantly decrease in the near future, unless emissions were to be drastically reduced). Second, the inertia of the climate system itself means that we can expect further warming from existing levels of carbon dioxide as the warming of the oceans slowly catches up to the change in the atmospheric energy budget. Third, it is likely that human use of fossil fuels will continue to grow, or at least not reduce signi□cantly in the near term.

The planet will warm through the 21st century

This leads to the conclusion that the earth will warm further before human activities can arrest further change.

2.3 Changes in Australia

In Australia we have seen an average warming of about the same as that observed globally and concomitant changes to other aspects of the climate (see for example, Hennessy et al, 1999; Manton et al, 2001; Nicholls, 2003, 2004). This has been manifest in an increase of the frequency of extreme events of high temperature and a decrease in the frequency of lower temperatures and more extreme storminess. The reader may access climatic trend data directly from the Australian Bureau of Meteorology web site (www.bom.gov.au/cgi-bin/silo/reg/cli_chg/trendmap.cgi) where it is possible to produce graphs of temperature and precipitation changes over selected periods for specific parts of the country.

The attribution of changes to the details of the climate system and to subsequent impacts on biological and human systems and behaviour to the influence of planetary and Australian warming is sometimes clear and other times obscure. This is first, because the physical connections between warming and outcomes may be more or less direct and for changes such as rainfall, evaporation and soil moisture these connections are complex. Second, some consequences of general warming are unlikely to be influenced by other factors, whereas for others these additional influences will be significant. For example, changing characteristics of regionally-based agricultural, industry or natural ecological systems may well reflect human intervention through changed land-use practices, or through other emissions such as air pollutants. Thus a spectrum of cause and effect will always exist where at one end we can have significant confidence that change is being driven by greenhouse gases and at the other extreme, where confidence is lower because other factors may influence system behaviour. Third, the climate system is variable so the detection of trends can be difficult until significant change has already occurred. This is particularly so for more local assessment of change.

The science reported by the Intergovernmental Panel on Climate Change suggests that global increases of sea level over the past century (about 15-20 cm) were probably mainly due to warming of the oceans and thermal expansion of the water. Studies of sea-level rise around Australia show that we have seen similar rises (Church et al, 2004, personal communication). The study shows how this has impacted on the frequency of extreme high levels of the sea observed at the two longest recording stations (Sydney and Fremantle); the occurrence of such extreme events in the second half of the last century was two to three times more often than before 1950. This illustrates two things. First, the global changes have manifested in changes in the frequency of extreme sea-level occurrences in Australia. Second, by and large, such changes have gone unnoticed as they occurred over a long period of time when other factors were undoubtedly impacting on those ports. In a sense, we were adapting to change in the course of normal development, without knowing it.

Projection of rainfall at a regional level is one of the more difficult, albeit important, challenges for climate scientists. This is particularly true in Australia where low rainfall is already a serious limitation on human occupation and agriculture. Observations show that within the large year-to-year and decade-to-decade variability particularly in Australia, rainfall across the southern and eastern parts of the country has decreased in the past century. Through the central part of Australia and the northwest, it has increased. Annual changes in both cases are between about 10 and 30 per cent. There is also clear evidence that the frequency of more extreme rainfall events has increased. The insurance industry is aware that many factors contribute to the increase of climate-related insurance claims they have experienced, but in general they are convinced that climate change (more extreme events) has been part of the explanation (see for example www.munichre.com/publications/302-04321_en.pdf).

There remains significant uncertainty concerning what has happened to evaporation. Simplistic arguments would suggest that evaporation should have increased; at least until the depletion of soil moisture limited further evaporation. Clearly soil moisture conditions are absolutely fundamental to the impact on natural and agricultural ecosystems. However, observations of evaporation from small open surfaces of water (pan evaporation) suggest that this may have decreased over the last century. This finding remains a challenge to the scientists. Are the basic data good enough for this kind of analysis? Does pan evaporation provide any real insight as to what happens to evapo-transpiration in a real ecosystem?

With respect to changes to ecosystems and human systems, impacts by the climate, then, as suggested above, it is often less clear as to cause and effect. Pittock (2003) has analysed the evidence for impacts at this level and shows suggestive, if not conclusive, evidence of

increase in woody biomass, five to ten per cent increased forest coverage and expansion of tidal creek systems in the Northern Territory, expansion of rainforest in Queensland, eucalypt die-back in Tasmania, range and breeding habit changes for animals and plants, increased frequency of coral bleaching, etc. The attribution process here is often complex but with strong implications of temperature/rainfall and sea-level impacts related to the changing climate.

2.4 Projection of changes globally and in Australia

While the science underpinning estimates of general planetary warming is robust, translating this into regional or local changes is more demanding and thus less definitive. Scientists use higher resolution (spatially) models of the climate system, or statistical downscaling techniques to relate courser-scale climate statistics from the global models to those of specific local areas. These underpin assessments of potential local impacts. It is likely that projections of temperature are more robust at this regional scale than rainfall, and general sea-level rise, more so than storm surges. It has already been suggested that we still have significant debate over the impact of warming on evaporation rates and thus something as important as soil moisture levels. This relates to the complexity of the processes that connect these events to the fundamental changes to the planetary energy budget. But, in any case, all projections can only be as good as our understanding of what humans will do in terms of greenhouse-gas emissions through the coming decades, and this is perhaps our greatest uncertainty.

Because of these dif culties, climate scientists speak about climate projections or in some cases, scenarios, rather than predictions. This emphasises that what is being projected are plausible futures, given a series of uncertainties about emissions, climate science and human reactions. Over the past decade or so, CSIRO scientists have periodically released projections for Australia that use a number of international climate models and wide range of future emission scenarios to describe the broad range of potential futures as a guide for policy development (Whetton, 2001).

Readers are encouraged to examine these scenarios. But in broad they de ne Australia's future by 2030 as likely to be as follows (from Pearman et al, 2003):

- warming of 0.4-2.0°C
- 10-50 per cent increase in days over 35°C
- 10-80 per cent decrease in days below 0°C
- up to 15 per cent less rainfall year-round in the south-east and in spring in Queensland
- up to 20 per cent less rainfall year-round in the south-west
- up to 15 per cent more summer rainfall on the east coast
- up to 15 per cent more autumn rainfall inland
- heavier rainfall where average rainfall increases, or decreases slightly
- stronger tropical cyclones, but uncertain changes in frequency and location.

3.0 ADAPTATION TO CLIMATE

CHANGE

The Commonwealth and State governments are major players, through local governments, in setting and enforcing building standards. The author is not an expert in these procedures, but it is clear that all jurisdictions are recognising the role of building regulations in the delivery of ‘greenhouse’ outcomes. Strategically, attention needs to be given both to existing regulation and the ‘greenhouse’ strategies of each jurisdiction.

3.1 Warming

Small levels of warming may be regarded by some as desirable; fewer of those cold nights and perhaps frosts. Indeed there are potential positives about such changes. However, small shifts in mean temperature bring about significant changes in the frequency of extreme warm days (or runs of warm days) and reductions to cold days to which natural ecosystems and humans may be less well adapted.

From a building perspective, it is these extreme events that lead to changing demands for energy for cooling or heating, or in a ‘carbon constrained’ world, greater demands for energy-use efficiency in the delivery of the amenity for occupants of the buildings. Thus the prognosis is that more and more, building regulations and community acceptance will seek to maintain that amenity through more clever and efficient building design, retrofit and technology options. Such a trend will be enhanced with the rising cost of energy likely as the environmental costs of the use of energy become more and more internalised (see Sections 4.2, 4.3). This will drive incentives to seek energy from a wider range of options, more attention to building orientation, passive cooling and ventilation in design (see for example www.cfc.acif.com.au/News-Detail.asp?NewsID=72 and www.greenhouse.gov.au/buildings/index.html), decentralised generation of electricity such as built-in power generation from gas combustion, and passive, thermal and photovoltaic solar sources.

Of course, these changes relate both to comfort as well as to health. Exposure to extreme temperature itself is a component of the risk of incurring health problems especially for the young and the elderly.

3.2 Winds

The impact of wind speed is quite non-linear because the kinetic energy of the wind rises as the square of the speed. Existing statistics from the insurance industry show clearly that effectively, thresholds exist above which existing building technologies and codes fail to deliver security of structures (see for example www.iag.com.au/pub/iag/sustainability/publications/climate/global_warming.shtml). The projection in the models is that wind speeds will rise around more intense low pressure systems, and thus represent a risk to existing structures and a challenge for new building projects. Of course, the season in which these effects will take place may shift with changing seasonality, and so too may the general expectation of wind direction for particular seasons. We can provide little advice about these regional changes and how to respond, other than through the precautionary

B D P E N V I R O N M E N T D E S I G N G U I D E

principle and through adaptive responses that minimise vulnerability through such practice.

3.3 Rainfall

Rainfall in Australia is highly variable from year-to-year, and we experience across the country a range of rainfall regimes, westerly frontal, cyclonic, tropical monsoon, northwest cloud bands, southeast trades, east coast lows, etc. Each system is impacted to some extent by the El Nino phenomenon and all are impacted by global warming. This brings about shifts to the seasons, the exact timing of rainfall periods, the absolute amount of rain delivered and the intensity of events in which the rain occurs.

Modelling suggests that the general loss of winter rainfall across the southern and eastern parts of the country and the increase in the northwest, that have been observed, are roughly the kinds of ongoing trends that we can expect for the future from our current understanding. These shifts to the temporal and spatial patterns of rainfall have implications for the survival of ecosystems, the runoff in rivers and subsequent silting and storage, the ef□ciency of water use and the transport and provision of water to urban environments. We are already seeing con□ict between the urban and rural use of water, between that required for natural ecosystems and for agriculture, and pressure on how water is managed. The implications for the built environment are many, to some extent irrespective of climate change,

but exacerbated by it. It is likely that the future will require re-plumbing of urban infrastructure for the more efficient use and recycling of water. This has implications for sewage, storm water, appliances, home water catchment, etc, with the likelihood that these changes in attitudes towards water conservation be reflected in new buildings and even into refurbishment programs.
Because of Australia's general shortage of water, this, together with the demand for energy efficiency, will be the major driver of reform and adaptation in the built environment sector.
There is extensive literature on water sensitive urban design that covers aspects such as reducing water demand, rainwater harvesting, on-site wastewater reuse, waterless toilets, storm water management, outdoor water use and water case studies (see for example http://www.greenhouse.gov.au/yourhome/technical/fs20.htm and EDG note DES 27).

3.4 Sea level

We have already seen that sea level has risen around the Australian coast line, and more increase is anticipated through this century; perhaps, on average around 40 cm. There is little doubt that this rise threatens a potential inundation of some low lying areas with consequent impacts on the built and natural environments of estuaries and particular sandy coastlines. In some cases this will lead to salt water intrusion of freshwater supplies and impact on structures affected by high levels of salt in water. In some cases, this may be exacerbated by land subsidence that is resulting from pumping of underground water and lowering of water tables.

But, as with changes of temperature and winds, the impacts related to buildings are more likely to be affected, as they are with natural climate variability, through the changed frequency of extreme events. Most damage on the coast line relates to distinct and extreme events that result from the coincidence of high sea levels (tidal conditions and mean level), low atmospheric pressure where the sea level rises up under conditions of low atmospheric pressure, like a barometer, and high winds in a particular direction that lead to water being driven on shore. The real risk of changes to these events relates to the fact that while the expectation is that sea levels will be higher, the climate models suggest that low pressure systems will become more intense and thus characterised by lower central pressure and higher winds. Here is the potential for quite disproportionate responses to the general warming.

From a building perspective, some codes of practice already incorporate anticipated sea-level rise and thus guidelines for assessing building requirements for docks, marinas, canals, housing and other developments. It remains uncertain if these will be sufficient to handle these non-linear changes. The most likely prognosis is a changing regulatory regime.

4.0 MITIGATIVE ACTION: AN ENERGY SECTOR REVOLUTION

Having assessed potential risk and vulnerability from climate change the management options are to adapt or to attempt to mitigate the problem, i.e. by reducing emissions. This section summarises the difficulty of mitigation and raises some of the options and how these may impact on the building sector.

4.1 The dilemma of energy demand and climate change

In order to assess the impact of climate change on the curtailment of carbon dioxide emissions into the future, we need to consider three steps. First, it is necessary to determine what level of global temperature increase represents an acceptable risk. Second, with the help of climate models, we can estimate the change in atmospheric carbon dioxide that should not be exceeded to ensure that we meet this target of acceptable climate change. Third, we could then devise strategies for delivering future emission scenarios that ensure this future atmospheric concentration is not exceeded. Each of these steps is difficult and remains uncertain, but some general views are emerging.

The first step is the most difficult because determining how much change in climate is an acceptable risk involves understanding how global-mean changes translate into regional climate changes and subsequent impacts, and, as already mentioned, this science is still rudimentary. Further, even if this was well established, and specific regional risks were well evaluated, then we would need to decide how to weigh risks for specific peoples/countries, related to specific outcomes (economic, social, and environmental) for today or

some time in the future. These are difficult questions that require consideration within the framework of Sustainability.

It is true, however, that despite the state of the science, there is an emerging view, particularly in Europe (EU 2004; Blair et al, 2005), that an acceptable risk would be incurred up until the planet warms on average by about 2°C (some would say lower and some higher). This temperature change translates into a concentration stabilisation in the future of no more than about double pre-industrial levels. Then, because of the quite long lifetime of carbon dioxide in the atmosphere, this concentration target translates into reductions of global carbon dioxide emissions this century of around 80 per cent. It is not important that these estimates are only very rough targets, but that the reduction of emission is so large. These have led to calls for emission reduction targets by the developed world of around 60 per cent through the middle of this century. It should be stressed that this view of what is an acceptable risk/change remains extremely tentative and undoubtedly will be revisited as both the science and the socio-political factors that underpin the number are revisited through the next few years. In this sense, it represents a risk in that there is as much likelihood that the target temperature will turn out to be lower than 2°C as it is that it will be higher. What is most likely true is that it will be close to this number.

An assessment of Australian future energy needs (www.dpmc.gov.au/publications/energy_future/index.htm) made last year suggests that we will have a growth of energy demand of 2.1per cent per year through this and the next decade. Similar analyses of most countries identify growth in energy demand, in some parts of the developing world, at over 10 per cent per annum. The anticipation is that much of this demand over this time period will need to be achieved through further combustion of fossil fuels, coal, oil and gas, and thus implies an ongoing increase in the emissions of carbon dioxide into the atmosphere. Indeed, attempts to estimate global demand over the next 80 years suggest that emissions would increase by a factor of 10 if there were no improvement of energy technologies. So here is the climate change dilemma. On the one hand economic growth appears to be demanding significant increases in emissions through much of this century, while the climate change issue is demanding very significant reductions.

4.2 Setting of emission targets

Of course, no one really expects technologies that are used to deliver or consume energy to remain unchanged. Indeed, normal economic forces will drive significant improvement/change as will changing levels of energy resource availability (e.g. oil). Thus, through improved end-use efficiency (domestic, commercial and industrial), new combustion technologies, the growth of renewable energy sources (solar, wind, geothermal), the decentralisation of energy generation, improved nuclear technologies, changes to the mix of energy sources to less carbon intensive options, new automotive technologies, carbon sequestration by vegetation and under the ground, etc, significant opportunities exist to improve this efficiency. However, there has yet to be developed a clear portfolio of energy technology options that translate into emission reductions of the magnitude demanded by the climate change issue. Thus the anticipation is that there will need to be strong governmental intervention through incentives and legislation to stimulate these changes. These will be resisted in some quarters, where continuation of past practices in energy production and use will be preferred; whilst in many other areas, the opportunities for new businesses, innovation and wealth generation will drive change.

Key technologies relevant to the building sector include building/development orientation and passive cooling, improved insulation, smart control of heating and air-conditioning cycles, thermal hot-water and photovoltaic collectors, distributed power generation, consumer feedback on energy consequences of actions and education on options.

4.3 Carbon accounting/training

market imperfections

The degree to which existing market forces will drive society towards reduced emissions is debatable. Most commentators believe that the magnitude of the challenge is such that it will not be achieved without governmental intervention in the setting of efficiency standards (buildings, appliances, motor vehicles, etc) or through government incentives that strongly encourage the revolution that is needed to reduce carbon dioxide emissions. Many are convinced that the setting of emission targets is an essential component of providing a strategic goal and operating environment for current investment in energy generation, distribution and usage, and that to encourage market forces to seek out the most cost effective solutions, a form of carbon trading will be necessary. Here, the government would set targets of emissions year-by-year over the coming decades that reflect a target for overall reduction. They would then allocate rights to current emitters to emit a component of that overall target. Companies/individuals who receive such allocations can find reduction methodologies appropriate for their own needs and then trade any unwanted rights to those in the community that need more rights than allocated. They can trade these rights for money. As the scheme develops the pressure on the overall reduction will increase as will the value of the tradable rights. The net result is that in the future, the emission of carbon dioxide into the atmosphere will have an ascribed economic value (similar to an internalised cost of climate change) and this will be a major driver for efficiency in the building and other sectors. The European Union commenced a carbon trading scheme in January this year (see for example www.frazerlindstrom.co.nz/CarbonMarkets.htm). On 4 May this year (2005) the New Zealand Government released a consultation document 'Implementing the carbon tax' (www.taxpolicy.ird.govt.nz/publications/files/html/carbontax/index.html). The implications of these changes are not entirely clear at this point, but it is likely they will impact

on the price of energy and drive innovation in energy efficiency in all sectors.

4.4 Regulation, partnerships

Further, current assessment of buildings (industrial, commercial and domestic) often finds that investment in retrofitted energy efficiency can have a payback time of one to two years; a very good investment in anyone's language. Yet that investment is not made. This is primarily because for many reasons the market does not work particularly well in these situations. These reasons include the fact that the incentive for developers to install energy efficient plant or make buildings energy efficient is low given that they will, by and large, never be the ones who pay the energy bills. Similarly in many institutions, the people who use and operate the facilities within a building are often not the ones who pay the bills. Further, effective market operation assumes that there is sufficient intelligence available for occupants to make informed decisions. This is rarely the case given that few people usually know which are the most energy consuming switches to turn off or on, and few know what the technological options are when it comes time to replace alliances/components of a building.

It is anticipated that these 'market' barriers will be overcome in part through regulation, in part through the costs of carbon/energy driving greater awareness and incentive, and in part through better education of building users as to what really consumes energy, its economic value and environmental consequences, and what options they have to minimise energy usage. These requirements may follow through to greater demands for thermal insulation of buildings, consideration of building orientation, installing of energy-competitive equipment, demands for the declaration of energy efficiency of buildings, account of and attention to building performance in this regard, inbuilt monitoring of energy use and direct feedback of information to occupations, etc. See for example, www.greenhouse.gov.au/yourhome/consumer/cg4.htm and www.greenhouse.gov.au/yourhome/technical/index.htm.

Finally, it is also anticipated that a growing commitment to sustainability, through processes such as triple bottom line reporting, or concern over ‘licence to operate’ in a world of changing attitudes towards the issue of sustainability, will drive building companies and developers towards considering their responsibilities to these issues.

5.0 SUSTAINABILITY

In recent years there has been growing attention given to the concept of sustainability. This means different things to different people, not surprising, given the early stage of development of the idea, opportunities and methodologies and the lack of a formal disciplinary structure that underpins education around the subject. In fact this diversity can be viewed as a strength - the more ideas flowing into the concept at this stage the better. There is a down side however, as we find that some people use the term sustainability to mean more of the same - this might be from the ‘green’ extreme-considering everything unchanged in the future, or from the ‘brown’ extreme - let our businesses continue to do what we have been doing forever. Neither represents a significant change from the old paradigm of the existence of two opposing and incompatible views of the world that operate in constant conflict.

5.1 The ethos of sustainability

There is evidence of a growing awareness that sustainability should be a new phase in human societal evolution. The beginnings of this ethos underpins commitment, as it stands, to management practices that include triple bottom line accounting and with the reservations expressed above, the reference often to sustainability as a laudable goal.

Emerging views of sustainability revolve more around the following key components:

- Seeking to simultaneously maximise opportunities for all avenues of human development: economic, social environmental and inter-generational.
- Assessment of options integrating across these components of development and making decisions that overtly recognise the tradeoffs.
- Being strategic in perspective; having a view of where we wish to go in terms of human development and setting a course to get there. This is the fundamental change in social evolution that ‘sustainability’ represents.
- Recognising that the vision of where we wish to go and the strategies to get there will be developed as knowledge improves. Thus there is a need for constant reflection on these directions and the maintenance of flexibility and adaptive capacity to

change mid course.

While there currently exists signi cant confusion as to what actually constitutes a sustainable future, or the relationship between sustainability, sustainable economic development and sustainable environmental development, this ethos is likely to grow with a degree of conformity developing around the concept and de nitions of the process as time passes. At the moment, community participation in this development is weak. But there is a signi cant likelihood that this ethos will grow in the general public through formal and public education and provide a signi cant impetus for 'sustainable' actions in the future. The building sector, like others, will be caught up in these changes.

5.2 Achieving multiple goals

But achieving multiple goals for human development is mainly beyond current ways in which reality is assessed by science (reductionism and disciplinary-based) and how this and other information is integrated into policy decisions. Barriers to success include the disciplinary structure so science and governance (both elected and company), the dominance of vested and short-term interests, the dominance of economic considerations in terms of human development objectives, etc.

5.3 Risk assessment

A component of any sustainability strategy is the lack of clarity as to what the future will bring. No climate model, for example can predict the future with clarity especially at the regional scale. Equally, no economic model reflects such complete understanding of the factors that really drive economic futures to be better than a broad indicator of potential futures. Thus, a fundamental component of sustainability is risk management – the identification of risk, the assessments of their probability of occurrence and magnitude of impact and the ability of societies or companies to adapt (Allen, 2005). Beyond that lies the risk of vulnerability. This is not to say that models have no role to play in risk setting. To the contrary, they are the way we take the very best current knowledge to assess risk and devise strategies to minimise that risk. But what it does say is that the level of uncertainty demands prudence and thus the incorporation of redundancy and flexibility (adaptability) into the management of risks. We need to be constantly, in view of new knowledge, revisiting the strategy and fine-tuning the directions.

5.4 Sustainability science, sustainability policy

A component therefore of our quest for sustainability is underpinning knowledge that is cross-disciplinary and integrative. This is a challenge for the science community (science here is meant to designate natural and social sciences, humanities, economic and technological science

– having in common the principles of rigour, rational argument and peer review, in particular).

6.0 CONCLUSIONS

The underpinning science of climate change tells us that the climate has begun to change and that this change will continue through the coming decades. It tells us that these changes, superimposed on natural year-to-year and decadal variations, can not easily be arrested. We have built in some future change, as the climate system continues to respond to existing changes to greenhouse gases in the atmosphere, and, given the difficulty of arresting the rise of these gases in the atmosphere, more change is likely.

We have two options that are not mutually exclusive. One is to mitigate against the levels of emission of these gases in the atmosphere through what can only be regarded as a revolutionary intervention into the existing energy cycle of our economies. Second, we need to prepare for change and to adapt to that change, minimising the impacts and maximising where possible the gains that can be made through pre-empting that change.

There are serious uncertainties existing in our current understanding that, rather than suggesting we delay actions, strongly suggest that we build into our polices, adaptability that allows future modification to our development pathways that themselves are not onerous. These uncertainties are of particular importance, because the magnitude of globally average warming that constitutes significant change to the planetary climate and the biological and human systems dependent on them is quite small. We are committed to a significant part of these changes irrespective of how quickly we can tackle the task of reducing emissions.

Climate change means quite massive changes to the way amenity from energy will be delivered in the future; more efficient delivery of amenity with lesser energy intensity, new ways of providing the energy in the first place, and human behavioural changes that are coupled to a changed energy system.

For the building sector the impact of climate change will occur through the direct effects of climate on the nature and facility of the buildings themselves being changed through new levels of environmental exposure to winds, precipitation, temperature and sea-level. But it will also be via increased pressure on the building sector to provide energy efficient buildings through new regulations and community expectations. Energy processing and competing energy sources will also open up opportunities in the building sector for inventive design.

Sustainability is about maximising performance with respect to all aspects of human development, and this is likely to underpin the response of communities and demand on the building sector as we progress through the coming decades.

GLOSSARY

Carbon accounting: The formal process of accounting for carbon emissions from human activities. It represents the first step in quantitatively identifying the source of carbon emissions and the opportunities to make emission reductions through cost effective strategies.

It also represents a prerequisite for the trading of emission rights, where those in the community who can use innovative approaches to reduce their emissions can trade their emission rights (their reward) to those who have greater difficulties. The government, in this regime would set total emission targets that prescribe an emission reduction target.

Climate models: Very complex computer models in which equations representing the physical processes of the global climate system (solar radiation absorption and interception, evaporation, cloud formation and precipitation and melting of ice, dynamical mixing of the oceans and atmosphere, surface inhomogeneities of elevation and roughness and reflectivity, etc) are solved simultaneously to produce a representation of the climate. The models are validated by comparison with the characteristics (daily seasonal and inter-annual variations of winds, temperature, humidity, rainfall, etc). Such models are the basis for determining the sensitivity of the climate system to future changes of carbon dioxide concentrations.

Earth's temperature: Used in this context to mean the globally averaged (overall latitude and longitudes and over a full year) temperature of the surface of the earth.

Ecosystems: Those assemblages of plants and animals that make up the biodiversity of a specific location.

Global warming: The globally averaged warming of the planet in response to the accumulation of greenhouse gases in the atmosphere. Other factors impact on global averaged temperatures from year-to-year, decade-to-decade, and on time scales of millennia to millions of years.

Greenhouse gases: These are gases in the atmosphere that are relatively transparent to solar radiation, but relatively opaque to thermal long wave radiation. They have the effect of keeping the surface of the earth about 30 ^{o}C warmer than it would otherwise be. The gases include water vapour, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. The longer-lived atmospheric gases, especially carbon dioxide have the effect of warming the surface of the earth and in turn changing the average level of water vapour (short lived responsive gas) and thus amplifying the warming effect.

IPCC: The Intergovernmental Panel on Climate Change. A mechanism established by the World Meteorological Organisation and the United Nations Environment Program to provide periodic assessments of the changing state of scientific knowledge concerning the climate change issue.

Sustainability: Has many meanings for different people. In the context of this paper, it is taken to mean, a new phase in human social evolution in which efforts are made to assess and weigh respective goals of social wellbeing, environmental resilience and economic performance for strategic use in policy formulation that underpins perceptions of desired human development.

REFERENCES

Allen, 2005, Climate change risk and vulnerability. Consultancy report to the Australian Greenhouse Office. The Allen Consulting Group, Melbourne. To be published.

Blair, A, and others, 2005, Meeting the Climate Challenge. International Climate Change Taskforce (including PM Tony Blair, Premier Bob Carr, Sen. Olympia Snowe, Hon. Timothy Worth, and others).

EU, 2004, European Council 2004, 25-26 March 2004, Doc 7631/04 (ANNEX), p 29; ACG 2004.

Hennessy, KJ, Suppiah, R and Page CM, 1999, Australian rainfall changes, 1910-1995, Aust Meteorol, Mag 48, 1-13.

IPCC (2001a). Climate Change 2001: The Scientific Basis. (Houghton, J, Ding, Y, Griggs, D, Noguer, M, van der Linden, P and Xiaosu, D, Editors). Contribution of the Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. World Meteorological Organisation and United Nations Environment Programme. Cambridge University Press, 944 pp.

IPCC (2001b). Climate Change 2001: Impacts, Adaptation and Vulnerability. (McCarthy, J, Canziani, O, Leary, N, Dokken, D and White, K, Editors). Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, World Meteorological Organisation and United Nations Environment Programme. Cambridge University Press, 1032pp.

IPCC, 2001c, Climate Change 2001: Mitigation. (Metz, B, Davidson, O, Swart, R and Pan, J, Editors). Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. World Meteorological Organisation and United Nations Environment Programme. Cambridge University Press, 700pp.

IPCC, 2001d, Climate Change 2001: The Scientific Basis. Summary for Policymakers. A report of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. World Meteorological Organisation, Geneva: United Nations Environment Programme, Nairobi. 98pp.

IPCC, 2002e, Climate Change 2001. Synthesis Report. Contributions of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. World Meteorological Organisation and United Nations Environment Programme, Cambridge University Press, 397pp.

Manton, MJ, Della-Marta, PW, Haylock, MR and others, 20012, Trends in extreme daily rainfall and temperature in southeast Asian and the South Pacific: 1961-1998. Intn. J. Climatol. 21, 269-284.

Nicholls, N, 2003, Continued anomalous warming in Australia. Geophys.Res. Letters 30, 1370.

Nicholls, N, 2004, The changing nature of Australian droughts. Climatic Change, 63, 323-336.

Pearman, GI, 2005, Climate Change. Chapter 2 (p 92-108) in Search of Sustainability. Goldie, J, Douglas, R. and Furnass, B. (Edts). CSIRO Publishing, Melbourne, 187pp.

Pearman, GI, and Hennessy, KJ, 2003, Climate science: what do we know? In: Living with climate change: a national conference on climate change impacts and adaptation: proceedings, Australian Academy of Sciences. Canberra: National Academies Forum. p. 3-31. Available from the Australian Greenhouse Office, or the Australian Academy of Science web sites or at (http://www.dar.csiro.au/publications/pearman_2003a.pdf).

Pearman, GI, Hennessy, KJ, Jones, RN, and Maheepala, S, 2003, Climate change and its projected effects. In: Water - the Australian dilemma. Parkville, Vic.: Australian Academy of Technological Sciences. 34-36.

Pittock, AB, Editor, 2003, Climate Change: An Australian Guide to the Science and Potential Impacts. Australian Greenhouse Office, Canberra. 239pp.

Whetton, P, 2001, Climate change projections for Australia. CSIRO Atmospheric Research, 8-page brochure. http://www.dar.csiro.au/publications/projections2001.pdf

WMO, 1986, The role of carbon dioxide and other 'greenhouse' gases in climatic variation and associated impacts. Conference Statement from the Second Joint UNEP/WMO/ICSU International Conference on the Assessment of the Role of Carbon Dioxide and other Greenhouse Gases in Climate Variations and Associated Impacts, Villach, Austria October 1885. WMO Bulletin 35, 130-134.

BIOGRAPHY

Dr Graeme I Pearman AM FAA BSc(Hon) PhD

Graeme Pearman is the Director of Graeme Pearman Consulting Pty Ltd, and works part time on issues of sustainability for Monash University. He joined CSIRO in 1971 where he was Chief of the CSIRO Atmospheric Research, 1992-2002. He contributed over 150 scientific journal papers primarily on aspects of the global carbon budget. He was awarded a United Nation's Environment Program Global 500 Award in 1989 and was elected to Fellowship of the Australian Academy of Science in 1988 and to Fellowship of the Royal Society of Victoria in 1997 for his contribution to scientific knowledge.

In 1999 he was awarded the Australian Medal of the Order of Australia for his services to atmospheric science and promotion of the science of climate change to the public. In 2002 he was a finalist in Prime Minister's Environmentalist of the Year, and in 2001 he was awarded a Federation Medal in 2003.