Qualitative Scenarios for Energy and Transport in Australia to 2050

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Important Notice

Use of this Report

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'Does your society have more memories than dreams or more dreams than memories…In societies that have more memories than dreams, too many people are spending too many days looking backward…Generally speaking imagination is the product of two shaping forces. One is the narrative that people are nurtured on – the stories and myths they and their religious and national leaders tell themselves – and how those narratives feed their imaginations one way or another. The other is the context in which people grow up, which has a huge impact on shaping how they see the world and others. Outsiders cannot get inside and adjust the Mexican or Arab or Chinese narrative any more than they can get inside the American one. Only they can reinterpret their narrative, make it more tolerant or forward looking, and adapt it to modernity.' [1]

[1] Thomas Friedman, the World is Flat

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1.0 INTRODUCTION

Australia's energy future will be created by forces that originate from a wide variety and number of governments, institutions, organisations, firms and households both within and outside the existing energy sector; some of these changes are able to be altered by people's individual and collective choices, other forces are not controllable, others are perceived to be inevitable. Our ability to quantify and model many of them is limited.

One of the reasons that the Energy Futures Forum (EFF) created qualitative narratives, or scenarios, is that it did not want to ignore the non-quantifiable forces underpinning and shaping change.

Scenarios are plausible stories about how the future may unfold. Scenarios are not predictions or models. They address different ways in which relevant issues outside our organisations might evolve, such as the future natural environment, social attitudes, technology and the strength of the economy. Because scenarios are not predictions, they are often created and used in sets that are taken to represent the range of plausible developments.

Scenarios are plausible stories about how the future may unfold. Scenarios are not predictions or models.

The qualitative scenarios draw on factual information and EFF members' experience and judgment about how the future may come together. The individual scenario narratives are less important than building a better understanding of the environment in which energy organisations and stakeholders will operate. Scenarios allow us to analyse changes in the environment, take new perspectives and develop new understanding. This improved understanding can be used to inform better decisions today and in the future.

The narratives in this companion report were prepared by EFF participants in late 2005. While some of the ideas have been overtaken by events, the lessons derived from undertaking the process and the issues identified and questions raised in the scenarios remain largely relevant.

2.0 FORCES THAT SHAPE THE FUTURE

A number of different forces will shape the future. Driving forces are the outside forces of change that will shape the future in both foreseeable and unpredictable ways. Driving forces include factors within the our working environment, like developments related to communities, and, shifts in the broader environment – social, technological, economic, environmental, and political – that could have an unexpected impact.

Driving forces can be either given or uncertain.

Givens are relatively certain forces of change. Over the next fifty years, changes that were considered to be locked-in included:

- Climate change will affect the natural and built environments[2]
- Some form of carbon constraints will be introduced[3]
- Australia's energy dependence will continue[4]
- Australia's population will grow to reach median projections of 28,000 million[5]

Some driving forces are unpredictable. While all driving forces are important, they are not of equal importance. The priority driving forces identified in this Report were chosen because of their (1) degree of importance to the future of energy in Australia and (2) the degree of uncertainty surrounding those forces.

The future energy scenarios in this report focus on how four forces central and influential to the future of energy in Australia may intermingle. These are:

- the global impact of and responses to climate change
- geopolitical stability
- sustainability
- technological innovation.

To ascertain a common understanding of these terms during EFF conversations these were defined for purposes of the qualitative scenarios as:

Table 1: Four driving forces for energy futures in Australia

Driver		Description
	Climate Change	Climate change refers to the build-up of artificially produced gases in the atmosphere that trap the suns heat, causing changes in weather patterns on a global scale. The effects include changes in rainfall patterns, sea level rise, potential droughts, habitat loss, and heat stress. The anthropogenic greenhouse gases of most concern are carbon dioxide, methane, and nitrous oxides.
	Geopolitical Stability	The term geopolitical stability refers to a situation where nations, commercial entities and other significant global actors are not motivated to unilaterally change their behaviour, and the global political system is at an equilibrium point. Instability occurs when one or more global actor makes unilateral decisions that affect other actors. It is similar to a chess game, when the global system is not stable it becomes progressively more difficult to anticipate other's actions or moves into the future.

[2] Owing to the long lead times between cause and effect, the degree of climate change that will occur between now and 2050 cannot be significantly influenced.
[3] Carbon constraints are already implicitly in place in many countries through a variety of existing policies, including fuel and technology taxes, and subsidies and quotas; businesses also take carbon constraints into account in exercising their commercial judgment and making decisions. It is expected that there will always be a carbon constraint in place in Australia and elsewhere throughout the focus period. However, the degree of carbon constraint is highly uncertain.
[4] Australia, as a nation, will remain dependent on energy, as will many major and emerging countries. Energy use is a cornerstone of society, however, the degree of dependence is uncertain.
[5] All scenarios adopt the Australian Bureau of Statistics median growth assumptions for population in Australia in 2050. Barring a pandemic, environmental refugees and radical changes to our approach to migration, it is expected that variability around this assumption can be expected to be insignificant for the purpose of this Report.

Driver		Description
	**Innovation**	This Report uses the OECD definition of technological innovation found in the Oslo Manual (1995). Technological product and process innovations comprise: implemented technologically new products and processes and significant technological improvements in products and processes. Technological product and process innovations involve a series of scientific, technological, organisational, financial and commercial activities. Technological product and process innovations have been implemented if they have been introduced on the market (product innovation) or used within a production process (process innovation).
	**Sustainability**	Sustainability is an economic, social, and environmental concept. It refers to the ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves. When a process is sustainable, it can be carried out over and over without negative consequences or effects or impossibly high costs to environmental and ecosystems health, economic growth, commercial development, and social organisation.

It is important to note that as the EFF gained greater understanding about the way in which the drivers of change might combine and evolve, it became clear that the climate change driver was uppermost of the four driving forces mentioned above (table 1). Later discussions confirmed this insight – that climate change was *primus inter pares*– or a first among equals of the four drivers that had been culled from a much larger selection of driving forces.

Climate change was considered the most important of four drivers that will shape change in the Australia energy sector.

The high level of importance about the impacts of, and responses to climate change, influenced the way the EFF discussed the future with the quantitative modellers, and helped the EFF determine the parameters of the economic modelling (refer Section 5, CSIRO 2006, *The Heat is On: the Future of Energy in Australia).*

Some drivers are so unpredictable that they are likely to take us by total surprise: this was a final category of forces for change discussed. These are the types of changes that occur so suddenly that we can neither forestall them nor manage an effective response to them. These 'wild cards', as they are often known, can create entirely different futures; for example, NASA engineers develop aircraft that can change shape to make them more manoeuvrable. As a result, the next generation of combat aircraft have wings that change shape and use devices within the wing skins to recover or 'harvest'' energy as the wings move. This technology is then widely adopted by the largest aircraft and automobile manufacturers, which in turn leads to the collapse of some of the world's largest steel companies.

3.0 A MATRIX OF NINE SCENARIOS

The EFF developed nine scenarios, which were created by combining the driving forces to create distinct narratives about what the future could look like. The goal was to develop a set of plausible scenarios that tell very different stories, and individually challenge assumptions and shed light on the strategic issues facing the Australian energy sector.

The details and reliability of the narrative content of the scenarios are less important than the types of conversations they start.

Developing qualitative scenarios is an art, rather than a science. A story should quickly capture a lot of complexity and leave a lasting message with the reader. Scenarios narratives need to stretch thinking to challenge conventional wisdom and show futures that could diverge widely, while staying close enough to the present to maintain relevance and credibility in the minds of decision-makers.

The details and reliability of their narrative content are less important than the types of conversations they start. Remember that the narratives are not predictions of the future; in fact, the narratives actually fell into the background of later EFF conversations, as the strategic opportunities and challenges facing the energy system in Australia rose to the surface.

Table 2: How the qualitative scenarios were created to accentuate different futures

Scenario	Driving Forces			
	Innovation	Geopolitical Stability	Climate Change	Sustainability
Power to the People	Significant technological innovations	Stable	Global management regime, effective	Improved sustainability
Centralised Failure	Late introduction of technological innovation	Stable	Global management regime, ineffective	Sustainability declines
Technology to the Rescue	Significant technological innovations	Stable	Global management regime, effective	Improved sustainability
The Day After Tomorrow	Moderate technological innovations	Stable	Global management regime	Improved sustainability
Atomic Odyssey	Significant technological innovations	Stable	Global management regime, effective	Improved sustainability
Cultural Revolution	Significant technological innovations	Stable	Global management regime	Improved sustainability
Clean Green Down Under	Significant technological innovations	Stable	Global management regime, effective	Improved sustainability
Rough Ride	Few technological innovations	Instability	Global management regime, ineffective	Sustainability declines
Blissful Indifference	Few technological innovations	Stable	Global management regime, ineffective	Sustainability declines

4.0 THE SCENARIOS IN BRIEF

Power to the People

It is 2050 …and a number of key developments over the past 50 years have led to a major restructure in the way Australians are meeting their energy needs. Residents and businesses now generate the majority of their own energy needs locally through a distributed generation network. The decentralisation of energy is reflective of the way government and society re-organised itself over the past 50 years. Today, more people are living in revitalised mid-sized cities, with a subsequent demand for more decentralised government decision-making.

Centralised Failure

It is 2050 …and for a variety of reasons, the large-scale roll out of greenhouse gas mitigation technologies have only been in place for some ten years, with actions to address climate change only beginning around 2040. The lateness of this action has Australia questioning whether it would be more cost-effective to focus on climate change adaptation, rather than mitigation. Driving this questioning is the failure of the international community to arrive at an enforceable and fully inclusive climate change mitigation agreement, and a consequent lack of policy certainty and price signals needed for privatised electricity markets to bankroll new technology deployment.

Technology to the Rescue

It is 2050 …and the world, including Australia, has rightly put its faith in technology and the wealth creation of free markets to tackle pressing energy challenges. This approach had its genesis in 2010 when world leaders agreed that the most painless way of achieving sustainability of energy use was by ensuring that societies' wealth was high enough to pay for necessary structural changes to change the current technological regime. As a result, after complex negotiations, it was agreed that greenhouse gas emissions would be reduced to 50 per cent below 1990 levels by 2050 and, at the same time, trade would be free of quotas, subsidies and tariffs by 2020.

The Day After Tomorrow

It is 2050 …and, so far, only a moderate number of greenhouse gas mitigation technologies have been implemented. The seemingly low take-up of such technologies has Australia questioning whether it would be more cost-effective to focus on climate change adaptation rather than mitigation. Behind this question is the failure of the international community to achieve an enforceable and fully inclusive climate change mitigation agreement, and a consequent lack of policy certainty and price signals needed for privatised electricity markets to bankroll new technology deployment. Nevertheless, in 2050 Australia and the rest of the world have achieved a 10 per cent reduction in greenhouse gas emission compared to 1990 levels.

Cultural Revolution

It is 2050 …and greenhouse gas emissions have been reduced to 50 per cent below 1990 levels. This is a direct result of the reassessment in the early years of the 2010s by the United States government of the geopolitical landscape, which led to an alliance between the US and China (with many others subsequently joining) to substantially reduce greenhouse gas emissions. The success of this alliance has had a general calming effect on global political stability.

Atomic Odyssey

It is 2050 …and greenhouse gas emissions have been reduced to 50 per cent below 1990 levels, led, in large part, by a landmark accord in 2010 between the US and China (with many others subsequently joining) to substantially reduce greenhouse gas emissions. Baseload power production is now largely provided by nuclear facilities, and supplemented by gas fired and renewables. The early adoption of nuclear technology was eased by a major technological breakthrough that allowed the heat from nuclear reactors to become the economic energy of choice for hydrogen production.

Clean Green Down Under

It is 2050 …and Australia has reduced its greenhouse gas emissions to 80 per cent below 1990 levels. Low emission transport and electricity generation technologies are now *de rigueur*, as is a consumer preference for energy end-use efficiency throughout the economy. This dramatic shift was predicated on several major climate events in the early 2010s that effectively removed virtually all global opposition to addressing climate change. Governments around the world agreed to reduce emissions from energy to 50 per cent below 1990 levels by 2050. Australia has gone a step further to reduce its emission to 80 per cent below 1990 levels by 2050.

Rough Ride

It is 2050 …and fundamental differences between various nations' worldviews remain unresolved, perpetuating a cycle of mid-level conflicts and new Cold Wars. With these geo-political distractions the international community has been unable to make any progress toward addressing the world's energy challenge, except with respect to each bloc's own energy security. The main response has been an increase in the rate of improvement in energy end-use efficiency driven by government legislation. Prices of fossil fuels have risen dramatically since the start of the century, but investors are wary of bringing new supplies on line in a more volatile economic and diplomatic environment. At the same time, little effort has been directed to developing energy alternatives, and Australia remains as dependent as ever on fossil fuels.

Blissful Indifference

It is 2050 …and in Australia public attitudes to climate change have hardly shifted to those held at the start of the century. Pressure to introduce measures to address climate change never seemed to reach above other political dialogue around economic reform, health and aged care, and education. On the world scene, relative political stability and strong economic growth has been achieved for an extended period. There continues to be little public pressure for innovation for energy efficiency and patterns of energy use largely remain the same.

5.0 KEY ISSUES FOR THE ENERGY SECTOR IN THE SCENARIOS

Each of the narrative scenarios raised issues for the EFF participants; some of these issues were able to be carried forward for use in the economic models.

Power to the People raised questions about:

- Infrastructure investment and ownership (and access) to energy and transportation services
- Energy sector restructuring, particularly for energy generation and distribution companies
- The potential for distributed generation to become a mainstream electricity source for Australians

Centralised Failure raised questions about:

- Energy demand and management patterns in highly urbanised environments
- The shift from private to public modes of transportation
- Whether strategies to combat climate change should focus on mitigation or adaptation
- The balance between intellectual property rights and industry development needs

Technology to the Rescue raised questions about:

- Whether technology change alone will meet future energy needs
- The extent of investment, and willingness to invest in energy and transportation related research and development
- The rate of change, timing of introduction and the willingness to adopt new technology (advances and breakthroughs)
- The possibility of 'stranded' assets, i.e. capital investments that are mistimed

The Day After Tomorrow raised question about:

- The implications of a failure to agree or introduce an effective global climate change management mechanism
- What constitutes an effective global carbon trading system and how is compliance for this type of regime best managed
- The likelihood of conflict being triggered by resource scarcity (in extremis, 'resource wars')
- The treatment of energy as a 'security' concern in international forums like the United Nations
- The imposition of economically harsher carbon constraints, later in the fifty year timeframe

Cultural Revolution raised questions about:

- How to best combat climate change
- How early, co-operative action at international level may eventuate
- Early establishment of international carbon price mechanisms
- The introduction of a broad portfolio of zero emissions technologies (for example, renewables, carbon capture and storage and nuclear energy) determined by market mechanism (i.e. pricing)

Atomic Odyssey raised questions about:

- The breadth and depth of renewable energy technologies and their capacity to meet future energy needs
- The effectiveness of future nuclear non-proliferation treaty management and compliance mechanisms
- The difficulties associated with nuclear safety and waste disposal
- The potential failure of carbon capture and storage technologies
- Production breakthroughs that create significant synergies in the co-production of electricity, hydrogen and water desalination

Clean Green Down Under raise questions about:

- Shifting consumer preferences, and what constitutes a (behavioural) tipping point that lasts
- The potential for Australia to make deeper cuts to emissions than global standards of the day
- What a prolonged, persistent period of political reform could look like
- How an increase in social equity could be achieved
- The impacts of low levels of energy intensity in the economy

Rough Ride raised questions about:

- The prices of fossil fuels and the economic consequences of a prolonged period of high prices
- Investor wariness
- Economic and diplomatic volatility

Blissful Indifference raised questions about:

- The extent to which public attitudes drive policy directions
- The difficulty of achieving changes in consumption behaviours on a voluntary rather than a ‘push’ basis
- The challenge of getting on a crowded public and political agenda where are priorities are pressing (e.g. economic reform, health and aged care, and education)
- The management of political stability and economic success that lasts for an extended period

6.0 LEARNING FROM THE QUALITATIVE SCENARIOS

Developing the qualitative scenarios provided participants with process and substantive knowledge of the issues.

In terms of process, it was found that having conversations for the purposes of collaboratively developing the scenario narratives:

- Led to an understanding that the process of developing the scenarios was more important than the individual scenario narratives.
- Allowed members to unpack the diversity of viewpoints in the room and, implicitly, the wider community.
- Focused these, and later, discussions, on what views were held in common, rather than on differences of opinion.
- Deepened participants' knowledge about the energy sector in Australia by sharing members' experiences, interests and their acquaintance with different constituencies.
- Created a richer, more complex picture of what the future could be than could be fashioned through quantitative modelling.
- Heightened awareness of the difficulty of conceiving new social, technological, political and economic arrangements and the condition of the natural environment and, at the same time, highlighted the need to do so.

The process of creating narratives also identified and confirmed the common views of members, notably, that:

- Climate change is the first among equals of the many processes creating future change that are in train today
- Community attitudes or behaviours may well change suddenly, in surprising directions, and in ways that limit or expand the adoption and use of particular technologies, programs and practices.
- New management measures of some form will be introduced for the international carbon economy, whether they are managed well or not remains an open question.
- A broader suite of technologies will play a role in the future than is possible to capture in quantitative modelling.

7.0 THE SCENARIOS IN DEPTH

What is in each scenario?

In each of the nine scenarios, readers will find:

- Summary – a brief overall description of the scenario
- Driving forces – a few of the most relevant issues and occurrences that finally cause the scenario to emerge, highly condensed and grouped together to show connections
- The storyline – a hypothetical description of the conditions in this world, answering who, what, when, where, why.

Remember, a scenario is only a tool to:

- Organise your thoughts about how today's decisions might play out in the future
- Understand different contexts for decisions, not to predict the future.

7.1 Power to the People

It is 2050 …and a number of key developments have led to a major restructure in the way Australians are meeting their energy needs. Residents and businesses now generate the majority of their own energy needs locally through a distributed generation network.

The key developments that led Australia down this path were:

- the development of cost-effective solar PV (photovoltaic) and electricity storage technologies around 2030
- the accession of Australia to a global greenhouse gas emission target of 50 per cent below 1990 emission levels by 2050
- a subsequent genuine economic advantage to be gained from installing localised generation relative to paying the retail price for electricity (inclusive of the costs of CO_2 permits)
- the emergence of energy service companies that pay the upfront costs of installing localised generation in return for the opportunity to exploit the generation-retail price gap, and thus optimise the financial and energy performance of many thousands of aggregated units across the electricity grid.

The decentralisation of energy is reflected, to some extent, in the way government and society re-organised themselves. The relatively small 'sea change' trend observed at the start of the century came, over time, to offset the then more dominant trend of the population centralising itself in capital cities. Today, more people are living in revitalised mid-sized cities, with a subsequent demand for more decentralised government decision-making.

The penetration of distributed generation and greater geographical spread of the population has accelerated energy end-use efficiency improvements in Australia. Energy service companies have not only provided the incentives for users to shift their loads to non-peak hours of the day, but the act of generating one's own power (much like the installation of rain tanks in the early part of the century that saw a lasting reduction in water use per head) has brought about a genuine cultural change toward minimising energy consumption. This attitude also spilled over into transport energy use, following an upward step change in oil prices that was never reversed.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
Distributed generation is dominant; solar photovoltaic (PV) and fuel cell systems to power homes or work premises. Carbon capture and storage and geothermal technology play a role.	The geopolitical landscape is stable, with a continuing dominance of democratic government structures and free market economies.	A global management regime is effective in managing the world's response to climate change.	There is an overall improvement in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves.

7.1.1 The Storyline

The central feature of the global political and governance structure has been the fragmentation of the large nation states along historical lines, together with the re-emergence of the United

Nations as a global governance authority and a global free trade agreement consistent with international fair trade principles. This latter agreement set in motion a series of targets to reduce all trade barriers. Together these have provided the basis for stability, the continuing dominance of democratic government structures and free market economies. These developments have been critical in securing commitment to a global response to climate change.

Whilst the Kyoto Protocol was largely discredited, the combination of its legacy and actions by the European Union (EU), Japan, China, India and the USA have led to an international climate change framework incorporating many of the elements of the Protocol. This framework, the core of which has been long-term global stabilisation targets and per capita emissions convergence, includes technology drivers consistent with the economic interests of the developed world. Major industry has come on board, driving an international carbon-trading scheme.

Growth in China and India is well above average levels, which has driven major investment in power generation, predominantly coal and nuclear, with clean coal and clean gas gaining greater significance in the later decades. In this context, 'clean' refers to high efficiency reformation, hydrogen-fuelled gas turbines and carbon capture and storage (CCS) in deep saline aquifers and deep oceans.

Nuclear power generation has also experience very strong levels of growth during the first two decades, with particular emphasis on the smaller scale (<200MW) plants, based on Pebbled Bed Reactor technology. Wind energy reached technology, cost and social limitations by 2010, although the development of storage technologies allowed it to reach levels that would have been otherwise unrealistic. The emergence of geothermal energy provided another balance between the cleaner fossil fuels and solar PV. This was critical as the long-term limits to CCS became evident. This allowed centralised generation to remain a force, albeit a diminished one, through to 2050, despite major rebalancing within the sector.

The post 2030 period has been dominated by the dual emergence of two commercially viable technologies within the global carbon regime. Technological and scale improvements in solar PV generation and the development of combined super-capacitor/battery storage technologies, permitted the widespread adoption of distributed energy generation. Many developing countries avoided the massive investment in electricity transmission and distribution infrastructure that had characterised the latter part of the 20th century for the developed world. Traditional energy utilities are long obsolete, although some evolved their business models to benefit from the technologies.

The adoption of fast rail systems, increasingly based on magnetic levitation technologies, have been strongly advanced by air traffic congestion around major cities, sustained high oil prices and then global constraints on aircraft emissions to offset global dimming factors. This development complemented the decentralisation of communities away from mega cities. In Australia, inter-centre transport is largely by MAGLEV trains; the last domestic commercial airline went into receivership in 2040.

Higher risk oil exploration, moderately successful through to 2020, did not dampen the parallel development in hybrids and low emission diesel vehicles. This occurred ahead of the fuel cell developments, initially incorporating on-board natural gas reformers and later based solely on externally supplied H2. The dominant source of this H2 is the home or car park, both of which

incorporate solar PV arrays with direct H2 conversion coupled with new electricity storage devices.

7.1.1.1 Built environment

Australia remains a largely urbanised society, although based within mid-sized cities; 50 per cent of Australia's 35 million population now live outside the regional hubs (previously State capitals). Green zones established around residential and commercial development complexes are complemented by mid-density housing design, incorporating local community orientation, grey water recycling and so on; a number of 'new' cities are relying primarily on desalination plants for water supply. Zero-emission homes are being built as part of the new resi-comm 2050 development that will contribute to Mt Gambier becoming the 50th Australian centre to host 100,000 people. These homes feature:

- High efficiency integrated solar PV roof
- The latest capacitor storage unit
- Solar-direct hydrogen production and storage facility device powering all mobile devices and personal transport pods (community-owned and used only for local transport).
- The first major development to be entirely without electricity, gas or telecommunications physical networks.

By 2020, energy demand, still growing, was well below GDP growth and below that forecast by ABARE and the energy supply industry. The growth in peak demand led to the adoption of peak pricing tariff structures (less complex that multi-part interval metering) and mandated building standards for both residential and commercial buildings. Steady increases in centralised energy supply costs accelerated the progressive uptake of more energy efficient technologies across industry.

The adoption of a national emissions target supported by a national emissions trading scheme, R&D funding for low emission technology development, major trials of FEED tariffs for solar PV, and a restructuring of the MRET legislation along lines earlier recommended by the maligned Tambling Commission of 2004. This adoption of market mechanisms to deliver the desired policy objective was critical in ensuring that Australia retained its international competitiveness. Progressively, the monopoly elements of the energy and telecommunications sectors became listed investment vehicles, relieving governments to focus on other service areas such as health and public transport infrastructure.

The early promise of wind energy in Australia was dampened by rising costs, particularly for transmission connection, and community lack of acceptance. Wind, supported by storage technologies (see also below), does have an ongoing role in smaller clusters of turbines relatively close to major centres. The logistics costs and absence of demand for low-grade biomass heat meant that it too achieved only niche status in Australia. The policy measures therefore drove the deployment of CCGT for base load generation whilst providing an impetus for the development of IGCC and similar high efficiency coal technologies, together with carbon capture and storage (CCS), which was also developed for major gas development projects and for base load gas generation, where it was commercially viable against coal (depending on the location with respect to the resource base and transmission infrastructure).

HFR technology emerged as a commercially viable alternative in the latter part of the second decade, with several plants of the 300-500MW scale being constructed. These developments

obviated the need to address the politically sensitive issue of nuclear generation to the extent that Australia could afford to watch and await international developments.

The critical developments in stationary energy were the major reductions in delivered costs for solar PV technology and the parallel developments in storage (battery and super capacitors in tandem) and fuel cells. The early years were characterised by the application of a deemed multiplier for solar PV under the extended MRET legislation, capturing the additional distributive benefits of this technology. Australian solar PV technology was a clear leader in achieving major cost reductions, driven by scale economies and technology developments. The nett result was residential and commercial sectors increasingly independent of the grid, the latter already faced with costs that had been escalating over many years and a physical network that was largely outdated. The grid, therefore, existed primarily for the flat industrial load, and the remaining large metropolitan load.

The first two decades of the century were characterised by diversification of the supply portfolio, whilst the middle decades saw the relative demise of centralised generation and the emergence of the distributed technologies. The distinctive nature of Australia's energy mix was the combination of HFR and solar PV, which not only led decentralised generation, but also enabled Australia to avoid the nuclear path followed by much of the rest of the world.

7.1.1.2 Transport

The number of kilometres travelled nationally by personal land transport declined steadily over the decades. Initially this was driven by the emergence of efficient inter-city and metropolitan rail and light rail networks. This was complemented by the competition between those automotive manufacturers who adopted clean diesel technology (an initial winner) and those who focused on petrol/electric hybrids. LPG and CNG had brief time in the sun in the 2005 to 2010 period, but failed to justify the high costs of the fiscal measures necessary to maintain their penetration. Over time, the use of personal transport was largely confined to the regions around the mid-cities serviced by the rail network, or for leisure transport beyond the rail system's reach. Congestion of air travel hastens both the demise of domestic air travel and, to a lesser extent, the move away from mega cities. Total and per capita emissions associated with transport began to decline in the second decade, and this trend accelerated by mid-period

Headline News

National Rural and Regional Population Tops 60%

7.1.1.3 Society and Culture

Australia adopted a combination of policy measures in the period 2005 to 2010 to create a national response to the widely accepted need for long-term deep cuts in greenhouse gas emissions. The core of these was a long term 2050 target of emissions at 50 per cent below 1990

levels, and an interim 2020 target of 20 per cent below. The need for specific adjustment mechanisms in the early years for the trade-exposed enabled the Government to secure major industry support, and these were phased out as a global system evolved.

For example, farming practices in Australia responded to more extreme climate patterns, further outbreaks of diseases and the need to curtail water consumption. This saw the demise of cotton, rice, tobacco and sugar cane farming in Australia. Aquaculture and organic crops, building on the clean marketing image pioneered by Tasmania, now dominate agriculture.

The Future Fund, established by the Federal government in the budget of 2008, has driven a national R&D program, a major element of which focuses on clean coal technologies specific to Australia, HFR and solar PV. This program has driven the technologies now deployed through the NETS scheme.

Australia now has two levels of Government, with central government representatives being directly elected from the 50 Australian regions, although the seven regional hubs have a proportionally larger number of representatives to the 100-member Parliament. National regulatory structures, supported by the ACCC and nationally consistent consumer protection legislation govern most societal and commercial transactions in Australia.

7.2 Centralised Failure

It is 2050 …and for a variety of reasons, the large-scale roll out of greenhouse gas mitigation technologies have only been in place for some ten years, with actions to address climate change only beginning around 2040.

The lateness of this action has Australia in 2050 questioning whether it would be more cost-effective to focus on climate change adaptation rather than mitigation. Driving this questioning is the failure of the international community to arrive at an enforceable and fully inclusive climate change mitigation agreement and a consequent lack of policy certainty and price signals needed for privatised electricity markets to bankroll new technology deployment.

Nevertheless, Australia and the rest of the world have embarked on an ambitious last-ditch attempt to implement the policy needed to reduce greenhouse gas (GHG) emissions, by imposing, from 2040, a very high CO_2 tax rate.

In the transport sector some improvements in energy efficiency have been achieved in the absence of a CO_2 price. Two factors are behind this. Firstly, oil prices increased and have remained moderately high relative to the prices paid in previous century. Secondly, as employment, and subsequently populations, have become more centralised in Australia's larger cities, the trend away from public transport has been finally reversed. Worsening traffic congestion, and a growth in higher density housing as the only affordable option for most tenants, has seen trains become the most convenient mode for the majority of urban dwellers.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
There are relatively modest improvements in energy efficiency have occurred. Electricity storage is cost-effective, with a subsequent focus of electricity generation on base load. Late introduction of technological innovation.	The geopolitical landscape is stable.	A global management regime is ineffective in managing the world's response to climate change.	There is an overall decline in the world's ability to provide for the needs of the current global population.

7.2.1 The Storyline

7.2.1.1 Carbon Constraints

The concept of carbon constraints and climate protection has been ever present since the Kyoto Protocol. A successor regime, Kyoto II, was agreed to following difficult negotiations. Kyoto II stipulates an aggregated emission reduction target of 20 per cent (from 1990) by 2030.

Kyoto II led to the establishment of an International Carbon Monitoring Agency, with steadily increased powers. However, weak and ad hoc national level targets, coupled with the use of loop-holes and 'flexible' mechanisms, has allowed many industries, including energy related industries, to delay fundamental changes of technology.

The lack of clear signals or enforcement early in the century has meant that building stock and consumer items are not significantly more efficient, and energy prices have not risen significantly because of carbon. The result internationally, and in Australia, is that the market pull on low emission technology for demand or generation is very weak. This has had an up-stream effect on the pace of research and development. Without this pull, the business attitude towards 'forced' R&D is that it is a cost only, with little commercial imperative or benefit.

A key hold-up that defines this scenario has been the lack of consistency and continuity that normally allow technologies and markets to capture incremental change and thus evolve to higher levels of performance. Ill-conceived policies, vested interests pushing their own technologies, and an ongoing lack of collaboration and technology sharing push nations to keep doing R&D, with little implementation.

The failure to deliver low emission technology for society is counter-balanced by an increasing awareness of building climate change impacts. In the post 2040 decade, this led to the introduction of strong carbon constraints but was accompanied by little ability to achieve these constraints without abstinence. The effect of climate change on day-to-day living and on national economies was dramatic. There were backlashes in several countries, with the international carbon constraints system finally unravelling in 2050.

Headline News

Australia Withdraws From Carbon Monitoring Agency, Abandons Greenhouse Gas Mitigation Strategy

Carbon constraints in Australia

In Australia, most of society did not feel the effect of carbon constraints until 2030. The constraints were quite weak and resources were put into industry to find silver-bullets. First coal CCS (carbon capture and storage), then nuclear fusion, then renewables - which one pundit called the 'flavours of the moment'. Because interest switched back and forth between these 'flavours', it hampered industry development and did not allow industry to capture incremental improvements through sustained and stable growth.

Initially the lack of signals beyond the R&D arena had little impact on wider society or the built environment. Housing became more dense in the capital cities, but it was inefficient housing and prices of energy were always kept as low as possible. This changed in 2030 when quite large carbon taxes were introduced, hitting the economy and people income quite hard. The houses they lived in and products they used were inefficient, so the only way to limit their

emissions was to limit their use of products and curtail aspects of their lives. The resulting slowing of the economy had the unexpected consequence of limiting the available resources for adoption of new technology – for example, energy efficient systems in the home.

The move from little to strong carbon taxes in 2040 and its sharp effect on consumer confidence and the economy, set up an oscillation with competing pressures to strengthen measures to curb impacts versus weaken measures to keep the economy going. This in some ways is the effect of leaving significant intervention too late.

7.2.1.2 Political and trading structures

The evolution of global governance systems occurred slowly, firstly in trading blocs like the European Union and ASEAN, and then through multilateral mechanisms like those for carbon. But the nation state has persisted as both a geographical and cultural aggregation. The effects of climate change have added to the sense of nations having to look after their own towards the 2050 point.

A critical development that has flowed from the strong centralisation of population and resources flows is the growth of the mega-companies. These were born from both a industry sector consolidation, such as oil companies amalgamating in the 1990s, and cross sector amalgamations, for example gas and power, then water, and the other commodities, such as fuel, food and finance. Slowly the multi-sector transnationals emerged and then merged until by 2050 there are two major competing mega-companies: Toyota-Barclays-Wal-Mart-Warner (TBWW) and General Everything (GE). The consequence of companies of this size is that they have stupendous economic and political influence though their buying power, their employment base and their media ownership.

There are close to total global markets and free movement of people and capital, but again the trading structures have become less meaningful as mergers and acquisitions have come close to their end point. The economies of scale created by the mega-city and mega-company combination has been very significant, but it has also lead to interdependence between countries that has left almost no country ‘independent’. This has introduced a new vulnerability that, in part, plays into the ultimate backlash towards independence.

7.2.1.3 International technology developments

The centralisation of population and resources has been the defining characteristic of the stationary energy sector. The developments have not been especially efficient, except for the period from 2040, and so there is significant housing stock that requires significant energy services and this is typical of many sectors where improvements in efficiency have been modest.

The result is a need for baseload and peak energy. The centralisation has lead to some advances in short-term storage that avoids excessive peaks, with some very large capacitors in each city building. As a consequence, the stationary energy sector requires only large baseload generation.

This differs from country to country. The USA uses mainly nuclear, the EU uses a mix of wind, biomass and fossil fuels, as each country focusses on its own resources. However, the global

energy companies also move large quantities of energy commodities, and these remain focussed on oil and coal.

The price of energy has become higher, though subsidies persist as nations try to secure manufacturing and processing in country.

An example of a failure, despite centralisation opportunities, was when the GE construction decided not to install a centralised heat and power system into its new series of 150-floor apartment blocks, noting that it could undermine the anticipated significant sale of electric fan heaters and air conditioners and cause mass unemployment in Slovenia where the fan factory is based.

7.2.1.4 Domestic technology developments

An over-arching change has been the shift of market power to the mega-companies and this has changed the front end of innovation.

In a broad sense, Australia is not an entrepreneurial country. There is neither little access to the local market for small start-up companies nor access to finance, so innovation has to go through the big companies. This dampening of the business dynamic and inventiveness has a major effect on the speed at which technology change happens across all sectors

7.2.1.5 Built environment

Australia has evolved slowly but surely into a heavily urbanised nation where 95 per cent of the 35 million-population live in the major cities. Housing densities have gradually increased towards levels that eclipse even Manhattan, yet there is still significant urban sprawl.

Rural Australia has lost most of its political influence, as the expanding population has become centred in the cities. The effect of climate change has also had an effect on smaller towns that have been unable to manage the costs of adaptation to climate change. For example, the historic town of Yass was the first to go, when its water supplies failed under sustained drought. Eventually Canberra itself had to be moved, when the city-states of Melbourne, Brisbane and Sydney refused the ‘Canberra Subsidy’, as it was called.

The effects of increases in temperature, higher density, and inadequately planned development have not left the Australian urban dweller the most contented person. People complain about air quality, commuting times, the poor quality of the food, the return of pollution to sea beaches, and so on. But there are few economic options, and living in the county is either for the farmers or those who can afford the fuel and the water to live outside the city, which is where the desalination plants are based.

People do make trips overseas, and movement is facilitated between continents because all professional work is based in English. However, many are dissatisfied by the experience, citing it as “like going for one MacDonald’s to another”.

7.2.1.6 Transport

The rise of the mega city, coupled with the congestion around airports, largely led to the demise of domestic air travel in favour of high-speed rail in the later half of the period to 2050, leaving the skies free for expensive and less frequent international trips.

The mega-city tends to have such significant critical mass that people rarely leave, indeed getting out is no small exercise, and internally mega cities depend on public transport. The car has lost much of its function in the city, but remains a status symbol – if only to demonstrate that one can afford the fuel and has found a way to avoid the carbon rations.

People in Australia's largest cities city use public transport but still travel large distances to work, often travelling as much as an hour and half per day. There are intercity trains, and planes still carry people overseas, though during times of carbon rationing this becomes difficult with families pooling rations to send people overseas.

7.2.1.7 Energy

Like all other international mega cities, Australian mega cities have a thirst for energy. The ability to store energy has meant that power stations are now mainly focussed on delivering baseload energy.

Renewables were pushed under MRET but then halted abruptly in 2007. This policy behaviour was repeated for coal capture and storage in the period to 2020, and then again for nuclear energy. It was also mirrored in global arenas too. The result is that by 2050 energy in Australia is represented by 20 per cent wind, 10 per cent nuclear, with the rest being integrated gasification combined cycle plants (IGCC),[6] of which about half is sequestered.

Housing is largely inefficient, despite its increased density and the economies of scale, and some point out that it is not the interests of TBWW or GE to build housing that would prejudice their future sales of energy. Homes are fitted with electric heat pump heating and air-conditioning as standard. However, the high density makes solar hot water heating impossible.

Energy products for entertainment come out year on year – holographic chess, 3D films, historic car race re-enactments, Artificial Intelligence gladiator contests for the toddlers and so forth – as computing and nano-tech ancillary devices develop.

The technology delivering this energy is from a mix of sources. Gas was a steady provider but was running out by 2040. Coal has never gone too far away, though roughly 50 per cent of coal emissions are now sequestered in a pipe network that was never quite affordable for the other 50 per cent. A half built fusion reactor is turned on twice a year for students to look at. Each city has a large-scale incineration plant burning all its wastes. Sewage streams are not recovered but discharged to sea.

[6] An alternative to coal combustion is coal gasification. When coal is brought into contact with steam and oxygen, thermochemical reactions produce a fuel gas, largely carbon monoxide and hydrogen, which when combusted can be used to power gas turbines. These systems give increased efficiencies by using waste heat from the product gas to produce steam to drive a steam turbine, in addition to a gas turbine.

7.2.1.8 Society and culture

Australia is serviced by large mega companies, like most other countries, and its economy has evolved little from its minerals and food base. It remains a two party democracy.

The role of government with respect to industry has become steadily weaker. In particular, the steady consolidation of industries has seen governments' ability to intervene in the marketplace wane.

The power of the mega city has become almost absolute with rural population having very little effect on politics. The role of mayors and internal city factions has become highly significant. In many ways, what started as state capitals have largely evolved to city-states serviced by the rural areas and the mega-companies.

7.3 Technology to the Rescue

It is 2050 …and the world, including Australia, has rightly put its faith in technology and the wealth creation of free markets to tackle pressing energy challenges.

This approach had its genesis in 2010 when world leaders agreed that the most painless way of achieving sustainability of energy use was by ensuring that societies' wealth was high enough to pay for necessary structural changes to change the current technological regime. As a result, after complex negotiations, it was agreed that greenhouse gas emissions would be reduced to 50 per cent below 1990 levels by 2050 and, at the same time, trade would be made free of quotas, subsidies and tariffs by 2020.

This decision was followed by a technology investment boom, which was later followed by 'alternative' energy technology companies being adopted as part of the mainstream energy landscape. With the free market determining the least cost way for Australia to meet its emission reduction target, a wide variety of technologies were adopted depending on the unique circumstances of each state and region.

The various spin-offs and long period of stability and growth from this jump in investment activity has been likened to the periods during the two World Wars, the Cold War space race and the 1990s information technology boom in the previous century. However, periods of structural change brought about by reduction in tariff protection did cause a period of domestic political unrest.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
There has been a suite of alternative energy technologies introduced, as technology is the basis, the motor and the mark of nearly every activity or field of study.	The geopolitical landscape is stable.	A global management regime is effective in managing the world's response to climate change.	There is an overall improvement in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves.

7.3.1 The Storyline

7.3.1.1 Built Environment

As Australia's population edges towards 35 million, capital cities have evolved from the 'hub and spoke' design into fully networked cities. Each metro area is, in reality, a collection of urban villages – smaller, self-contained closely linked neighbourhoods designed to encourage higher density, energy efficient living with high social amenity. Mandatory high standards of

building energy efficiency, coupled with intelligent energy systems that determine the need for heating, cooling and lighting, further drive energy efficiencies that result in extremely energy-efficient buildings.

Headline News

Premiers Agree to National Urban Planning Commission with Teeth

Zero waste policies encourage secondary raw material streams that have an economic value in their own right. All such material streams are fully integrated into the modern economy; even former tip sites are now being mined for their resources.

The mining and metals industry works closely with new resource recovery companies leading to improved efficiencies in resource utilisation. Like other primary producers of metal, the aluminium sector has shifted its focus to recycling and reduced its production of virgin metal to some 20 per cent of what it was at the turn of the century, dramatically reducing its emissions.

7.3.1.2 Transport

The majority of transport kilometres are now in the form of high quality public transport. Changes in the design of cities and the advent of truly effective public transport systems have reduced the role of the personal vehicle to merely being a fashion accessory. Modern cars are much smaller in size, and powered by fuel cells or by electricity from high efficiency storage device that can be recharged while the vehicle is in use. The big gas-guzzlers of the past are but a distant memory. A majority of urban Australians subscribe to auto co-ops, drawing on an on-demand pool of motor vehicles.

The transport system is powered by direct electricity or other non-polluting energy system, such as hydrogen, fuel cells or high capacity electrical energy storage devices. Extensive interchanges allow for rapid inter-modal transfers and from local to regional to national or international transport hubs. The metro systems of Sydney, Melbourne and Brisbane are each larger than the Melbourne tram system, once one of the largest in the world. The very fast train (VFT) network, based on MAGLEV technology, now connects Perth with the Adelaide and the eastern seaboard network.

Telecommuting and shared office hubs integrated into urban villages have reduced the necessity for commuting drastically in this service economy.

Australia has ratified Kyoto IX; greenhouse gas emissions are 50 per cent of the 1990 baseline. Due to carbon constraints, cheap mass domestic and international air travel largely disappeared between 2015 and 2035, but new high altitude fuel cell technologies jointly developed by Boeing, Airbus, Mitsubishi, Tata Industries and the Chinese Aerospace Corporation overcame the carbon hurdle by the late 2030s and air travel is now more affordable than ever.

Line haul road transport is virtually non-existent and freight is almost exclusively carried by rail. Extensive inter-modal hubs allow for the efficient distribution of goods and materials to the local level. Driving the interstate highways is a breeze, and is largely the preserve of those with a nostalgic yen for twentieth-century road movies and who can still withstand the boredom. Most non-urban travel is confined to visits to regional centres outside the VFT network.

7.3.1.3 Energy

The energy mix has changed markedly in the last 20 years. Energy efficiency and generation has become far more sophisticated. Energy use per unit of GDP continues to decline and greenhouse gas emissions have declined in absolute terms to less than 50 per cent of the 1990 baseline. Gone are the days of unconstrained combustion of fossil fuels. The last of the pre-IGCC integrated gasification combined (IGCC) coal fire power plants were phased out in the 2040s. All utilities are using IGCC technology with carbon capture and storage (CCS), as do the remaining gas fired plants. As useable reservoirs for the storage carbon dioxide continue to decline, new forms of sequestration are being deployed including the use of mining and metal processing residues that will extend the use of IGCC and CCS to the turn of the century.

The limited application of nuclear energy as the new Generation V power plants came to be seen as a viable route to eliminating the unconstrained release of greenhouse gas and particulate emissions, despite the storage of nuclear waste, nuclear proliferation and costs being important drawbacks. Support for the nuclear option is conditional on the development of additional new clean technologies, and the five power plants commissioned in the 2020s and 2030s under the Australian Federal Government's Interim Nuclear Greenhouse Gas Abatement Agreement are not expected to be replaced when the end of their useful lives are reached in the 2060s and 2070s. The flip side of this has been an increased support for a diversity of technologies, with the catch phase for his replacement process being 'let a thousand flowers bloom'.

Examples of the diversity of technology include not only the expansion of existing renewable technologies, such as wind, solar and biomass, but also the development of new technologies, for example, geo-thermal power stations using on hot dry rocks.

A critical breakthrough in high capacity storage technologies mean that power plants can run for 24 hours per day at their theoretical maximum efficiency with excess power generated in off-peak periods being stored for return to the grid as demand grows towards peak periods. These storage technologies allow energy output to be smoothed and eliminate the risk of instability in the power grid caused by the natural fluctuations in energy production with changes in the availability of solar energy across the day and seasons. Increases in efficiency and the use of these same storage technologies have allowed the widespread use of large photovoltaic arrays as clean energy sources. The development of amorphous silicon road surfaces in the 2020s means that roads are now a source of energy and the national road traffic authority is a registered power company.

The centralisation of people and industry has facilitated economies of scale in power generation, storage, distribution and the maintenance of this infrastructure. The use of existing distribution infrastructure has led to the continued concentration of generation capacity along the grid although some supplementary use of grid-connected solar PV technology has developed. The growth of cities has also supported the continued use of centralised generation facilities – power can be generated in a few large facilities (not necessarily in their current locations) and distributed to a few large centres for the bulk of the demand. Super-conducting transmission is

standard and heat losses in the system and in many major end use technologies have been eliminated.

Private enterprise continues to invest heavily in new generation and storage technologies, which has resulted in the generation of significant locally owned intellectual property. Emission Free Power Pty Ltd is now the second largest industrial company listed on the Australian Stock Exchange and its grown beyond our continental borders by direct investment, technology licensing and joint ventures. Free trade agreements signed with China back in 2006, and with India the following year, has allowed Australian companies to be major players in the east and west Asian clean energy sectors, now the biggest slice of the global energy market. In China and India greenhouse gas emissions are once again below those of the United States due the world's two largest economies embracing world's best practice in all aspects of power generation and industrial production.

7.3.1.4 Society and Culture

Society is led by a secularised faith in technology – 'technicism' – as a saviour of the human condition. Technology and human ingenuity have indeed 'come to the rescue'.

Australia is a vibrant technologically aware society, recognised as a world centre for science, education and training. Large, early investments in energy R&D have generated substantial spin-offs in many economic arenas, just as the NASA programs of the mid-twentieth century were a kick-start to many new technologies.

7.4 The Day After Tomorrow

It is 2050 …and, so far, only a moderate number of greenhouse gas mitigation technologies have been implemented. The seemingly low take-up of such technologies has Australia questioning whether it would be more cost-effective to focus on climate change adaptation rather than mitigation. Behind this question is the failure of the international community to achieve an enforceable and fully inclusive climate change mitigation agreement, and a consequent lack of policy certainty and price signals needed for privatised electricity markets to bankroll new technology deployment.

Nevertheless, in 2050 Australia and the rest of the world have achieved a 10 per cent reduction in greenhouse gas emission compared to 1990 levels.

The moderate CO_2 price has been large enough to convince vehicle manufactures to roll out more energy efficient hybrid electric vehicles, but it should be noted that the appeal of the cars is due more to their significantly better acceleration performance and high-tech appeal rather than their energy efficiency. Nevertheless, economies of scale make this the new standard.

Driving Forces

Innovation

Moderate technological innovations

Geopolitical Stability

The geopolitical landscape is stable.

Climate Change

A global management regime is effective in managing the world's response to climate change.

Sustainability

There is an overall improvement in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves.

7.4.1 The Storyline

In 2050, for most of the world's population, climate change is a matter of daily reality, affecting everything from their diet to the global balance of power between nations. It is forty-five years after the United Nations Environment Program (UNEP) produced its report "Environment and Human Well-being: A Practical Strategy". At best, the world has muddled through the last 50 years and, at worst, it has missed the window of opportunity to mitigate the most serious impacts of climate change that are now locked in for the next fifty years.

Attempts to coordinate global action in the face of climate change have largely been ineffective and it has only been through strong action post 2025 that the 10 per cent emission target has been reached. National self-interest, poor planning and ad hoc responses marked previous years. The events that have forced this late action include a series of resource-based conflicts and the erosion of the value of carbon credits held by complying countries. In order to deal with resource-based conflict, the need for coordinated measures to deal with climate-induced crises

and the undermining of carbon trading by non-compliant rogue states, have led the major powers to establish a Global Climate Mechanism under the auspices of the UN Security Council.

In 2025, the UN Security Council took control of the global climate convention and its enforcement measures through establishment of the Global Climate Mechanism (GCM). The UN Security Council agreed on the immediate imposition of strict carbon controls and a target of 10 per cent reduction in CO_2e from 1990 CO_2e levels by 2050. The Security Council was given the power to intervene directly where countries breached the GCM.

Given the lack of preparation and action during the most part of the period leading to 2050, the drastic actions required by most countries towards the end of the period result in dramatically high costs of adaptation to climate change. Socially, there has been a major divide between those that have argued the need to fix immediate problems and react to crises – and those that argue "what about the day after tomorrow?"

The world environment can be seen to evolve in three distinct phases:

The ICC Era (2012-2025): Fiddling while Rome burns

The International Climate Commission (ICC), established in 2012 by the UN to oversee and coordinate the post Kyoto global climate response, was more successful than the Kyoto Protocols preceding it, but plagued by internal dissent. In fact, strong parallels were drawn between the ICC and the International Whaling Commission (IWC) of the late 20th Century. As with the IWC, national interest frequently stood in the way of global cooperation on climate change. An ICC-set Global Carbon Trading Mechanism (GCTM) is largely seen as a failure, due to national interests, non-compliance and market distortions.

In the particularly difficult years of 2015 to 2020, criminal cartels added trade in bogus carbon dioxide emission permits to their portfolio of human body parts, drugs and armaments. Several large and strategic oil reserves were also seized for a number of years by mercenary armies in Russia, West Africa and Colombia. In Brazil, a series of aluminium smelters were established to capitalise on the booming price of aluminium and their abundance of raw materials. These used coal fired power plants for their electricity source, further undermining global efforts and destabilising efforts to regulate world markets in both aluminium and CO_2 emission permits.

The Resource Wars: a turning point in history

The economic and human cost of severe weather events is on the increase. The most significant impact of this has been the intense debate on whether to continue investing in mitigation measures for the long-term benefit of society, or to spend the same funds in adaptation measures to cope with short-term crises. This debate was thrown into stark relief during the period of the so-called Resource Wars.

By 2020, a number of countries were either already experiencing, or anticipating, critical shortages of natural resources, including energy, water and fisheries. Nationalists, charismatic religious and ethnic leaders led often panicked societies into desperate measures – such as the frequent water wars during the period up to 2030 that centred on access to the Mekong, Indus, Jordan and Nile Rivers, and the US-Mexican border conflicts over access to the waters of the Rio Grande.

Hostilities broke out between maritime nations and distant water fleets over access to the dwindling tuna supplies of the Indian and Pacific Oceans. Russian, Chinese and Japanese governments sent naval support to their tuna fisheries in the western Pacific and Indian Ocean.

The potential collapse of international markets for fossil fuels owing to disputes over emissions trading, widespread civil and military unrest, climate-induced disasters and the consequent collapse of the insurance markets, meant that governments struggled to maintain law, order and social cohesion.

The US occupied Venezuela in 2023; this was quickly followed by the Chinese occupation of Burma in 2024. In both cases, the action was driven by security concerns in their region as well as the need to protect the value of their own emission permits and technology advantages. For the same reason that Australia, France and South Africa in 2004 sent warships to the Antarctica waters to protect fish stocks, these countries also participated in joint military interventions to protect their share of global carbon dioxide emission permits. The threat of other countries following suit eventually lead to the establishment of the Global Climate Mechanism (GCM).

The GCM Era (2025 – present): The rise of the Global Climate Mechanism

In 2025, the UN Security Council established a Global Climate Mechanism (GCM). The impetus for this move was as much about economic security concern as environmental and social concerns. Resolution 3106 (2025) Adopted by the Security Council at its meeting, on 20 November 2025 established ‘a global and enforceable mechanism – the Global Climate Mechanism – to immediately control the further release of greenhouse gases and reduce global CO_2 equivalent emissions to a level at least 10 per cent below 1990 levels by 2050’. The key premise of this mechanism was the gradual ramping up of the recognition of the CO_2 value in the life cycle costing of products and services. Under this mechanism, by 2045, the CO_2 value was to be fully reflected in the costs of all products.

Markets for GHG began to operate effectively in some cases, but are still being undermined. The proportion of the carbon market that is a ‘black-market’ is declining, but still significant. At first, the costs of carbon were applied politically, and not equitably, across all sectors and special interest groups to this day continue to influence decisions and argue hardship or special circumstances. Within the first decade of the GCM, however, a stable international CO_2 permit system was operating under a global-cap-and trade approach.

Approaching 2050: Society cannot cope and social cohesion is lost

For much of the past 50 years, long term adaptation and mitigation measures have been displaced by shorter-term needs. Some economies have gone into collapse as climate change impacts their economy and social order. Responses to short-term crises continue to constrain international growth and trade. Consumer confidence weakened across the OECD and short-term investment patterns emerged more strongly as US pension funds, in particular, hit a long period of negative returns during the period 2025 to 2045. The funds for long-term infrastructure investment and climate adaptation are simply not available.

In 2018, marketing companies defined the “Day after Tomorrow Generation” as a cohort of 15-20 year olds who believe that, for the first time in thousands of years, human social and economic progress is in rapid and irreversible decline. Furthermore it is their unbelievably wasteful and shortsighted parents and grandparents that are to blame.

The rise of the black markets for fossil fuels, widespread civil and military unrest in the 2020s and increasing rate of climate-induced disasters meant that governments struggled to maintain law, order and social cohesion.

Resource security became the key driver of global politics by 2030. The export of water from Canada to the US became the world's largest international water trade deal in 2037 – significantly easing tension between the two countries. In a deal referred to as the UN Fish for Land Program, five small island states in the Pacific and Indian Ocean were purchased by Australia, the US and Japan in 2039 order to obtain their fishing rights in exchange for re-settlement of their populations.

By 2050, the 46 year old DATgenners have grown ever more pessimistic. The number and popularity of both the Genesis and Revelation Churches soars as people seek spiritual answers for the world's problems. The Revelation Churches promote the concept that climate change was foretold in the Bible, and is a welcome harbinger of the world's end and eternal salvation for the chosen. The Genesis Churches, on the other hand, promote the story of Noah and argue that a new and sustainable world civilisation will appear from the corruption and excess of the past.

It is clear to all, however, that the economic and human cost of severe weather events is on the increase. The most significant impact of this has been the intense debate on whether to continue investing in mitigation measures for the long-term benefit of society (a view favoured by the Genesists), or to spend the same funds in adaptation measures to alleviate present suffering and cope with short term crises (the favoured view of the Revelationists). This same philosophical divide is played out between the major political parties and sections of society – the old dichotomy of 'right' and 'left' wing politics being long past. Deep divisions appear as these fundamentally opposed ideologies compete.

Headline News

Perth Limits Population Following Water Shortages

7.4.2 The Australian Story

7.4.2.1 Climate change

The current and future impacts of climate change in Australia are well understood by 2050. Although increasingly severe, they are nowhere as severe as experienced by the more densely populated regions of the world, particularly in the low countries of Europe, the east coast of America and the Caribbean Federation, the Gangetic Plains of India and Nepal, and the megalopolis of Greater Beijing. In these densely populated regions even relatively moderate climate change impacts are having a significant effect on society.

CSIRO modelling on the impacts of climate change during the first decade of the 21st Century prove to be remarkably accurate. There have been severe impacts on sensitive ecosystems. The last ski run in Australia closed in 2026 and snow has not been recorded on a regular basis in Australia since. Coastal inundation has seen large parts of the northern coastline disappear. Large saline lakes develop throughout much of the Murray-Darling Basin. Coral bleaching of the Great Barrier Reef is now an annual occurrence, and the reef ecosystem and much of the tourism it supports is not expected to exist for much longer. The opening of the first Club Med on the mostly ice-free Antarctic Peninsula, however, has proved popular with those that can afford the once in a lifetime opportunity of an international flight.

Consistent with early climate change projections from CSIRO, annual average temperatures were 1.2°C higher in 2030. Given the excellent correlation between CSIRO's model predictions and actual happenings to date, it appears that by 2070 temperature may increase by a further 2.0 to 4.0°C relative to 1990. Predictions of run-away climate change have not eventuated, but cannot be dismissed as a future possibility.

There have been substantial reductions in autumn, winter and spring rainfall (the main rainfall seasons) for much of southern Australia, particularly in the south west of Western Australia. In northern Australia increases in summer rainfall (the main rainfall season) have been recorded for some regions. In most areas an increase in rainfall intensity has been evident even where decreases in rainfall have occurred.

Overall, the climate is more variable and unpredictable in Australia, with increased incidences of extreme events such as fires, floods, droughts and tropical storms.

One of the greatest concerns for policy makers and planners in 2050 has been the lack of a coordinated and early response to adaptation. Failure to invest in water saving technology, recycling and grey water management in Australia on a widespread basis, for example, has left Australia's water supply system fragmented and unreliable. The costs of adaptation are high and constrained by available funds. A significant proportion of Australia's capital is tied up in many private and public assets invested around the time of the advent of the GCM, which now have become stranded.

As a result of the actual and predicted impacts of climate change, coupled with recent and massive increases in energy prices, Australia's population distribution in 2050 is quite different to that of 2025 as people believe they will not be able to live in many parts of Australia due to future changes in water availability, livelihood opportunities, or the costs of insurance against climate change induced disasters. Long-distance travel is prohibitive for many Australians and a major imposition on rural economies.

The 'sea change' communities, which formed ribbon developments on the coasts of NSW and Victoria during the decade to 2010, were hard hit as storm surges resulted in regular flooding. With insurance unavailable most of these communities were abandoned, resulting in a drift back into the major cities. Many formerly wealthy individuals saw their investments disappear as property became almost worthless.

In 2025, Melbourne, Adelaide and Perth imposed population limits as a result of severe water stress, but appeared to be coping after decades of strict water restrictions. Sydney on the other hand was forced to make huge investments to secure water supplies through the building of desalination plants – the first being completed in 2010. The energy required to operate the plant also contributed further to greenhouse gas emissions.

7.4.2.2 Infrastructure and the built environment

In 2030, in a joint project with the Dutch Government, a dyke was built across the Sydney Heads. This $40 billion project was paid for by a one-off $10,000 property tax and was designed to protect Australia's largest capital asset – Sydney waterfront real estate.

Urban settlements in many areas of Australia have become unsustainable due to the costs of adaptation. Parts of inland New South Wales, parts of southwest Western Australia, Darwin, and coastal northern Queensland have been substantially depopulated, or replaced by seasonal itinerants.

In Australia, communities drift away from some badly affected regions, only to be replaced by itinerant and immigrant communities until the next climatic disaster. In some parts of Australia the "Dreamtime Movement" has been successful in re-establishing sustainable patterns of living based on Aboriginal practices, but these reflect a tiny proportion of the total population. Frequent clashes occur between the "New Settler Movements" from inundated regions of Indonesia and the "Dreamtime movement". By 2040, under pressure from the UN, Australia established the Kimberley region as the basis for a new Indonesian colony and began an orderly re-settlement scheme.

Significant ecological limits (for example, water and productive land) have now been reached that have effectively limited further growth in sectors heavily dependent on natural resource inputs. Sectors moderately dependent on natural resources (eg tourism) are also impacted and strong constraints are now imposed on urban expansion by lack of secure water supplies.

Many agro-ecological systems in Australia have collapsed and are no longer capable of providing for society (food, fibre, shelter, water). Although Australia has not run out of food, there is little surplus left to export and the imposition of carbon taxes means that most Australian agricultural exports have been priced out of global markets. Beef, for example, has become a high cost luxury item with very limited production, as realistic water pricing and carbon taxes have put the cost out of reach of most domestic consumers.

Biological systems are managed to act as carbon sinks on an ad hoc basis. This was partly a failure of planning, but also a factor of the unpredictability of the weather – for example forestry plantations were abandoned as carbon sinks in 2035 as they could no longer be guaranteed water at a reasonable price over a 50 year harvest period and were subject to frequent intense fires.

7.4.2.3 Energy

Australia's energy infrastructure system in 2050 is changing but the market structure is not substantially different from the early 21st Century, with generation generally owned by a few major operators. The supply mix has changed substantially following the strict emissions targets imposed in 2025. The requirement to rapidly reduce emissions meant late adoption of zero CO_2 emission technologies, which relied heavily on subsidy.

In Australia, the Coalition of Organised Australian Labour Parties (COAL) narrowly lost power in the 2022 Federal election to the Liberal New Green (LNG) Coalition. Elected on the platform of "a new green industrial revolution", the LNG Government responded positively to the GCM and began to develop enabling legislation and powers to control carbon dioxide emissions. One

of the responses to the global GCM emission limits by the Federal LNG Government in Australia was to introduce significant carbon taxes in 2025. These taxes initially applied only to stationary energy sources (a measure vociferously opposed by COAL) and by 2045, all goods and services were taxed on the basis of their carbon intensity.

A mixture of renewable energy sources supplies electricity in 2050, old and new coal technologies almost all involving carbon capture and storage, and gas co-generation.

The progress on development of very low emissions or zero emissions technologies was slow in the early years due to the lack of facilitation and the inadequacies in the volume, as well as penalty costs for the various mandated schemes for the greenhouse gas abatement, such as MRET, NGAC in the early 2000s. Government and industry assistance in the development of these new technologies did not result in major scale deployment of these new technologies. Subsequent increases in the mandated schemes, as well as the GCM, have enabled some large-scale developments of very low emissions technologies. However, some new developments still require subsidies to remain competitive with more established, and hence larger scale technologies.

7.4.2.4 Transport

In 2050, the era of private transport is virtually over. The last petrol engine cars were sold in 2037, but the cost of fuel sees their use largely limited to ceremonial purposes, such as Presidential inaugurations. Mass urban transit and hydrogen-based personal transporters operate throughout the major urban regions, but long journeys in private vehicles are simply unaffordable. Given the vast distances in Australia, much of Australia's carbon credits are consumed by the freight, shipping and air transport sector, albeit in highly efficient hybrid engines. Interstate road-rail combined transport systems carry people and goods in a manner that is orders of magnitude more efficient than in the early 21st century.

The gradual decline and eventual cessation of mass international tourism to Australia coupled with the prohibitive costs of transport by 2050 have been an added impetus for large parts of the country to be effectively abandoned.

7.5 Atomic Odyssey

It is 2050 …and greenhouse gas emissions have been reduced to 50 per cent below 1990 levels, led in large part by a landmark accord in 2010 between the US and China (with many others subsequently joining) to substantially reduce greenhouse gas emissions.

Australia joined the alliance and implemented an emission-trading scheme in Australia which sent the necessary price signals to bring about investment in low-emission infrastructure.

After it became clear in the mid 2010s that carbon capture and storage was not going to be successful, and the continued used of fossil fuels would not allow longer-term CO_2 targets to be met, baseload power production is now largely provided by nuclear facilities and supplemented by gas fired and renewables. The early adoption of nuclear technology was eased by a major technological breakthrough that allowed the heat from nuclear reactors to become the economic energy of choice for hydrogen production.

Concerns over the storage of waste material or its potential use in weapons are outweighed by the ability of nuclear power to cut greenhouse gas emissions. There have also been some promising technological breakthroughs in fission waste disposal and fusion generation technologies.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
There are significant technological innovations, as a result of carbon capture and storage (CCS) proving unviable. Nuclear power is more efficient; hydrogen is co-generated from process, and waste disposal costs fall.	The geopolitical landscape is stable. Global confidence in the deployment of nuclear power for peaceful use improves as a result of the UN effectively implementing the nuclear non-proliferation treaty.	An efficient and effective governance structure for dealing with climate change exists. The early start to effective abatement means that subsequent measures have greater impact.	There is an overall improvement in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves.

7.5.1 The Storyline

7.5.1.1 The Rise of Nuclear Energy

It is the year 2050…and the commitment to nuclear as a significant pathway to reducing atmospheric CO_2 concentration provides the impetus for building third-generation nuclear plants as the interim step, and accelerates the development and subsequent deployment of the fourth generation machines with significantly improved fission waste disposal capability.

Thanks to the early adoption of nuclear by some countries, the technology developed strongly up to 2015 when its use accelerated significantly. Nuclear facilities gradually provided the

backbone for baseload power production, replacing the current stock of coal-fired plants once these plants passed their useful economic life in a carbon-constrained world.

Baseload nuclear capacities are supplemented by gas-fired and renewables, and are more likely to be located along the coastal areas for water-cooling, but also to provide the energy source for potential water desalination and hydrogen production plants. A major technological breakthrough allows the heat from nuclear reactors to become the economic energy of choice for hydrogen production.

In the longer term, major breakthroughs in nuclear fission waste disposal methods and the success of nuclear fusion will enable the widespread development of power stations in developing countries, which are still reliant on fossil fuels as a primary energy source. The world is on a path to a sustained economic development towards 2100.

Similar to the Cultural Revolution scenario, the Atomic Odyssey scenario sees:

- The major greenhouse gas emitting nations cooperating to reduce emissions by 50 per cent below the 1990 baseline by 2050
- A global market for CO_2 established and working from very early in the period
- A stable geo-political situation
- Urbanisation continuing unabated

Headline News

MIT Announces Trial of Radical Nuclear Waste Disposal Technology

7.5.1.2 Nuclear Non-Proliferation Treaty (NPT)

Despite the lack of progress of the previous 5-yearly reviews of the Nuclear Non-Proliferation Treaty (NPT), participants persevere.

A breakthrough during the 2005 discussions led to a renewed confidence of international co-operation. This review established an action plan that included clear and unambiguous obligations by the participating nations under the treaty, a mechanism for the robust control and verification of nuclear fuel and wastes, and the establishment of a global framework on nuclear counter-terrorism.

The 2010 review represented a watershed in global cooperation with respect to nuclear waste and counter-terrorism. The International Atomic Energy Agency was given real power to prosecute countries for breaches of the control and verification framework, and the United Nations Secretary General was given direct responsibility for the successful deployment of the Global Counter-Terrorism Taskforce.

There has also been a fundamental change in the global energy infrastructure systems.

The early adoption of the full range technologies that support near zero emissions has seen pre-2010 infrastructure phased out of and a portfolio of energy generating sources introduced.

The foresight in keeping available all power generation technology options paid very early dividends.

By mid 2010s, it was evident that the technology for carbon capture and storage (CCS) was not going to be a major success, and a prompt move into nuclear technology was required if the longer term CO_2 targets were to be met. Nuclear technology could be accelerated, thanks to the lessons learned in the continuing deployment in major countries experiencing rapid increase in electricity demand, such as China, India, South Korea and South Africa, as well as established nuclear powers, such as Britain.

The success of the NPT and efforts to eradicate global counter-terrorism, also played an important part in the increased deployment of nuclear power.

In addition, the breakthroughs in technologies have allowed co-production of electricity, water and hydrogen from the same atomic energy source. This has a tremendously beneficial impact on the energy conversion efficiency, limiting the waste energy. The low-cost water desalination plants located in the same energy parks as the power stations are ideal for cities such as Adelaide and Perth that are facing limited renewable generation sources and water storage.

Policies still support the continued reduction of CO_2 emissions, and decisions makers are today clear about their future responsibilities when choosing technologies.

While climate change policies are the principle driver, wider sustainable development and energy security concerns are also factored into energy policy. The policies that supported this concentrate on the long-term need for emissions reduction and allow investors at both private and government levels to select the appropriate technology for their region. These decisions take into account the emissions profile required over the life of the investment and use market forces, government subsidies and targets to follow the lowest cost abatement while meeting the long-term target.

7.5.1.3 The Australian Story:

Natural environment

Severe impacts of climate change on sensitive systems continue to be experienced but major agro-ecological systems remain capable of providing for society (food, fibre, shelter, water).

Biological systems are managed as carbon sinks, and the impacts of climate change on vulnerable peoples is planned and addressed (for example, communities are relocated or sea walls constructed). The costs of adaptation are known and planned.

Built environment

Australia's population distribution follows the trend of continuing urbanisation and coastal strip development.

Other energy sources

Renewables are part of the overall energy mix, but they are not sufficient to cater for the majority of power needs. The move to nuclear as a fossil fuel replacement commenced from around 2020; fossil fuel plants were phased out as they become uneconomic. Transport energy is now significantly dominated by hydrogen, with plentiful supply from atomic reactor co-production process. At the same time, the use of distributed energy increased.

Transport

Congestion taxes, parking levies and the price of carbon is factored into the price of fuel at the petrol pump; this has led to an increase in demand for mass-transport systems.

Overall transport needs have declined with widespread ultra-broadband communications and the acceptance of video interaction as a replacement for face-to-face meetings.

Freight movement is dominated by rail transport. Air travel is still based on fossil fuels and costs are high, resulting in reduced demand.

Society and culture

Genesists – or those that believe in the future – dominate society. Consumer preference is strongly directed towards low carbon products, and the public attitude to nuclear has changed dramatically from the largely negative view held at the beginning of the 21st century. Three factors drove this thinking: an increased concern for climate change, a concern for the cost of coal with no CCS, and technology breakthroughs in nuclear waste disposal for nuclear.

One measure of the success of the planning and ensuring action is the reducing trend in the costs of emergency activities, including insurance costs following extreme weather events.

7.6 Cultural Revolution

It is 2050 …and greenhouse gas emissions have been reduced to 50 per cent below 1990 levels. This is a direct result of the reassessment in the early years of the 2010s by the United States government of the geopolitical landscape that led to an alliance between the US and China (with many others subsequently joining) to substantially reduce greenhouse gas emissions.

Australia joined the alliance and implemented an emission-trading scheme in Australia which sent the necessary price signals to bring about investment in low-emission infrastructure.

The success of this alliance has had a general calming effect on global political stability. Australia has benefited from such stability and has developed a 'can do' culture around managing and prioritising business activities to achieve sustainable outcomes for the community. As a result, energy end-use efficiency improvements have accelerated well above predicted levels.

Driving Forces

Innovation

There are significant technological innovations.

Geopolitical Stability

The geopolitical landscape is stable. This leads to high world economic growth and improved standards of living.

Climate Change

An efficient and effective governance structure for dealing with climate change exists. The early start to effective abatement means that subsequent measures have greater impact.

Sustainability

There is an overall improvement in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves.

7.6.1 The Storyline

It is the year 2050…and actions taken in response to forecasts over the last 50 years of adverse climate change are having a significant effect on the globe.

The global community has achieved reductions in greenhouse gas emissions (measured in CO_2 equivalents) of 50 per cent from the 1990 baseline. The policy framework, systems, technologies and research efforts in the past 50 years have contributed to this success as well as creating a regime where continued reductions will continue over the next 50 years with the aim to achieve 90 per cent reduction by 2100 and stabilising the global mean temperature change below two degrees Celsius.

In 2050 the global economy is in a period of good growth and productivity, although there are still areas of poorer local economies due to local governance procedures rather than global influences. Australia's economy remains in the top quartile in terms of performance, but still small on a global scale. Trade is open but there are differences in 2050 from 2000 in the types

of goods and services traded. These are increasingly characterised by the progressive demand for commodities and services used for adaptation and mitigation of climate change effects.

7.6.1.1 International 2010 Accord

The driving force behind the reduction is the coordinated and collaborative approach of the now dominant nations. In the landmark Accord of November 2010, the nations that were predicted to contribute 80 per cent of the global emissions in 2020, signed a negotiated agreement for coordinated international action, with a global 50 per cent reduction target by 2050.

The agreement also stipulated interim targets at the end of each decade to ensure that the 2050 target would be met. The interim targets were principally based on increasing reductions to be met by cumulative actions taken from prior years and would be equal to 10 per cent by 2020, 20 per cent by 2030 and 35 per cent by 2040. Inter-temporal allowance trading in the years leading up to 2050 was factored into meeting these targets, that is countries or businesses could buy options for the future if this was judged as more cost effective. Subsequent meetings in 2030 set an even greater target for 2075.

Throughout the 21st century, a number of developed countries, and in particular Australia, contributed financial resources and co-operated to facilitate research and development in existing and new technologies. These technologies have the potential to radically lower CO_2 emissions intensity from energy-related activities in both the short and long-term. Results have been very encouraging, giving policy makers further confidence in setting the framework for CO_2 reductions that could be feasibly delivered without detrimental effects on the world economy.

It was, however, the 2010 event that precipitated a significant change in the levels of action and commitment for R&D, implementation and a supporting policy regime to tackle the challenge of climate change. The final step was a change in attitude by the US Senate.

This change in attitude by the Senate reflected the change in the American population's perception. The key to the latter's change is unknown, but some claimed it was the 2008 Hollywood blockbuster *The Giant Panda* that revealed the technological and political advances of China allowing it to become the only world superpower. Others have claimed the 'Call to Climate Responsibility' campaign by evangelical religious leaders and groups also had a significant impact.

The negotiated agreement has had far reaching benefits, not fully appreciated at the time of signing of the original agreement.

7.6.1.2 A strong alliance and a global carbon market

An outcome of the 2010 Alliance is the global market mechanism for carbon, which captures the total carbon intensity for domestic and traded products. This has resulted in the full cost of carbon being included in all products; for example, a steak for sale in the United Kingdom now includes the costs of carbon used in the production and transport of the beef to market. Consumers now show a strong preference for low carbon intensity products, supported. at least in part, by the full costing of carbon in the price of goods.

The Alliance also recognised that near emission technologies need to supply most of the energy by 2100, and in order to meet these goal nations undertook significant actions to increase the share of extremely low emissions technologies in their energy mixes. The encouraging emergence of new carbon emission free fuels, particularly hydrogen, for use in industrial, domestic and transport processes, gives further confidence to the achievement of the 2100 targets without significant impeding world growth.

In 2012, the EU, and the G10 Countries outside the EU, agreed, in the spirit of the November 2010 accord, to mandate fossil fuel-based greenhouse gas emissions from transport vehicles to 70 per cent of the 2005 levels by 2025, averaging three per cent improvement per year, with further deep cuts to 20 per cent by 2035, averaging five per cent pa. Following this lead, most countries adopted similar policy framework by 2020, using various levels of efficiency improvement benchmarks, to suit their own particular situations. In 2015 the EU and G10 countries also finalised a mechanism to optimise the distance travelled by domestic and small transport vehicles, while still satisfying people's needs for mobility. The vehicle registration and insurance charges based on the previous year's kilometres travelled appeared to be a success, with the emissions inventory for the year 2018 showing a marked reduction, with little adverse reaction from motorists.

An additional benefit is that the Alliance of nations has led to a planned approach to adaptation for climate change. Areas affected by the change in climate, whether they be areas subject to more frequent extreme events or a sustained change in regional climate, have been systematically addressed. The funding for this has been through a global fund and prioritised on areas of need irrespective of the national contribution to greenhouse gas emissions. Examples include the installation of sea walls in Bangladesh, Sydney, Brisbane and Perth, and the orderly long-term movement of people out of the south west of Western Australia to new areas of agriculture productivity. Australia's population distribution follows the trend set in 2000 of continuing urbanisation and development of coastal strips. One measure of the success of the planning and action is the reducing trend in costs of emergency activities, including insurance costs, following extreme weather events.

While the realisation of climate change has had severe impacts on sensitive ecosystems, the major agric-ecological systems are still capable of providing for society (food, fibre, shelter, water). While coral reef systems are in significant decline, people dependent on these systems have been compensated for damage caused and have been helped to move from tourism and fishing based communities. Biological systems are now routinely managed to act as carbon sinks.

The strength and stability of the political alliance in 2050 that maintains the regime for continued reduction in emissions, comes from the incident in 2024 where India did not meet the agreed requirements for starting its reductions programs and tried to continue its 'business as usual' growth pattern of the previous 25 years. India found the previously accepted political bargaining processes were not supported, with its traditional allies instead supporting the international accord. This event was the most serious test of the enforcement mechanisms put in place in the three years after the 2010 alliance. The leadership showed by China and the US, together with the powerful international broking undertaken by the president of Nepal, truly signalled the new era of international co-operation with respect to climate change.

7.6.1.3 Built environment

In 2050, all urban planning decisions take into account the long-term greenhouse implications; public transport, cycling and urban sustainable villages are the norm. Light rail networks been established in all major urban settings and there is an emphasis on rail transport for freight and long-distance travel.

During the latter part of the 21st centuries, epidemics of asthma and respiratory diseases choking the health facilities in Paris and Los Angeles, and which were causally linked to the poor air quality, forced a reappraisal of the total societal cost assessment of isolated policy formulation process. This resulted in further extension of the odds and evens system for cars (that is, odd number plates for travels on odd days) to outside the metropolitan areas of Los Angeles, as well as major provincial cities in California. Following the orderly application of this law, major cities of the world followed suit, and by 2015, this system was operational in world cities with populations greater than three million.

Headline News

Low Emission Pioneer Names as Highest New Entrant to Fortune 100

7.6.1.4 Energy

There has been a fundamental change in the energy infrastructure systems of the world. The early adoption of the full range technologies that support near zero emissions has seen the orderly phase out of pre-2010 infrastructure and a stable portfolio of energy generating sources now operating in 2050.

Policies still support the continued reduction of CO_2 emissions and decisions-makers are clear of their future responsibilities when choosing technologies today. While climate change policies are the principle driver, wider sustainable development and energy security concerns are also factored into energy policy. The policies that supported this have concentrated on the long-term need for emissions reduction and allowed investors at both private and government levels to select the appropriate technology for their region. These decisions have taken into account the emissions profile required over the life of the investment and have used market forces, government subsidies and targets to follow the lowest cost abatement while meeting the long-term target.

The successful demonstration of carbon capture and storage (CCS) technologies early in the period was instrumental in enabling the large-scale change to near zero emissions power generation for baseload power generation. This technology is particularly important for Australia. However, CCS is not the only technology used and, like the rest of the world,

Australia chooses its energy mix from a full range of renewable and nuclear technologies, optimising its energy supply to meet its demand profile.

A further technology improvement in the drive for low CO_2 emission power generation technology was the successful demonstration of a large-scale power station having significantly improved combustion efficiencies, resulting in CO_2 emissions lower than that achieved by the Combined Cycle Gas Turbine (CCGT) technology of the early 21st century. As the pioneer in this technology, Australia took the lead, and was soon followed by other developed countries, in developing policy framework for new power generation developments. This policy called for any major power generation projects commissioned by 2015 to have a CO_2 emissions intensity of less than 300 kg/MWh, with a demonstrated plan to reduce this to 100 kg/MWh by 2030, which was also the benchmark level for new major plant commissioned from 2030. This technology breakthrough reduced the cost of CCS where that could be added, and where CCS was not possible it could still contribute significantly to the CO_2 reduction goal.

The technology ride has not been a smooth one with many entrepreneurs having chosen technologies that did not make the grade. On the other hand there is a new generation of the powerful (the Chilean Santonis and the Indian Singhs being the new Rothschilds) whose investment decisions, in hindsight, were the right ones. The survival of these technologies will be dependant on their ability to meet the future emissions reductions regimes. The advantage for this generation over those in 2000 is that the policy regime in which they have to work takes into account the cost of carbon.

7.6.1.5 Transport

Similarly in transport, people need for individual mobility has been maintained with the new ‘pods’ but the carbon emissions from these sources of mobility are nearing zero. The gas guzzling cars of the previous century are now the preserve of history.

The breakthrough in transport followed the change in rules to Formula 1 racing in 2015, which only allowed the GHG emissions equivalent of 50 litres of fuel for the entire 4-day race. Since 2030 the advances made from the Formula 1 racing were everyday in personal mobility. Today, Formula 1 racing still exists with a zero GHG emissions requirement for the 4-day race.

Initially, a number of developed countries mandated that road and sea transport systems must continuously improve on their annual benchmarks. The air transport system, however, was not subject to this mandate, on the basis that fossil-based fuels continue to be the primary source of energy for the world’s fleet of jet transport. Air travel in the year 2050 is an expensive undertaking, given that this is still one area where the CO_2 intensity, given that the fuel is still petroleum based, is still high which reflects in the high cost of travelling.

7.7 Clean Green Down Under

It is 2050 …and Australia is a leader in clean green solutions and respected worldwide for its role in the climate negotiations of the 2020s. There has been a paradigm shift in how it considers (and measures) its economy. Social, environmental and ecological sustainability measures are now routinely taken into account. All decision-making incorporates lifecycle costing, including environmental and social effects. The push towards low resource use has transformed production and lifestyles have moved away from consumer goods towards leisure, quality time, and family. Participatory democracy is at an all time high. The 'throwaway society' has reinvented itself.

The energy system has been transformed, with energy services provision and distributed generation the norm. Demand management and energy storage techniques have become so sophisticated that base and peak load are close, and worries about intermittency are trivial. Renewable energy technologies dominate on the supply side.

There has been a revolution in energy efficiency in buildings, appliances, and equipment, with energy and resource intensity at a low level unimaginable at the start of the century. Zero energy buildings are the norm. Innovation has spilled over into all sectors of the economy, and the rate of technological change is doubling every 12 years.

The emphasis on education and accelerated innovation has helped make real the transition to the knowledge economy, and the rest of the world bemoans the 'brain drain' to Australian shores.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
Significant technological innovations	Stable	Global management regime, effective	Improved sustainability

7.7.1 The Storyline

The late 2000s found the world both changeable and uncertain. Globalisation was fast being replaced by bilateralism with trading bloc arrangements and economic communities being formed. Many in the world were fearful of the future. Terrorism and national and international unrest continued to increase with major ideologies flexing their muscle – both religious and political – for the inevitable showdown. Environmental degradation, most notably the degradation of water, and high fossil fuel consumption was a rising concern. Climate change was starting to bite.

The global gap between rich and poor was increasing and living standards on the African continent and in Central Asia and South America were deteriorating. A series of events hit hard:

- Devastating European weather events in 2008 and 2009
- Famines in India and much of Africa from 2006 to 2009
- A humanitarian crisis in China in the spring of 2010.

As a consequence, a Kyoto II treaty, with overall 20 per cent reduction in emissions below 1990 levels by 2025, was brokered.

The Kyoto II Agreement included a mechanism – brokered by China – to support the accelerated development of the poorer nations, including Bangladesh, North Korea and Myanmar, and to provide low emissions technology assistance to the emerging nations of Indonesia, Pakistan, Malaysia, The Philippines, Thailand, Cambodia and Vietnam.

The more developed nations, including China, Japan and Australia, accepted stricter emissions reduction targets in excess of 20 per cent to drive further R&D investment following recent breakthroughs in photovoltaic technology, hydrogen transportation and agricultural methods. The developed nations would also invest low emissions technology into the developing nations with zero interest funding in return for tariff-free trade within the trading bloc.

The optimism following the Kyoto II treaty in 2012 was short lived, for in 2014 an unusually severe El Niño coincided with high average temperatures in the Indian Ocean.

By early 2016 the predicted collapse of many reefs, including the Great Barrier Reef and the Maldives, had occurred.

Litigation was filed against large companies by island and other states directly affected by cropland inundation and severe food and water shortages.

In the face of continuing instability and growing resources scarcity, the UN established the Global Equity Commission in 2020. The Commission set up the Global Resources Utilisation Bank (GRUB), a fund that collected contributions from richer nations to infrastructure development projects in developing nations.

Under Kyoto II and the New GRUB supported by China, India, the US and the EU, committed to significant and coordinated investment in R&D. Major breakthroughs in solar technology, photovoltaics and hydrogen production were achieved.

In May 2030, the first large scale, low emission, transport ship was launched in Bombay. By 2038 these super ships were running on most established trading routes. By the mid 2040s, emissions were down to 48 per cent of the 1990 levels and there were early signs that the carbon intensity in the atmosphere had peaked.

7.7.2 Australian Story

Unexpected events linked to climate change, early in the century, laid the groundwork for development of a new policy direction centred on sustainability in Australia. In 2010, a Genuine Progress Indicator (GPI) replaced GDP as the means of measuring Australia's national accounts. Successive governments, swayed by vocal public views, built on this change.

Headline News

GDP or not to GDP? What Makes the GPI a Better Measure

The loss of the iconic Great Barrier Reef coupled with an 'enduring drought' further changed the political landscape in Australia.

Lifestyles changed towards quality rather than quantity – quality time, a slower pace, greatly enhanced participation in leisure, sport, and the arts, and an emphasis on enjoyment rather than consumption. Status was reflected in what people did and what they made or recycled, rather than what they bought, wore, or drove. Intensive consumption became very 'uncool' and was considered old-fashioned – indeed, the 'low consumer' lifestyle had great chic attached!

Successive governments responded by dramatically increasing national emissions target to an 80 per cent reduction by 2050.

7.7.2.1 Natural Environment

The rapid and early barrier reef collapse in 2015 had a major effect on the Australian psyche, with habitat protection and enhancement assuming vital importance. The fact that scientists had warned the reef could collapse and government took no action made the public reaction particularly strong.

In the following decades, the public widely debated:

- Reforestation, with areas permanently set aside becoming widespread, partly funded by carbon credits.
- Biodiversity Conservation Legislation for protecting threatened and endangered species
- The impact of salinity on agricultural production and a more general 'rethink' of Australian agricultural systems
- A moratorium on land clearing and a major investment in restoring natural landscapes
- Access to energy guarantees, with special provisions made for low-income earners.

By 2050, nearly all food is grown without petrochemicals because of carbon taxes and the high value placed on habitat protection. Pesticide and herbicide use has been replaced by finely tuned biological control and concentration on healthy agricultural ecosystems. Much of our food is now grown in the catchment where it is retailed.

All annual crop systems include bands of woody coppice to provide structural diversity, shelter, salinity protection, and a bio-energy crop. Indeed, some 10 million hectares of woody species were planted for salinity control between 2010 and 2020, with the secondary benefit of bio-energy provision. The planting was funded in part by salinity credits.)

7.7.2.2 Built environment

Major urban redesign was undertaken between 2008 and 2020. This followed the interest of the early 21st century in sustainable cities, but engaged the whole community and committed serious resources to change.

There was increasing frustration with urban congestion and associated poor health in the first decade of the century, with a vision of escalating deterioration as city populations swelled.

By 2050, cities have been redesigned as a series of interlinked communities, with more people living within walking distance of work, shops, and a major public transport node. Public spaces are primarily for people, and the space previously relinquished to traffic and parking has been converted into spaces to relax, garden, or meet.

Communities incorporate a mix of living styles and demographics; community-housing cooperatives cater to a range of demographics and housing modes are more common. Community gardens with a major element of permaculture are now commonplace, largely resulting from the zero waste policies instituted in 2020, which meant that all organic waste would be composted.

Water efficiency and recycling are integrated into all urban and building design, including improved technology for capture, storage and treatment of water.

7.7.2.3 Energy

In 2010 the new Federal Government started their sustainability drive with a ‘Kyoto plus’ target of returning emissions to 1990 levels by 2020, and a Mandatory Renewable Energy target of 20 per cent by 2020.

A national carbon-trading scheme was introduced in 2010. Following intense negotiations, the Federal Government agreed to accept an emissions target of 25 per cent below the 1990 level by 2025 in the lead up to the Kyoto II negotiations. In return, Australia received access to the markets in the Asian trading bloc to invest in recently developed low intensity technology and photovoltaics.

After the collapse of the Barrier Reef in 2015, Federal and State Governments held crisis talks to fast track further greenhouse measures. Between 2018 and 2035, successive Australian governments committed to a domestic emission target of 80 per cent reduction below 1990 levels by 2050, with progressive cuts until that date.

By 2050 the energy system has been transformed. Energy intensity of the economy is at a level barely imaginable 50 years before. The stationary energy sector made the easiest transition to ‘clean and green’: most buildings are net energy exporters, and communities look to an imaginative mix of energy efficient design and distributed generation.

Innovation in response to regulation and the rapid rises in energy prices from 2005 to 2020 meant that equipment delivered the same services while consuming much less and sometimes as little as one per cent of the previous energy take. This spilled over into innovation in non-energy sectors of the economy, with dramatic improvements in the rate of technological improvement.

Some energy intensive manufacturing industries did not survive the transformation but others exploited the value of recycling and minimising waste. The paper industry, for example, substantially reduced dependence on virgin timbers and developed more effective techniques to reuse paper at a fraction of the energy cost.

In the energy sector, incentivised R&D initiatives led to early commercialisation of low emission technology. Coal gasification and liquefaction developments provided a stopgap measure for plastics and other oil based industries as oil stocks continued to decline. They also provided reliable fuel for gas plant and other industrial uses during the transition period from reliance on fossil fuels to renewables. Note: carbon capture was considered to be a potential interim measure to assist in achieving the emission target during this period.

The concentration on R & D and the new emphasis on the skills economy ultimately enhanced Australia's reputation as a world-class innovator. This eventually led to significant export revenue streams. For example, by 2040 Australia became the major exporter of PV and biomass technology, as well as a number of low cost energy storage systems for integration into electrical equipment. The emerging frictionless travel also created much international interest. Overseas developments in ceramic technologies allowed for further efficiency gains in electricity distribution, motors and electronic components.

Concurrently, management of energy demand reduced peak load to no more than 1.2 times baseload, and the 'spikes' of the early century are considered shockingly inefficient. Managing intermittency has become much less problematic.

Remote disconnection arrangements are now taken for granted, and are invisible to the user as improvements in internal storage systems for equipment mean that loads can be effectively spread. Excess supply times are automatically used to 'top up' internal storage for equipment and vehicle charging. Distributed generation solutions, particularly small fuel cell cogeneration systems, are also used as load equalisers, as hydrogen is generated on site at times when there is excess capacity in the system.

There was a similar revolution in energy efficiency for both buildings and equipment. Post 2030, all new housing and business developments were required to be net zero energy unless special dispensation was obtained from planning authority.

Performance standards are in place for electrical equipment – the '1 Watt' standard became mandatory for all equipment from 2025, reducing progressively to 0.1 W by 2040. Many manufacturers chose to leapfrog straight to 0.1 W.

Ownership of generation equipment was generally decentralised, with a mixture of individual (for example, micro generation such as PV roofs, fuel cell cogeneration), and community (for example, rural wind farms and neighbourhood biomass cogeneration), and enterprise (for example, hospitals and universities). Wind farms were strategically located around most regional communities and some urban areas in Australia, with community ownership the norm.

Energy retailing has generally been replaced by energy services provision, and most commercial buildings run on facilities management basis.

The march towards lower emissions on the supply side was also strong; all new generators are net zero emitters by 2030. There are fewer coal-fired power stations with solar, biomass and hydrogen fuelled plants taking up the slack. By 2050 the small number of fossil fuel power

plants all use ultra low emissions technology with either ultra clean coal or natural gas, and generally include cogeneration. Geosequestration technology was not extensively pursued as a means to reduce emissions, because of concern about the longevity of storage and questions of liability in the case of storage failure.

Similarly, a renewed debate for nuclear power in the early part of the century, ruled out expansion of this power source because of the unresolved issue of waste disposal.

7.7.2.4 Transport

In 2010 petrol prices jumped to $10 per litre as a result of producer pays legislation and global oil prices. This sent shock waves around Australia, and fed into the 'urban rethink' that was driven by health and liveability concerns to produce a radical overhaul of transport systems.

By 2050 travel choices have undergone radical change. The design of cities means that walking and cycling are the most common urban transport options. Light rail is the fastest, easiest travel route between urban nodes and private cars are very unusual. However, everyone is able to meet their mobility needs to move between homes, work, shopping and leisure locations with ease, affordability and minimum environmental impact – but there has been a considerable reduction of the 'normal' trip length for these purposes.

Improvements in virtual link technology have meant that business travel is considered very old fashioned. Air travel is very unusual, as carbon taxes virtually put it out of the reach of most people. There has been resurgence in international travel by sea, with the development of high-speed low emission ships with communications facilities so that work can carry on uninterrupted.

The tax system was reformed in 2010 after the 'Sustainability election' to progressively remove all incentives and subsidies from vehicle use by 2015.

Minimum fuel efficiency standards for vehicles were set in 2010 after the price shock, and then progressively tightened to 2020. A 1.3 litre engine limit was introduced for all new conventional petroleum/ diesel vehicles from 2020. This was followed by incentives to phase out old (pre-2020) vehicles, and transitional assistance for designated remote communities to convert to low emissions vehicles. At the same time the Government set R&D targets for zero emission transport. Australia became an exporter of some new vehicle technology.

In 2030 zero emission standards were made mandatory for all new private vehicles from 2040 and for all new public vehicles by 2050. As a result, by 2050 most vehicles are powered by solar, hydrogen, biofuels or electricity with advanced storage systems.

7.7.2.5 Society

A Sustainability Commission (set up in 2020) coordinates community and peer review for all policy development and major infrastructure decisions, to ensure policy and programs respect the concepts of sustainability (intergenerational equity and following the precautionary principle), and social well being are not neglected in the emphasis on environmental improvement.

Cities are ‘compact’ – a series of interlinked communities, with more people living within walking distance of work, shops, and a major public transport node.

The health scares of the early 21st century have been reversed – asthma rates in children, childhood obesity) and potentially declining life expectancy; heart and respiratory disease – have been somewhat reversed.

The working week has been shorter since 2025; Australians are now more selective about what they do for work, as ‘meaningful employment’ is important; full employment is achievable if wanted, through job sharing and increased choice of part time employment. Work is more flexible; people work from home, shared ‘work hubs’ and in traditional workplaces.

Australians are generally more technology literate in 2050. Education has improved as a result of the developments in ‘virtual’ technology and a commitment to lifelong learning.

Financial literacy approaches have helped reduce average household debts and a poverty elimination program, started in 2012, has fostered initiatives that have helped narrow differences between rich and poor.

7.8 Rough Ride

It is 2050 …and fundamental differences between various nations' worldviews remain unresolved, perpetuating a cycle of mid-level conflicts and new Cold Wars. With these geo-political distractions the international community has been unable to make any progress toward addressing the world's energy challenge, except with respect to each bloc's own energy security. In this case, the main response has been an increase in the rate of improvement in energy end-use efficiency driven by government legislation.

In Australia, there has been strong growth in public support for energy efficiency and energy savings measures. These increasingly are the focus for governments, planners and for the people of many countries. Technology developments for the military and the 'soldier in the field', involved in interregional conflict, have led to an increase in military research and development spending; some of these technologies are suited to and adopted for broader civilian purposes, for example, solar powered laptop computers.

Australia's economic environment is less healthy than was the case at the start of the century; indeed from 2030 global growth stagnated. Major trade initiatives have ultimately failed and been swept away. This has left the global economy more dependent than for many previous decades on bilateral trading agreements and less open commerce.

Prices of fossil fuels have risen dramatically since the start of the century, but investors are wary of bringing new supplies on line in a more volatile economic and diplomatic environment. Coupled with the continuing controversy around claims for anthropogenic climate change, little effort has been directed to developing energy alternatives, and Australia remains as dependent as ever on fossil fuels.

Driving Forces

Innovation	Geopolitical Stability	Climate Change	Sustainability
Few technological innovations	Instability	Global management regime, ineffective	Sustainability declines

7.8.1 The Storyline

It is the year 2050…and Australia and its energy needs are in a less healthy state than was the case at the start of this century. Major international trade initiatives, chiefly the World Trade Organisation, eventually failed and were swept away. This has left the global economy more dependent than for many decades on bilateral trading arrangements and less open commerce.

The US, in particular, responded in the 2010s to the emerging economic power of China with attempts to build a web of treaties with various allies. To this day, US policy towards China remains characterised by 'congagement' – a combination of engagement and containment.

7.8.1.1 A conflicted world

Conflict has been a recurring issue since 2005. In conditions of fragmented multi-polar power the worlds' economies have proven very susceptible to regional and local conflicts often played out in the form of sanctions and embargoes. Open conflict between India and Pakistan witnessed the first modern nuclear conflict with bombing of major cities on both sides. War also once more became endemic throughout much of the rest of Asia and across Africa. Apart from South Asia, the most critical element of conflict has been renewed 'strategic rivalry' between the US and China from the 2020s, with the dispute over the fate of Taiwan deepening.

China and India did experience solid economic growth during the decades from 2010 to 2030. However, a desire to protect their national economic interests led to open competition, for example in the drive of both countries to build 'blue water' navies to rival that of the United States. China proved unable to sustain high growth; its eventual economic stumble reverberated through the region, slowing economic growth throughout East Asia.

In a world beset by various forms of conflict the problem of 'terrorism' has remained. Although every decade leading up to 2050 has seen examples of this form of conflict, the largest single incident was the detonation of a 'dirty bomb' in the United States in the 2020s.

Conflict coupled with the negative conditions for world economic growth has spread what was once dubbed the 'Japan syndrome'. From the 2030s global growth has stagnated.

Headline News

Dirty Bomb – What's Next?

7.8.1.2 Energy

Energy security, more difficult goal to achieve in a world experiencing high levels of conflict between and within nation-state, has become a greater priority for most countries. Globally trade tends to be limited to within economic and political blocs. Prices of fossil fuels have risen dramatically since 2005. An important factor has been declining production from Saudi oilfields. Investors have been wary of bringing new supplies on-line in a more volatile economic and diplomatic environment. Few successful energy alternatives have been devised. The industrialised and developing nations remain as dependent as ever on fossil fuels and the result has been occasional periods of rationing, particularly in the 2030s. A number of countries have again invested in nuclear power as an option; even though the 'nuclear option' has potential consequences including the more widespread development of nuclear weapons. In Australia this continues to be considered seriously as an option.

Strong public support for energy efficiency and energy savings, have moved placed energy on the agenda for governments, planners and for the people in Australia and elsewhere. Inter-regional conflict has led to an increase in military R&D directed to these ends.

7.8.1.3 (Military) Spending diversions

Coincident with low economic growth overall has been the diversion of significant investment and economic activity to military purposes. This increased military expenditure was not sufficient to prevent the 2040s economic depression in the United States created by shortcomings in the competitiveness of the US economy, a situation that remains today. Important consequences followed for economic growth in Australia and other countries reliant on the value of the US dollar. The continued 'cold war' involving China and the United States means the threat of another recession looms.

7.8.1.4 Transport

Additional resources have been funnelled to other critical industries. Decentralised transport systems have been pursued since the 2030s. Yet, the collapse of the Kyoto agreement in the 2020s and the continued controversy around claims for anthropogenic climate change has meant that little of this effort has been driven by environmental pressures and little new technology has emerged in this area. The resort to nuclear generation of electricity is argued to have reduced greenhouse emissions in any case.

7.8.1.5 Social equity

For the developed world, poorer economic outcomes have entrenched income inequality both internally and by comparison with the industrialised world. In 2050, it is recognised that some countries may never 'catch-up' with the developed world. This is the case most clearly in Africa, which remains burdened throughout by dictatorships and AIDS. Religious conflicts and sometimes-outright civil war in a number of countries have undermined growth in many areas throughout the non-industrialised world. In these conditions medical science and public health have failed to keep pace with the emergence of new mutations of old diseases.

7.9 BLISSFUL INDIFFERENCE

It is 2050 …and in Australia public attitudes to climate change have hardly shifted compared to those held at the start of the century. Pressure to introduce measures to address climate change never seemed to reach above other political dialogue around economic reform, health and aged care, and education.

On the world scene, relative political stability and strong economic growth has been achieved for an extended period. Greater trade between nations and the development of key, large national economies has combined with technological change to maintain stability in the balance between supply and demand of energy. Free trade was eventually introduced in 2020.

Not all conflict has been resolved, however. Terrorism remains an issue. However, today's threat to energy infrastructure from this source is restricted to a small number of very localised conflicts.

Major new oil supplies from Central Asia were opened up in the 2020s and new supply from these sources drove oil prices down for some years. However, more widespread growth in the 2030s and an eventual reduction in supply from the Middle East put an end to a sustained period of low oil prices from the early 2040s. Technology has also allowed for more complete exploitation of natural resources as previously 'uneconomic' sources now are more easily accessed. There continues to be little public pressure for innovation for energy efficiency and patterns of energy use largely remain the same.

Driving Forces

			
Innovation	**Geopolitical Stability**	**Climate Change**	**Sustainability**
Few technological innovations	The geopolitical landscape is stable.	A global management regime is ineffective in managing the world's response to climate change.	There is a decline in in the world's ability to provide for the needs of the current global population without damaging the ability of future generations to provide for themselves

7.9.1 The Storyline

It is the year 2050…and the energy picture for Australia is dominated by a world scene that, since 2005, has enjoyed relative political stability and strong economic growth. Greater trade between nations and development of key, large national economies has combined with technological change to maintain stability in the balance between supply and demand of energy. This has provided a direct challenge to the attempts of the world community over the past 50 years to deal with significant climate change. In Australia public attitudes to climate change hardly have shifted. There has been little public pressure for innovation in energy efficiency, and, patterns of energy use largely remain the same.

7.9.1.1 Strong Growth

The first decades of this half-century saw strong economic growth continue in China. India followed soon after. More importantly, a number of long-running conflicts were resolved during these years. In other cases nation-states made crucial steps towards more democratic forms of government. This was especially the case in West Africa and Egypt. 'Peace' also broke-out in the Middle East, with Palestinian-Israeli accords. Pakistan continues to lag behind India; the period to 2050 has seen continued diplomatic tension between these neighbours though without major military conflict.

Not all conflict was resolved. Asymmetric conflict in the guise of 'terrorism' remains an issue. However, in 2050 the threat to energy infrastructure from this source is restricted to a small number of localised conflicts.

Economic growth has been contagious, spreading around the globe. For example, a Russian 'renaissance' beginning about 2025, quickly replicated the experience of China and India, and has revitalised their once moribund economy. Economic growth is not without its complications. The democratisation of China in the 2030s posed significant challenges to economic achievements in that country. However, decades of high growth had led to a middle-class of such size and economic strength as to make substantial political reforms unavoidable.

7.9.1.2 New economic powerhouses

These changes were underpinned by the return in the 2040s of Taiwan to a newly democratic China. Together, these two East Asian powerhouses helped sustain world economic growth at levels close to four per cent per annum throughout the 2020s and 2030s. India, too, has experienced rates of growth previously known only in China (consistent with four per cent plus growth rates) through the 2040s and 2050s. Growth has contributed to massive demand for energy around the world.

Headline News

Steppin' on up: China's Economic Ascension

Much of this economic development has been underpinned by closer co-operation between the United States and Europe, which have entrenched and spread the now dominant model of capitalist democracy. The World Trade Organisation (WTO) has prospered after some difficult post-Doha years. This was complemented by the Chinese removing exchange rate controls on the Yuan soon after 2010. The international General Agreement on Trade in Service (GATS) was completed under the banner of the WTO in the 2020s.

While the US and Europe continues to dominate the global financial, legal and trade systems, the axis of the global economy has shifted. Trade and development are dominated by a number

of multi-polar alliances. A new alliance in South and East Asia has taken the form of a modern 'Silk Road', culminating in the construction during the 2040s of the South Asia Superhighway. The 'Silk Road' links China and India with Europe via the Middle East. The Superhighway has integrated tourism and communications into a single corridor with freight and energy transport.

7.9.1.3 Energy

The collapse of OPEC in the late 2020s, following the opening up of major new oil supplies in Central Asia and on the ocean bed, drove oil prices down for some years. However, more widespread growth in the 2030s, married to new technologies, has reversed this downward trend in global demand for energy. High demand alongside reductions in supply from the Middle East put an end to a sustained period of low oil prices. While 'hyper-ageing' eventually put a brake on China's and India's expansion, persistent high growth in industrialised nations (averaging above two per cent through to 2050) and large economies combined with the possibility of inadequate supply to drive oil prices upwards once more from the early 2040s. Nonetheless, in overall terms energy is less costly than in 2005 for both industrial and domestic applications. With few 'brakes', consumption is at much higher levels both per capita and in total.

Oil prices have risen but remain relatively stable due to the increased use of gas and continued reliance on coal as well as minor technological innovations, which have made alternative energy sources more economically viable. In Australia this has played out through higher oil imports being matched by higher energy exports. Continuing high living standards have insulated most Australians from the effect of higher oil prices.

Technological developments have been an important part of the global energy story since 2005. A new mass transport system has emerged in the form of the 'Rotocraft', which has preserved mobility for many urban populations without massive investment in traditional transport infrastructure. Technology also has allowed for more complete exploitation of natural resources as previously 'uneconomic' sources now are more easily accessed. However, technology transfers have been achieved in response to environmental threats. Technology also has placed serious pressures on development in Third World economies by allowing industrialised countries to compete more directly with the low-wages in less developed nations. This created a cycle of 'ups and downs' in the value of labour and economic development in the less industrialised countries.

7.9.1.4 Social equity

It remains true that there are serious disparities in wealth between wealthy and poor countries. Yet, global economic growth has meant that in 2050 there is less income inequality in the world than in 2005. Some regions have done considerably better than others. The market in services has grown, with much of this concentrated in developing nations. Higher levels of education have been achieved in developing nations. Better education, higher incomes and improved public health have raised the standard of living for most of the world's peoples yet population growth has been slower than predicted at the start of this century.

7.9.1.5 Climate Change

The challenge of climate change, however, remains. This is not least because of much higher levels of economic activity and energy consumption. The evidence for anthropogenic

environmental shifts is irrefutable now and technology increasingly is being pressed into service to solve these challenges. Equally, climate change has created ‘winners and losers’ with, for example, shifts in agricultural production as changes in rainfall become more established.

ANNEX

Table 3: Basic Scenario Logics – Agreed by Forum Participants
The table describes important differences in the scenario logics and provides some insight into how the scenarios differ qualitatively

	Dominant World View	Geopolitical Stability	Global Carbon Compliance	Technology & Innovation	Social/Cultural Innovations	Climate Change Impacts
Rough Ride	Fundamental differences between nation's world views are unable to be resolved without outright warfare or new 'cold wars'. With these distractions the world is unable to make progress solving any of the major problems (e.g. developing nation poverty, climate change, disease)	Key feature is smaller trading blocs in a multipolar world of many alliances. Other issues include WTO failure, Congagement between US and China, Nuclear war between India and Pakistan, 'Japan Syndrome' becomes dominant economic state	Some countries make progress. However, overall the world is unable to agree or make any significant progress in total	Some countries have success but it is not shared. General progress in energy efficiency to address energy security and for military reasons	Countries move toward military footing	The scenario is silent on climate impacts
Smooth Ride	The world appears capable of achieving long periods of relative peace. Capitalist democracy underpins this achievement.	Stable geopolitical situation exists. China democratic and reunited with Taiwan. WTO rounds successful	The world is distracted by its own prosperity. Firm action fails to take hold and what action there is late.	Reasonable technological change in mainstream technologies but no driver for uptake. A breakthrough in transport that is taken up	Countries converge towards developed nations in most respects	Winners and loser particularly with shifts in rainfall affecting agricultural production
Technology to the Rescue	Technicism – faith that technology/ humans can solve most problems	Stable geo-political system based on successful wealth creation which flowed from technology and innovation in medium sized nations	Steady progress towards successful compliance. Nuclear accepted as needed as an interim option in the 2020s	Strong RD&D base	Cities evolve into smaller, self-contained high density communities	Emission reductions of 50% below 1990 levels are achieved. The scenario is silent on climate impacts but strong R&D theme implies adaptation through technology would be society's response

	Dominant World View	Geopolitical Stability	Global Carbon Compliance	Technology & Innovation	Social/Cultural Innovations	Climate Change Impacts
Power to the People	Economic rationalism – free market economies	Stable global geo-political system, strong UN, 'managed' emergence of China and India	Early accession to an international framework incorporating many of the elements of the Kyoto Protocol proves effective	Considerable improvements in known technologies support distributed energy system and lifestyle	Restructured federal system supports devolution and decentralised lifestyle	Failure of crops associated with a series of natural disasters across the globe in the latter part of the first decade of the century – not necessarily associated with climate change
Centralised Failure	Economic rationalism – failure of market based mechanisms – giving way to intervention and non-least cost decision-making	Failed multilateral relationships/investments heighten 'each country for itself' attitudes, underlying potential for conflict	Compliance is erratic leading to failure to create an effective international carbon program, in spite of early agreements to pursue one	Innovation is suppressed by targeting of specific new technology. These investments fail to deliver	Significant potential for well-being disparities and social cleavages	Emissions are little improved from 1990 levels. Significant degradation of environment and changes in climate patterns – mean Australia has abandoned mitigation strategies and is now focusing on adaptation
Day After Tomorrow	Two ways of thinking revelationists, genesists	Resource security a key geopolitical driver - Attempts to coordinate global action in the face of climate change have been ineffective but strong action post 2025.	Early attempts to coordinate global action have largely been ineffective and it has only been through strong action post 2025 that the 10% emission target has been reached	Major new clean energy sources come on stream late in timeline	Major social schisms	Climate change is a matter of daily reality, affecting everything from their diet to the global balance of power between nations. A 10% emission target has been reached.

	Dominant World View	Geopolitical Stability	Global Carbon Compliance	Technology & Innovation	Social/Cultural Innovations	Climate Change Impacts
Cultural Revolution	Economic thinking underpinned by recognition of ecological costs of 'doing business'	Strong, stable political alliance with Chinese and US leadership	Global market mechanism for carbon, which captures the total carbon intensity for domestic and traded products	Fundamental change in energy infrastructure systems - early adoption of a full range technologies that support near zero emissions and orderly phase out of pre 2010 infrastructure and a stable portfolio of energy generating sources now operating in 2050	Significant attitudinal shifts open door to global cooperation on 'commons'	Areas affected by change in climate, whether they be areas subject to more frequent extreme events or a sustained change in regional climate have been systematically addressed. The global community has achieved reductions in greenhouse gas emissions of 50% from the 1990 baseline.