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Carbon

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Carbon

Why all the fuss?

Carbon, the way we view it, measure it, control it and price it has come to dominate debates of all kinds. Wherever you turn it seems that everybody has something to say about carbon. So, what's it all about?

Depending on how you look at it, carbon can be either good or bad. In this book, 'carbon' largely refers to emissions of heat-trapping (or greenhouse) gases, particularly carbon dioxide or CO_2. Other greenhouse gases, like methane and nitrous oxide, are often converted to carbon dioxide equivalents (CO_2-e). CO_2 is the gas emitted when oxygen and carbon are combined – either by nature via living organisms through respiration and decomposition – or when humans burn carbon-based 'fossil fuels', such as coal, gas and oil, to release energy.

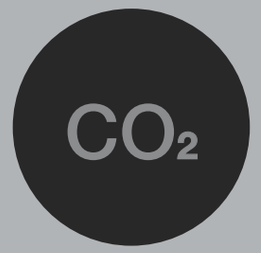
Rising emissions of CO_2 from the burning of fossil fuels and deforestation are altering the atmosphere and changing the global climate. As a result, and on the back of more than a century of scientific research, there is intense interest in carbon: from scientists, economists, companies, governments and the community. There is no doubt that as carbon concentrations rise the world will warm. Scientists predict that, if we allow carbon emissions to continue to increase, we will see the average global temperature rise to an extent and at a speed not seen since the end of the last Ice Age. With billions of people living on an already stressed planet, a changing climate will put our farming and food supply, cities, coasts, and communities at risk.

Engineers, educators, economists and entrepreneurs are working to develop viable low-carbon alternatives. All have the potential to reshape the way we power our cities and towns, the way we produce and haul goods, and the way we manage the land. The ingenuity required to move to a prosperous zero-carbon future is readily available. All too often, what is lacking is not the right technology or knowledge, but the visionary leadership and political will. No one can say exactly what the future will look like, but one thing is sure: the world is changing because of carbon. We still have a choice to make that change a change for good.

Carbon Jargon

Carbon

An element whose atoms easily attach to other atoms to become the basis of all living organisms. Also shorthand for carbon dioxide (CO_2) and other greenhouse gases.



Carbon Dioxide

A colourless greenhouse gas that traps heat in the Earth's atmosphere, formed by respiration or the combustion of carbon. Other greenhouse gases are often converted to CO_2 equivalents (CO_2-e).

Carbon Footprint

A measure of the CO_2 released into the atmosphere as a result of particular human activities or industries.

Carbon-Neutral

Achieved where there is no net release of CO_2 into the atmosphere; either through zero emissions or offsetting.

Carbon Cycle

The continuous exchange of carbon in various forms between the air and the oceans, and with living things by plant photosynthesis and plant and animal respiration.

Carbon Pollution

CO_2 and other greenhouse gases released by humans which accumulate in the air, trap heat, and raise the average global temperature, upsetting the natural balance.

Zero-Carbon Future

A term used to describe a future global economy where economic activity produces zero net carbon emissions.

Carbon Competitiveness

A country or company's level of readiness to prosper in a low-carbon global economy

Carbon Productivity

The amount of GDP produced per unit of carbon pollution emitted.

Carbon Budget

A cap on the total quantity of carbon pollution emitted by a person, industry, country or the world as a whole; indicating how much can be released to keep global temperatures below an agreed limit.

Carbon Price

A monetary cost on carbon pollution, intended to stimulate investment in clean energy, energy efficiency and other low-carbon technologies.

Carbon Offset

An activity that reduces emissions or removes CO_2 from the atmosphere to counterbalance activities that release CO_2.

Carbon Permit

The right to emit carbon pollution, measured in tonnes.

Carbon Trading

Buying and selling carbon permits in a market.

Carbon Capture & Storage

Capture, transport and geological (or other) storage of CO_2 from electricity generators and other industrial sources.

Carbon Farming

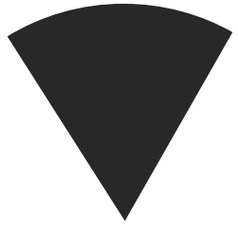
Farming and other land uses that store carbon in soil and vegetation and reduce emissions from livestock and other agricultural sources.

Carbon 101

Essential Carbon

To appreciate the influence of carbon, a little basic science is helpful. The flexible qualities of carbon stem from its chemistry: put simply, a carbon atom readily attaches itself to up to four other atoms. Unlike many other players in the table of elements, carbon is not selective about its attachments. It can be found transforming itself from liquid to gas to solid, depending on the conditions.

Carbon is the sixth most abundant element in the universe. There are nearly ten million known carbon compounds and an entire branch of chemistry, organic chemistry, is devoted to their study. Renowned for its ability to stitch living things together, carbon has earnt its nickname as the ‘duct tape of life’. With attachments in the millions, some carbon compounds are good and some not so good.

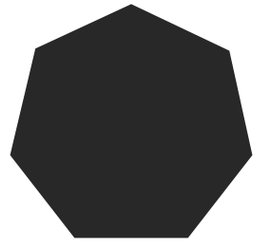


18

Carbon makes up 18% of human bodyweight.[2]

660,000,000,000

Trees in Australia’s native forests are natural stores of about 660 billion tonnes of carbon.[3]

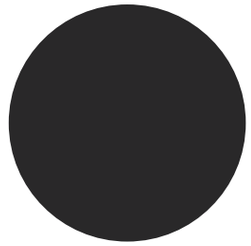


10^{22}

A one-carat diamond can be considered a single huge molecule consisting of 10^{22} carbon atoms.[4]

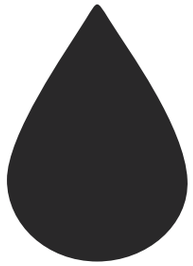
9

A 90-tonne whale contains approximately 9 tonnes of carbon.[5]



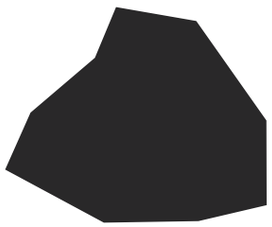
100

100% of life on Earth contains carbon compounds.



50

There is 50 times more carbon in the ocean than in the air.[6]

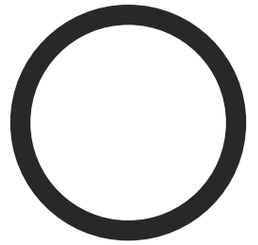


65,500,000,000,000

Most of Earth’s carbon, about 65,500 billion tonnes, is stored in rocks.[7]

60

Nearly 60% of decomposed organic matter in soil is carbon.[8]



6

Carbon is the sixth most abundant element in the universe.[9]

All life is based on carbon. Just as water is essential for life, carbon too is fundamental. From ocean-travelling whales to soil-residing earthworms, from ancient rocks deep underground to free-flowing gases high in the sky, carbon is everywhere.

We humans are 18 per cent carbon.[1] We eat carbon, exhale carbon and excrete carbon. Part of the carbon cycle known as photosynthesis enables plants, algae and certain types of bacteria to convert CO_2 into energy and delivers our life-sustaining oxygen supply. Carbon, in all its different forms and functions, is breathtakingly important.

Too Much of a Good Thing

A System out of Balance

Earth's natural systems are only able to absorb approximately 50% of our current annual CO_2 emissions.

Atmospheric Concentration of CO_2

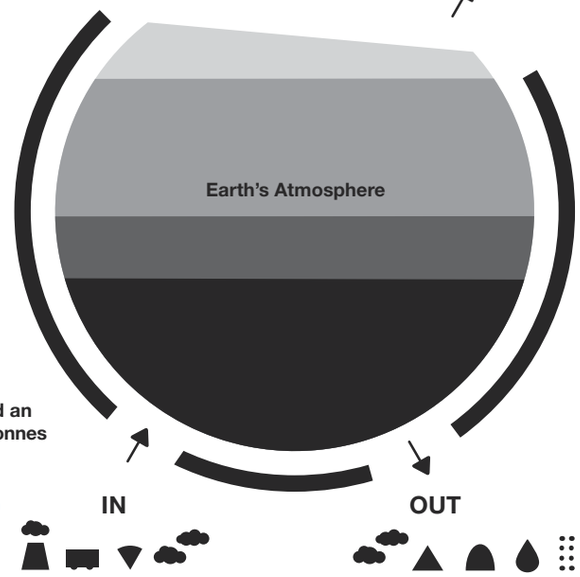
450 parts per million
Forecast level before mid-century if current emissions trends continue[11]

400 parts per million
Current level[12]

350 parts per million
Safer levels of CO_2; below 300ppm should be the ultimate goal

299 parts per million
Highest ice core reading 330,000 years ago

271 parts per million
Pre-Industrial level



Around 50% of CO_2 emissions stay in the atmosphere each year

Approximately half of annual emissions are currently left in the atmosphere causing a growing imbalance in the carbon cycle.[14]

Emissions of CO_2 reached an all-time high of 35 billion tonnes in 2012

This is actually only four-fifths of global CO_2 emissions, those from fossil fuels and cement. Nearly all the rest is from deforestation and other changes in land use (averaged over 2000 - 2008).[13]

About 50% of CO_2 emissions are absorbed by the Earth's natural systems each year

Plants and soil absorb about a third each year, and ocean surface waters absorb about a quarter. The rest stays in the atmosphere for centuries.

Where Does Good Carbon Go Bad?

If carbon is natural, and essentially a good and crucial element, where do things go wrong and why has it become so contentious?

Carbon is not itself the problem. Even CO_2 cannot be blamed. CO_2 occurs naturally and is necessary to life. In fact, without the heat-trapping properties of CO_2 Earth would be a frozen world. But carbon pollution is upsetting the natural balance.

The movement of carbon through the air, earth, water, and living things is called the carbon cycle. Within the natural carbon cycle are assorted sources and sinks of CO_2. Living and decomposing animals and plants, are the primary sources. Oceans, forests, other kinds of vegetation and soils act as natural sinks.

Problems only start to arise when carbon emissions increase dramatically and overwhelm the capacity of natural systems to absorb or counterbalance them. CO_2 levels are higher today than at any time in at least 800,000 years, indeed fossil evidence suggests the last time the world knew 400ppm was 3 million years ago.[10]

We need to better understand the carbon cycle, to slow certain processes so specific gases don't build up in excess in the air, and find ways to reduce the amount already released. It is an issue of management.

At the current emissions rate, CO_2 is released into the atmosphere nearly twice as fast as it is removed, so the levels will continue to rise.

CO_2 causes warming because it absorbs the heat radiation coming off the earth's surface and radiates it back downwards.

The oldest bubbles found in the Antarctic ice cores show that CO_2 hasn't been this high for at least 800,000 years and it is now thought it could be up to millions of years.

No one is sure how much is too much. Most scientists think we need to reduce the atmospheric concentration of CO_2 back down to 350 parts per million and below to avoid serious climate impacts. To do this we need to reverse the imbalance of greenhouse gases and remove CO_2 from the atmosphere.

When we burn fossil fuels we release carbon that was locked away millions of years ago, putting it back into the carbon cycle as CO_2. Oceans and forests have soaked up lots of this extra carbon, but these ecosystems have their limits. The huge amounts of CO_2 being absorbed by the world's oceans is making them more acidic than they have been for tens of millions of years. The more acidic the oceans become, the lower their capacity to store excess CO_2, meaning more will accumulate in the air.[15] Some of these natural carbon sinks have been further undermined through deforestation and certain types of farming that have introduced methane, another more potent greenhouse gas, into the mix.

So, the carbon cycle is out of balance, with too many sources of CO_2 and too few sinks. This thickening atmospheric coat of CO_2 traps more heat.

Excess greenhouse gases are now the main cause of the global warming observed by scientific instruments on land, in the seas, and in space. Even after scientists have filtered out other influences on the climate, such as the sun, volcanoes and clouds, a strong, long-term warming trend can still be seen. The facts are clear: unless we change tack, this burden will be shouldered by us and generations to come in the form of an increasingly unpredictable global climate.

Carbon Conscious

More

Less

Produce

Reduce

Since the start of the Industrial Revolution, human activities have been largely responsible for lifting atmospheric levels of CO_2 by 40 per cent; levels not seen for at least hundreds of thousands if not millions of years.[16]

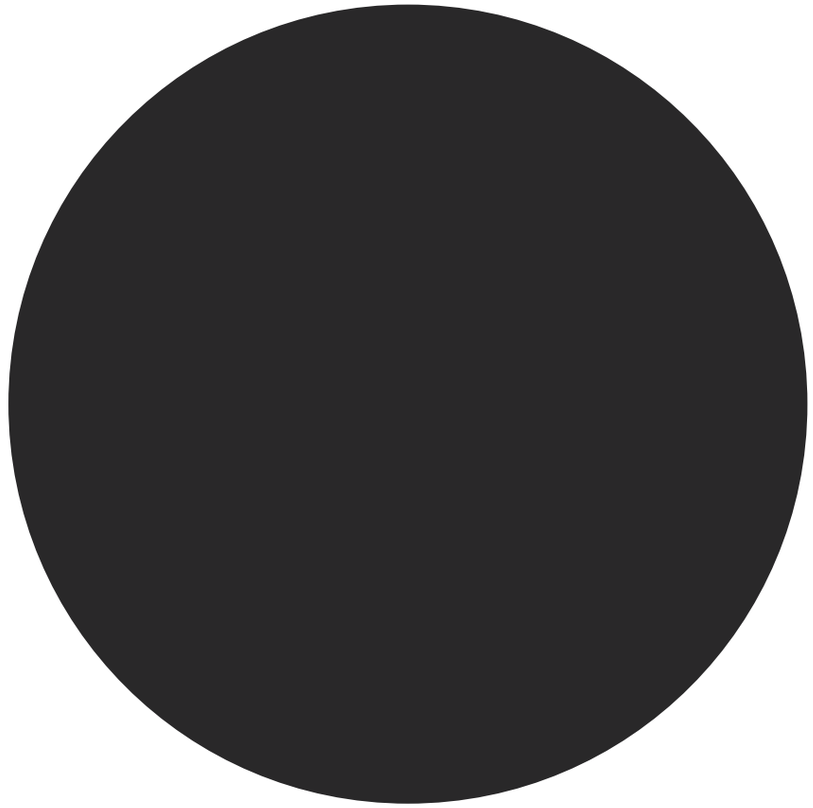
Throw

Keep

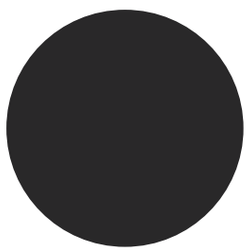
Today

Tomorrow

Bursting the Carbon Bubble



Only 20-40% of Earth's known fossil fuel reserves can be burned unabated, leaving 60-80% of assets unburnable and therefore worthless.[18]



Insight v. Hindsight

The international community has set a goal to stabilise concentrations of CO_2 and other greenhouse gases in the air at a level that aims to keep global warming to below 2ºC. They are currently working to review this limit with the potential to reduce it to 1.5ºC. Average global temperatures have already risen by nearly one degree since the start of the Industrial Revolution in the nineteenth century.

To stay below 2ºC means limiting cumulative CO_2 emissions over the period between 2000 and 2050 to 1,000 billion tonnes.[17] Within the first six years of this century around 25 per cent of the 1,000 billion tonne limit has already been used,we have no time to lose.

Environmentally speaking, carbon has been identified, charged and is under strict surveillance. From an economic perspective, however, carbon is still at large. If all of the Earth's known fossil fuel reserves were burnt it would release an extra 2,800 billion tonnes of CO_2. But here's the problem: no more than 20 - 40 per cent of these reserves can be burnt if we want to keep average global temperatures below 2ºC.

In other words, 60 - 80 per cent of our known fossil fuel reserves could be obsolete and therefore worthless.[18] Fossil fuel assets could quickly become liabilities.

Getting the all-important carbon balance right is one of the primary challenges of our time. Human society can and will continue to develop and grow, but sustainable progress and prosperity is only possible if we disconnect carbon from our growth model.

Playing Fair

Carbon Equity in a Global Context

Questions of fairness are central to the question of climate change. If the amount of carbon is to be limited who has the right to use the remaining atmospheric space? Is it fair that large powerful countries continue to emit large amounts of carbon when this activity threatens the existence of entire nations and cultures? Industrialised nations like Australia have contributed over 70 per cent to the build-up of carbon pollution in the atmosphere so should they take the lead in reducing emissions even if China and other emerging economies are now the fastest growing source of emissions?

The average Australian produces four times more CO_2 than the global average. A citizen of Kiribati, a small island country in the Pacific that is threatened by climate change, produces around 1/16th the amount of the global average. One person from the USA or Australia produces 64 times the amount of CO_2 that a person in Kiribati and over three times the average person in China.

Ultimately a fair distribution of the global carbon budget is what we should be aiming for. Scientists suggest that by 2050 annual CO_2 emissions should converge to around 1 tonne per person worldwide.[19]

How Much is Fair?

Average per person contributions of energy-related CO_2 to the atmosphere in selected geographies since 1950.[20]

Australia
4.2 x

The average Australian has contributed over 560 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 18.7 tonnes

USA
4.1 x

The average American has contibuted over 842 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 18.6 tonnes

Developed World
2.5 x

The average person in the developed world has contributed over 534 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 11.1 tonnes

China
1.2 x

The average Chinese person has contibuted over 84 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 5.4 tonnes

Pacific Island
0.06 x

The average person from Kiribati has contibuted 12 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 0.3 tonnes

Developing World
0.6 x

The average peson in the developing world has contributed over 56 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 2.9 tonnes

Global Average
1 x

The average person worldwide has contributed 148 tonnes of energy-related CO_2 to the atmosphere.

Annual CO_2 emissions per person
= 4.5 tonnes

Global Target 2050
0.2 x

The annual target of CO_2 emissions per person worldwide by 2050.

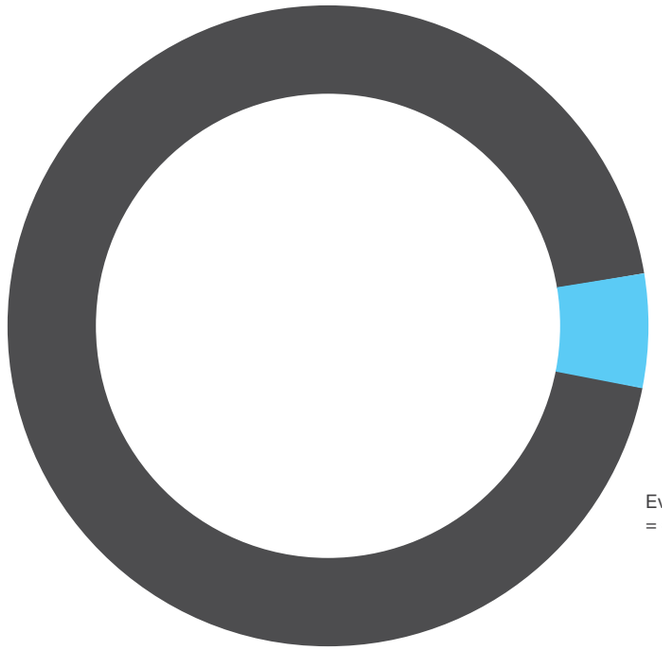
Annual CO_2 emissions per person
= 1 tonne

Thriving in a Zero-Carbon Economy

Australia's Current High-Carbon Economy 2012

In 2012, Australia's economy will be worth close to $1.4 trillion[21]. But for every million dollars of wealth created, Australia produces 443 tonnes of CO_2-e.

Australia's economy
= $1.4 trillion



Every $1 million wealth created
= 443 tonnes of CO_2-e produced

Smarter Prosperity

In a high-carbon economy, carbon emissions are coupled to economic growth, whilst future generations and the environment are largely excluded from the equation. The pursuit of short-term growth at any cost is neither sustainable nor fair. We need to factor in the finite nature of our natural resources and the real cost of carbon pollution. When we first started to use fossil fuels in pursuit of prosperity, we weren't aware that their benefits came at a high price. Now, the science is clear; a high-carbon economy is also a high risk one.

A low-carbon development model takes the costs and risks of carbon into full account, embedding them into business, political and community decision-making. A price and limit on carbon is one important step in the recalibration of our economics and the environment. It makes big polluters accountable and consumers more aware of their consumption. It provides businesses with a powerful incentive to re-think their strategies, and drives innovation and competition towards a smarter prosperity. Backed by complementary policies and incentives, a price and limit on pollution will play a big part in the shift to a zero-carbon economy.

To remain competitive and prosper in a future carbon-constrained world, Australia will need to shift to a lower carbon economy.

Australia's Future Zero-Carbon Economy 2050

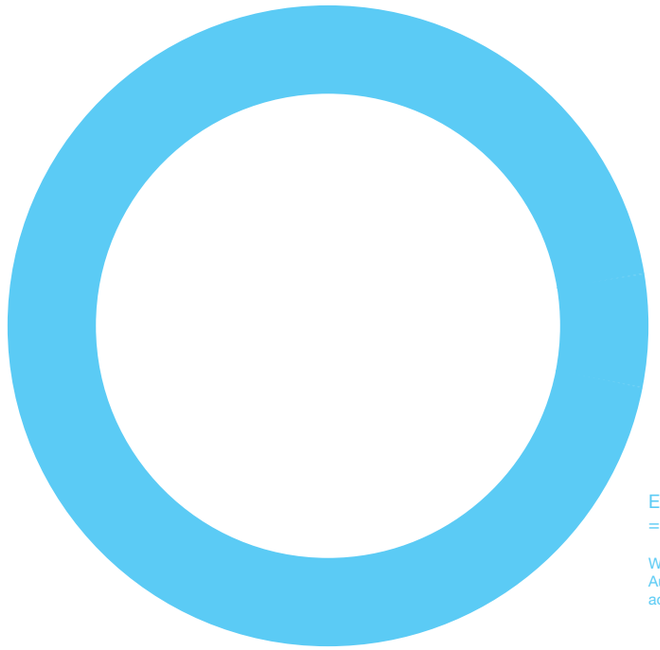
In 2050, with a price and limit on carbon and other complementary policies, innovation, smart investment and continuing growth, Australia's economy is forecast to grow close to $3.5 trillion[22] with the opportunity for up to five times less carbon pollution to be released for each dollar earned. With further innovation and more ambitious policies we should be aiming for zero net carbon emissions by 2050.

Australia's economy
= $3.5 trillion

Change In Sectoral Output[23]

Agriculture: 135% increase
Mining: 181% increase
Manufacturing: 69% increase
Construction: 181% increase
Services: 239% increase

Emissions intensity of electricity generation is projected to fall by 90%, while total demand for electricity is expected to increase by close to 40%.



Every $1 million wealth created
= 0 tonnes of CO_2-e produced

We need to continue to accelerate Australia's economic transformation to achieve zero net carbon emissions.

Greater Resilience

The transition to a zero-carbon economy is about more than just cutting pollution. It is an opportunity to build lasting environmental, economic and social resilience. Resilience will be strengthened by ending our economy's dependence on pollution, leaving us less at the mercy of the ebbs and flows of global energy markets. We can smooth the transition through greater efficiency in the use of energy and other resources, further development of renewable energy technologies, and targeted government assistance to help manage bills and assist industry over the hump.

Action on climate change can deliver many benefits. It can improve our connections with each other, with our natural environment and with healthier concepts of the good life. Cost-effective, community-empowering, wealth-creating solutions for low-carbon growth do exist. Identifying them and making them happen will mean a better future for everyone.

Carbon Clever

Re-Generation

When sparked, human ingenuity can reach unimagined heights. The Industrial Revolution was an era of extraordinary ingenuity in manufacturing and, at the time, the use of new energy sources like coal and petroleum. Today, the world needs a similar spirit of innovation and optimism to flick the switch to a zero-carbon economy. By developing new ways of manufacturing, moving and producing, and using more sustainable sources of power, heat and light, we can usher in a new generation – the Re-Generation.

We are already re-purposing, re-imagining and re-thinking how things are made, what materials are used and in which manner they are delivered. The goal of zero-carbon can drive future prosperity with no carbon strings attached, decoupling economic growth from emissions growth along the way. The Re-Generation will grow more powerful and lucrative each year as clean energy innovation, cleaner manufacturing and smarter farming become more viable and more widely adopted.

The human ingenuity required to constrain carbon has already arrived in many different forms: from protecting forests and landscapes as carbon sinks (biosequestration); to a shift from coal, oil and gas to renewable energy sources like solar, wind and wave (clean energy technologies), from capturing CO_2 at its source (carbon capture) and burying it beneath the earth (carbon storage), to learning how to do more with less (energy efficiency); low-carbon innovation has arrived.

Countries around the world are introducing markets with carbon as the commodity, where businesses innovate and compete to cut the carbon intensity of their processes, products and services. Many of these innovations have already been introduced in prosperous countries eager to get a head start on the competition. Sticking to business-as-usual is fast becoming a formula for business-is-over.

Re-Thinking

Breaking with Tradition

We are not building this zero-carbon world on a blankslate. We have inherited a deeply entrenched manufacturing and business base that is embedded in carbon-heavy practices. Evolving current systems and thinking is just as important as encouraging breakthrough technology. From boardrooms to living rooms, Australia's response to climate change requires a transformation of existing, outdated mindsets.

Concepts like cradle-to-cradle[24] encourage businesses to rethink how they source, produce, transport and dispose of their products to create systems that are efficient and essentially waste free.

Advancing the way we produce, move and consume electricity by deploying clean energy technologies, smartening up our electricity grid and using energy more efficiently will enable us to realise our clean energy future. Re-thinking our approach to urban design and transport by making buildings less demanding on natural systems and energy infrastructure, introducing green precincts and choosing healthier and more sustainable transport alternatives can all significantly reduce our carbon pollution.

New Thinking

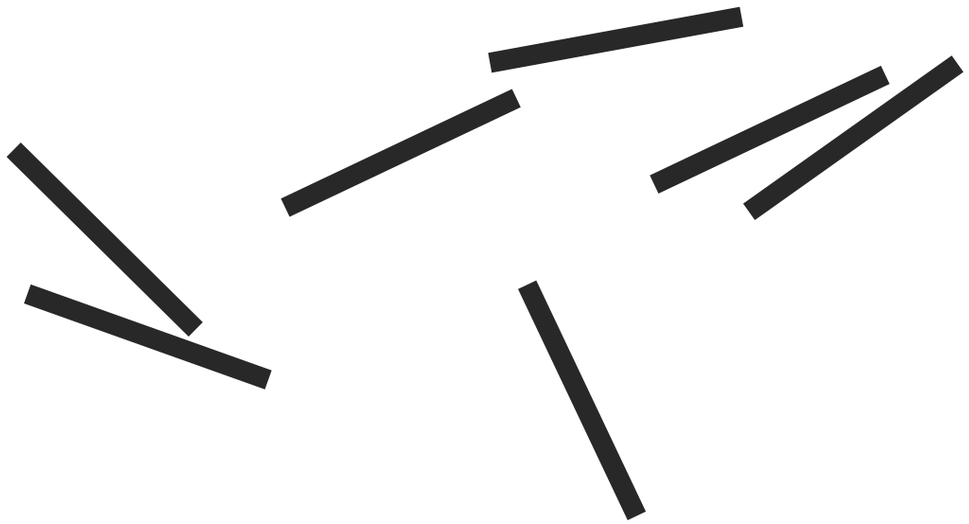
Embracing the Future

Re-thinking will only get us part of the way. Finding new solutions is also key. Australia has a breadth of opportunities to show true leadership in the global search for climate solutions.

There are many promising examples on the horizon. The shift to renewable energy has begun, but Australia's most abundant resources, including solar, wave, wind and geothermal, remain largely untapped. Some of these energy sources have already been proven at scale in other countries. A mix of technical, financial and policy solutions are now needed to unlock their potential here in Australia.

Australia is also well placed to test the viability of carbon capture and storage (CCS) technologies. As well as helping to clean up traditional forms of energy, CCS is considered a necessary technology for stabilising atmospheric CO_2 concentrations at the lowest possible levels, if combined with renewable biomass as an energy source. Increasing the amount of carbon that can be stored in the landscape is also necessary. Planting trees, as well as reducing emissions from livestock and land clearing, are obvious and well-established ways of doing this.

Collective Carbon Commitment



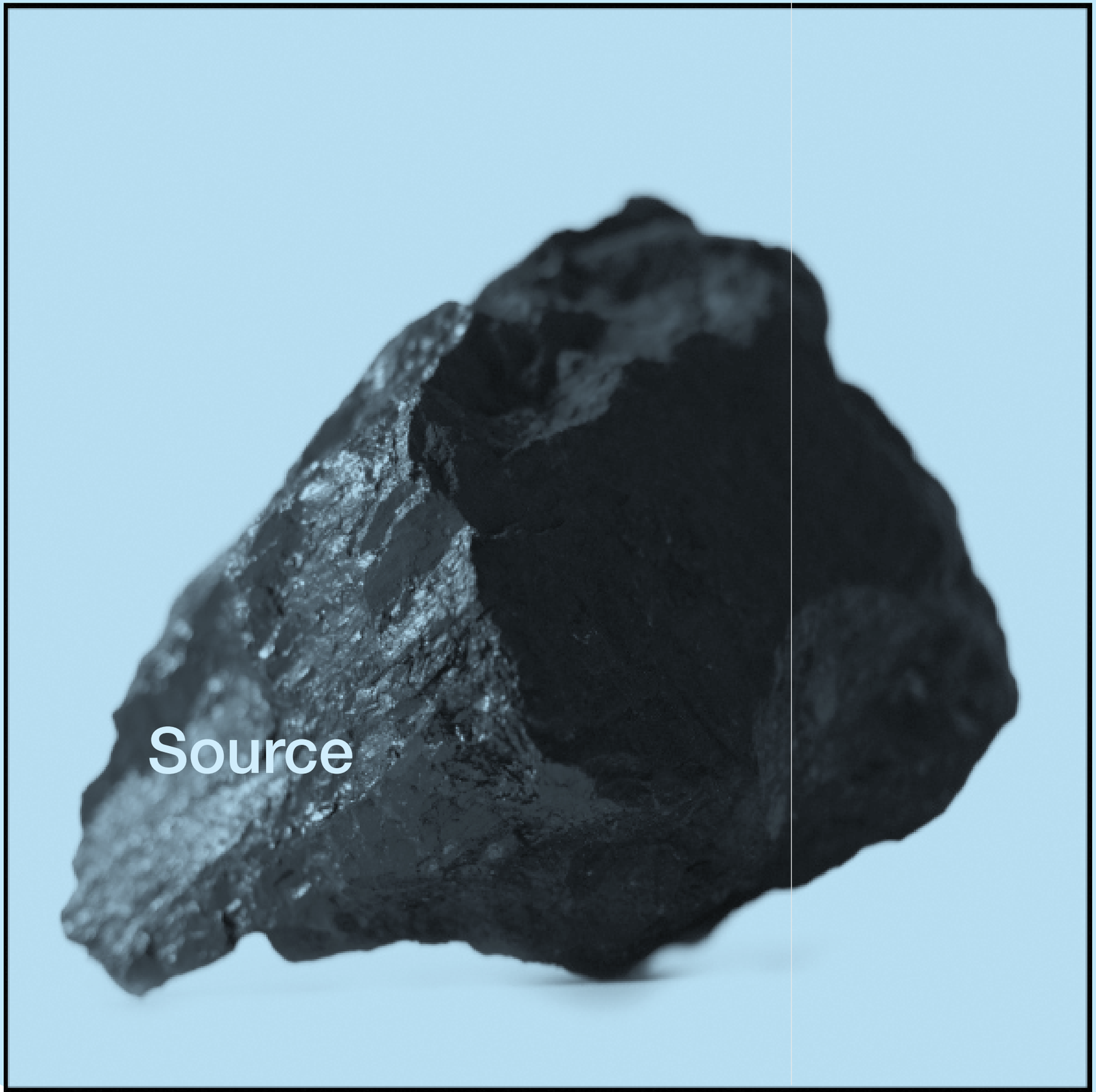
Diamond in the Rough

A zero-carbon future will not be achieved by a few clever brains alone. It will only be realised when a multitude of stakeholders begin speaking the same language. Low-carbon language is not culture-specific, age-specific or gender-specific. From sensitive international negotiators, to astute corporate investors, to informed school teachers: the new value of low-carbon living will need to be universally expressed and understood.

Just as chlorofluorocarbons (CFCs) are now understood to be dangerous and in need of constraint, so the threat of unrestrained carbon is becoming more widely recognised. CFC bans required collective action and demonstrated that our resolve and capacity for change, once mobilised, can be swift and effective. While the carbon challenge is a more difficult test, that experience reminds us that collective determination can bring us to the tipping point that is necessary to drive significant political, economic and behavior.

The changes needed to transition to a low-pollution economy and society will occur on many fronts. At a community level, understanding and working to reduce our personal carbon footprints will play an important part. At a corporate level, a commitment to restructuring assets and driving innovation will be invaluable. And at a government level, redirecting investments to zero- and low-carbon solutions and demonstrating leadership that rebalances long- and short-term interests will be vital.

In its most enduring and perhaps unexpected form, carbon exhibits an unparalleled intensity of both strength and clarity. Under extreme pressure and heat, carbon can transform into a diamond. Rising to meet the climate change challenge may well be rough going, but it will also reveal our best qualities: the determination, resilience and clarity of vision that can capture both the intellect and the imagination. It may just be our shining moment.



Source Notes

To read more about carbon and how we can achieve a zero-carbon future, and for all the sources referenced in this book, please refer to the following:

1 http://www.livescience.com/3505-chemistry-life-human-body.html

2 http://www.livescience.com/3505-chemistry-life-human-body.html

3 http://adl.brs.gov.au/forestsaustralia/facts/carbon.html

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5 http://www.physorg.com

6 http://earthguide.ucsd.edu/virtualmuseum/climatechange1/03_2.shtml

7 http:earthobservatory.nasa.gov/Features/CarbonCycle/

8 http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_organic

9 http://www.physicscentral.com/explore/action/graphene1.cfm

10 http://keelingcurve.ucsd.edu/what-does-400-ppm-look-like/

11 http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx

12 http://keelingcurve.ucsd.edu

13 C. Le Quéré et al. 'The Global Carbon Budget 1959–2011' Earth System Science Data Discussions, 5, 1107–1157, doi:10.5194/essdd-5-1107-2012, 2 December 2012, http://bit.ly/UY8GTQ

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15 Khatiwala, S. and Primeau, F., 'Reconstruction of the history of anthropogenic CO_2 concentrations in the ocean', Nature, 462 (2009), 346–349.

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17 M. Meinshausen, N. Meinshausen, W. Hare, et al., Greenhouse-gas emission targets for limiting global warming to 2°C, Nature 458, 1158-1162, doi:10.1038/nature08017, 30 April 2009

18 http://carbontracker.live.kiln.it/Unburnable-Carbon-2-Web-Version.pdf Unburnable Carbon 2013: Wasted capital and stranded assets

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The Challenge Needs You + You + You

(+ You)

Throughout history, there are countless examples of people drawing on tremendous courage in the face of adversity to effect fundamental social change: rights for indigenous peoples, women's rights, and ending apartheid and slavery, to name but a few. All these profound generational shifts occurred because communities worked together over many years for a better world.

We invite you to join us in making a better Australia; resilient, prosperous and proud in a zero-carbon world.

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