

## List of figures and tables

### Figures

Figure 1.1	The risk–uncertainty spectrum	8
Figure 1.2	A probability distribution	8
Figure 1.3	The four types of climate change impacts	10
Figure 1.4	Utility with and without mitigation	16
Figure 1.5	Utility under a more ambitious level of mitigation	16
Figure 1.6	Utility with more climate change impacts taken into account	17
Figure 2.1	Trends in atmospheric concentrations of carbon dioxide, methane and nitrous oxide since 1750	26
Figure 2.2	A stylised model of the natural greenhouse effect and other influences on the energy balance of the climate system	28
Figure 2.3	Contribution of human and natural factors to warming since 1750	30
Figure 2.4	Steps in the causal chain of greenhouse gas emissions leading to climate change	31
Figure 2.5	Effect on extremes of temperature from an increase in mean temperature, an increase in variance, and an increase in both mean temperature and variance	41
Figure 2.6	Inertia in the climate system	42
Figure 2.7	Response of different carbon sinks to the rate of emissions over time	44
Figure 2.8	Different pathways of emissions reductions over time to achieve the same concentration target	45
Figure 2.9	Temperature outcomes of varying levels of overshooting	46
Figure 2.10	Emissions pathways required to achieve a low concentration target following an overshoot	47
Figure 3.1	The 20 largest greenhouse gas emitters: total emissions and cumulative share (%) of global emissions, c. 2004	54
Figure 3.2	The 20 largest greenhouse gas emitters: per capita emissions including and excluding emissions from land-use change and forestry, c. 2004	55
Figure 3.3	CO <sub>2</sub> emissions/GDP, energy/GDP and CO <sub>2</sub> emissions/energy for the world, OECD and non-OECD, 1971–2005 (1971 = 1)	57
Figure 3.4	Energy intensities of GDP for China and other developing countries, 1970–2005	57
Figure 3.5	The reference case: global population, GDP and GDP per capita, 2001 to 2100	59
Figure 3.6	The reference case: global population, GDP, GDP per capita, and CO <sub>2</sub> -e emissions, 2000 to 2100—average growth rates by decade	60
Figure 3.7	Shares in global output of various countries and regions, 2001 to 2100, under the reference case	61

Figure 3.8	Global CO <sub>2</sub> emissions growth rates from fossil fuels and industrial processes to 2030: a comparison of Garnaut Review no-mitigation projections with SRES and post-SRES scenarios and historical data	62
Figure 3.9	Global greenhouse gas emissions growth rates to 2030: a comparison of Garnaut Review no-mitigation projections, SRES and post-SRES scenarios, and historical data	63
Figure 3.10	Global greenhouse gas emissions to 2100: a comparison of Garnaut Review no-mitigation projections and various SRES scenarios	64
Figure 3.11	China total energy consumption, levels and growth, 1978 to 2006	66
Figure 3.12	Oil, gas and coal prices, 1970 to 2008	67
Figure 3.13	Global energy use and CO <sub>2</sub> emissions, 1970 to 2007	68
Figure 4.1	Selected regional climate change observations	76
Figure 4.2	Average global air temperature anomalies, 1850–2005	78
Figure 4.3	Global average sea-level rise, 1870–2005	80
Figure 4.4	Concentrations of greenhouse gases in the atmosphere for the three emissions cases, 1990–2100	86
Figure 4.5	Global average temperature outcomes for three emissions cases, 1990–2100	88
Figure 4.6	Spatial variation in temperature change in 2100 for the three emissions cases	90
Figure 4.7	Temperature increases above 1990 levels for the three emissions cases	92
Figure 4.8	Abrupt or rapid climate change showing the lack of response until a threshold is reached	97
Figure 5.1	Australian annual average temperature anomalies, 1910–2007	107
Figure 5.2	Annual streamflows into Perth's dams (excluding Stirling and Samson dams)	110
Figure 5.3	Best estimate (50th percentile) of Australian annual temperature change at 2030, 2070 and 2100 under three emissions cases	114
Figure 6.1	Vulnerability and its components	125
Figure 6.2	State and territory impacts of climate change by 2100 under the no-mitigation case	126
Figure 7.1	Per capita greenhouse gas emissions	154
Figure 7.2	Greenhouse gas emissions by sector, 1990 and 2006	155
Figure 7.3	Greenhouse gas emissions by sector: 1990, 2006 and reference case scenarios	156
Figure 7.4	Per capita emissions due to energy use, 2005	157
Figure 7.5	Factors underlying per capita energy emissions, 2005	157
Figure 7.6	Fuel mix contributing to total primary energy supply, 2005	158
Figure 7.7	Trends in average emissions intensity of primary energy supply, Australia and OECD, 1971–2005	159
Figure 7.8	Primary energy consumption in Australia, by sector, 2005–06	159
Figure 7.9	Per capita emissions due to electricity, 2005	160

Figure 7.10	Factors underlying per capita electricity emissions, 2005	160
Figure 7.11	Per capita emissions due to transport, 2005	161
Figure 7.12	Factors underlying per capita transport emissions	162
Figure 7.13	Per capita emissions due to agricultural production	163
Figure 7.14	Per capita area of forested and wooded land, 2005	164
Figure 7.15	Emissions attributable to Australian industry by sector, 2006	166
Figure 7.16	Emissions attributable to the Australian mining and manufacturing industries, disaggregated by sector, 2005	167
Figure 7.17	Ratio of permit costs to value of production, 2005	169
Figure 7.18	Direct emissions intensity of Australia's agriculture industry compared with selected OECD countries, 2006	170
Figure 8.1	Kyoto targets and 2005 emissions, relative to 1990	181
Figure 9.1	Different concentration goals: stabilisation, overshooting and peaking	193
Figure 9.2	Different cumulative emissions from the same end-year target (y)	195
Figure 9.3	Emissions trajectories for the no-mitigation, 550 and 450 scenarios, 2000–2100	206
Figure 9.4	Per capita emissions entitlements for the 550 scenario, 2012–2050	208
Figure 9.5	Per capita emissions entitlements for the 450 scenario, 2012–2050	208
Figure 10.1	Energy research and development expenditure by the public and private sectors in the United States	218
Figure 11.1	Australia's carbon prices under different mitigation scenarios and technological assumptions	251
Figure 11.2	The modelled expected market costs (median case) for Australia of unmitigated climate change, 2013 to 2100 (Type 1 costs only)	253
Figure 11.3	Change in annual Australian GNP growth (percentage points lost or gained) due to gross mitigation costs under the 550 scenario strategy compared to no mitigation, and under standard and enhanced technology assumptions, 2013–50	264
Figure 11.4	Change in annual Australian GNP growth (percentage points lost or gained) due to net mitigation costs under the 550 scenario compared to no mitigation, 2013–2100	265
Figure 11.5	Change in Australian sectoral growth rates (percentage points lost or gained) due to net mitigation costs under the 550 scenario compared to no mitigation, 2013–2100	266
Figure 11.6	A comparison of the modelled expected market costs for Australia of unmitigated and mitigated climate change up to 2100 (Type 1 costs only)	267
Figure 11.7	Change in annual Australian GNP growth (percentage points lost or gained) due to gross mitigation costs under the 450 compared to the 550 scenario and under standard and enhanced technology assumptions, 2013–50	268

Figure 11.8	Change in annual Australian GNP growth (percentage points lost or gained) due to net mitigation costs under the 450 compared to the 550 scenario, 2013–2100	269
Figure 12.1	Australian emissions reductions trajectories to 2050 (reduction in total emissions)	284
Figure 12.2	Australian emissions reductions trajectories to 2050 (per capita reduction)	284
Figure 15.1	Areas for further support and investment in the climate change research system	366
Figure 15.2	Impact of climate change on probability loss distribution and implications for risk capital requirements	372
Figure 16.1	How will an emissions price flow through the economy?	387
Figure 16.2	Expenditure on basic goods as a share of disposable income	388
Figure 17.1	Residential per capita electricity consumption in the United States, California and as predicted for California	416
Figure 18.1	The innovation chain	425
Figure 18.2	Market failures along the innovation chain	426
Figure 19.1	Major sequestration sites and carbon dioxide sources in Australia	454
Figure 20.1	Installed electricity generation capacity, 2005–06	469
Figure 20.2	Comparison of industrial electricity prices	470
Figure 20.3	Average electricity market prices, 1999–2008	471
Figure 20.4	International energy commodity prices, indexed to 1994	473
Figure 20.5	Australia's electricity demand	483
Figure 20.6	Electricity demand reduction in selected sectors, 550 scenario	484
Figure 20.7	Residential demand, 2005–2100	484
Figure 20.8	Australia's electricity technology shares, 550 scenario	485
Figure 20.9	Australia's electricity generation technology shares, 550 scenario with zero-leakage carbon capture and storage	486
Figure 20.10	Australia's electricity generation technology shares, 450 scenario	487
Figure 20.11	Electricity emissions intensity	487
Figure 20.12	Total wholesale electricity costs, with and without nuclear, 550 scenario	488
Figure 20.13	Technology mix under an enhanced technology scenario	489
Figure 20.14	Wholesale electricity prices, 2005–50	490
Figure 20.15	Electricity generated from coal	491
Figure 20.16	Generation capacity, 550 scenario	492
Figure 20.17	Generation capacity, 450 scenario	492
Figure 20.18	Carbon capture and storage scenarios	496
Figure 20.19	Projections for aluminium and alumina industries	497
Figure 20.20	Electricity from gas sources	498
Figure 21.1	Australian domestic transport emissions, 2006	505
Figure 21.2	Passenger travel per capita by various modes, 1970–71 to 2006–07	506

Figure 21.3	Emissions intensity of passenger modes, 2007	509
Figure 21.4	Projected emissions from the domestic transport sector with standard technology assumptions, 2006–2100	512
Figure 21.5	Breakdown of transport sector emissions in the 550 standard technology scenario, 2006–2100	513
Figure 21.6	Modelling of road transport fuel use in a 550 standard technology scenario	514
Figure 21.7	Average new car emissions and oil price, January 2002 – April 2008	518
Figure 21.8	Trip mode, population and emissions in 57 high-income cities, 1995–96	520
Figure 21.9	Mode share for journeys to work in Australian capital cities 1976–2006	521
Figure 22.1	Prices paid by Australian farmers, 1998–2007	533
Figure 22.2	Australian farmers' terms of trade, 1998–2007	534
Figure 22.3	Non-combustion emissions for agriculture, forestry and land-use change for the no-mitigation and 550 standard technology scenarios	537
Figure 22.4	Change in emissions intensity over time in response to carbon price, 550 standard technology scenario, 2006–2100	538
Figure 22.5	Contribution to Australia's agricultural emissions, by subsector, 2005	544
Figure 22.6	Ratio of emissions permit costs to value of production, by subsector, 2005	545
Figure 22.7	Australian real retail prices for meat, 1960–2006	546
Figure 22.8	Australian per capita consumption of meat, 1960–2006	547
Figure 22.9	Per capita area of forested and wooded land, 2005	555
Figure 22.10	Carbon removal potential for environmental plantings (tonnes CO <sub>2</sub> -e per ha per year)	555
Figure 23.1	Australia's emissions in the 550 backstop scenario (global entitlement, net of trading)	571
Figure 23.2	Sources of mitigation under the 550 backstop scenario	572
Figure 23.3	Direct emissions per million dollars value added, 2005	573
Figure 23.4	Direct and indirect emissions per million dollars value added, mining and manufacturing, 2005	573
Figure 23.5	Emissions sources (not including forestry) in the 550 backstop technology scenario	574
Figure 23.6	Australia's emissions in the 450 backstop technology scenario (global entitlement, net of trading)	575
Figure 23.7	Total emissions for the no-mitigation, 450 and 550 backstop scenarios	576
Figure 23.8	Sources of mitigation under the 450 backstop technology scenario	577
Figure 23.9	Emissions sources (not including forestry) in the 450 backstop technology scenario	577

## Tables

Table 2.1	Sources of greenhouse gases	31
Table 2.2	Estimates of the amount of carbon stored in different sinks in 1750 and how they have changed	36
Table 3.1	Growth in CO <sub>2</sub> emissions from fuel combustion, GDP and energy	56
Table 3.2	Shares of total greenhouse gas emissions by country/region in the Garnaut–Treasury reference case	65
Table 3.3	Time to exhaustion of current estimates of reserves and reserve base for various metals and minerals, and fossil fuels	71
Table 4.1	Summary of extreme climate responses, high-consequence outcomes and ranges for tipping points for the three emissions cases by 2100	102
Table 5.1	Projected changes to statewide annual average rainfall, best-estimate outcome in a no-mitigation case (per cent change relative to 1990)	115
Table 5.2	Projected changes to statewide average rainfall, dry and wet outcomes in a no-mitigation case (per cent change relative to 1990)	116
Table 5.3	Projected increases in days over 35°C for all capital cities under a no-mitigation case	117
Table 5.4	Projected per cent increases in the number of days with very high and extreme fire weather for selected years	118
Table 6.1	Sectors and areas considered in this chapter	122
Table 6.2	Climate cases considered by the Review	124
Table 6.3	Differences between probable unmitigated and mitigated futures at 2100—median of probability distributions	127
Table 6.4	Decline in value of irrigated agricultural production in the Murray-Darling Basin out to 2100 from a world with no human-induced climate change	130
Table 6.5	Percentage cumulative yield change from 1990 for Australian wheat under four climate cases	132
Table 6.6	Magnitude of impacts to water supply infrastructure in major cities under four climate cases	136
Table 6.7	Infrastructure impacts criteria	137
Table 6.8	Magnitude of impacts on buildings in coastal settlements under four climate cases	138
Table 6.9	Change in likely temperature-related deaths due to climate change	140
Table 7.1	Comparison of the highest per capita emissions among OECD countries (tonnes per person per year)	154
Table 7.2	Agricultural emissions and land use, land-use change and forestry emissions, by commodity and economic sector, 2005	168
Table 9.1	2020, 2050 and 2100 global emissions changes for the two global mitigation scenarios, relative to 2001 (per cent)	205

Table 9.2	Emissions entitlement allocations for 2020 and 2050 relative to 2000–01 and Kyoto/2012 (per cent)	209
Table 9.3	Emissions entitlement allocations expressed in per capita terms in 2020 and 2050 relative to 2000–01 and Kyoto/2012 (per cent)	210
Table 11.2	Assessing the market impacts of climate change	254
Table 11.3	Net present cost of the 450 ppm and 550 ppm scenarios (in terms of no-mitigation GNP) and the '450 premium' to 2050 and 2100	270
Table 12.1	Summary of interim targets in 2020 (per cent)	283
Table 12.2	Reductions in emissions entitlements by 2050 for policy scenarios (per cent)	283
Table 12.3	Modelling results in 2020 for policy scenarios	296
Table 13.1	Attributes of mitigation and adaptation shocks	303
Table 14.1	Governance of an Australian emissions trading scheme	352
Table 14.2	Interaction between the emissions trading scheme and the Mandatory Renewable Energy Target	355
Table 14.3	Overview of the proposed emissions trading scheme design	358
Table 17.1	Four kinds of principal–agent problems	414
Table 18.1	Brief assessment of two technology categories against criteria for national strategic interest	432
Table 18.2	Research and development programs in Australia targeting low-emissions technologies	435
Table 18.3	Mechanisms for directly subsidising positive externalities in demonstration and commercialisation	437
Table 18.4	Estimates of private and social rates of return to private research and development spending	441
Table 21.1	Transport sectors	504
Table 22.1	Vulnerability of Australia's agricultural industry to the biophysical impacts of climate change, by subsector	535
Table 22.2	Potential for emissions per annum reduction and/or removal from Australia's agriculture, forestry and other land use sectors	542
Table 22.3	Impact of emissions permit prices on cost of meat production	546
Table 22.4	Technical potential for CO <sub>2</sub> removal by soil—selected estimates	549
Table 22.5	Estimated oil yield per ha for biodiesel production	553
Table 22.6	Area of selected land uses in Australia	554
Table 23.1	Total after-tax per capita income (2005 dollars)	569
Table 23.2	Annual average growth rates for GNP and GDP under the no-mitigation, 550 and 450 scenarios with backstop technology (Type 1 and Type 2 benefits of mitigation) (per cent)	570

## List of shortened forms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACCESS	Australian Community Climate and Earth System Simulator
ACIAR	Australian Centre for International Agricultural Research
APEC	Asia–Pacific Economic Cooperation
BoM	Bureau of Meteorology
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CFCs	chlorofluorocarbons
CO <sub>2</sub> -e	carbon dioxide equivalent
CO2CRC	Cooperative Research Centre for Greenhouse Gas Technologies
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCC	Department of Climate Change
GDP	gross domestic product
GEF	Global Environment Facility
GGAS	New South Wales Greenhouse Gas Reduction Scheme
GIAM	global integrated assessment model
GNP	gross national product
GTEM	global trade and environment model
HCFCs	hydrochlorofluorocarbons
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
LNG	liquefied natural gas
LUCF	land use, land-use change and forestry
MMRF	Monash Multi Regional Forecasting
MRET	Mandatory Renewable Energy Target
NEMMCO	National Electricity Market Management Company
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
R&D	research and development
SRES	Special Report on Emissions Scenarios of the IPCC
UNFCCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization



**Units of measurement**

Gt	gigatonne (one billion metric tonnes)
kWh	kilowatt hour
Mt	megatonne (one million metric tonnes)
MWh	megawatt hour
PJ	petajoule (10 <sup>15</sup> joules)
ppb	parts per billion
ppm	parts per million
TJ	terajoule (10 <sup>12</sup> joules)
TWh	terawatt hour

## Glossary

Definitions are taken from the Intergovernmental Panel on Climate Change wherever possible. A list of sources is provided at the end of the glossary.

Terms in a definition that appear elsewhere in the glossary are italicised.

- abatement.** Activity that leads to a reduction in *greenhouse gas* emissions.
- abrupt climate change.** The nonlinearity of the *climate system* may lead to abrupt *climate change*. The term 'abrupt' often refers to time scales faster than the typical time scale of the responsible *forcing*.
- adaptation.** Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
- adaptive capacity.** The ability of a system to adjust to *climate change* (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
- additionality.** Reduction in net emissions by sources or enhancement of removals by *carbon sinks* that is additional to the reduction that would occur in the absence of an incentive provided through a program.
- aerosols.** A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometres (a millionth of a metre) that remain in the atmosphere for a relatively short time.
- afforestation.** Planting of new forests on lands that historically have not contained forests.
- albedo.** The amount of *solar radiation* reflected by a surface or object, often expressed as a percentage.
- Annex B countries/parties.** Industrialised countries and economies in transition countries listed in Annex B to the *Kyoto Protocol* that have emissions reductions targets for the period 2008–12.
- Annex I countries/parties.** Industrialised countries and economies in transition listed in Annex I to the *United Nations Framework Convention on Climate Change*. They include the 24 original OECD members, the countries of the European Union, and 14 countries with economies in transition.
- anthropogenic.** Resulting from or produced by human beings.
- Bali Roadmap.** The key decisions agreed at the 2007 Bali Climate Change Conference, charting the way for the UN negotiations on a post-2012 UN climate agreement.

- base case.** In the Review's modelling, the evolution of the global and Australian economies and associated *greenhouse gas* emissions to the end of the 21st century taking into account the impacts of *climate change*.
- biochar.** A charcoal product made through anaerobic combustion of biomass (for example, farm or wood waste) at high temperatures.
- biosequestration.** The removal from the atmosphere and storage of *greenhouse gases* through biological processes, such as growing trees and practices that enhance soil carbon in agriculture.
- business as usual.** A scenario of future *greenhouse gas* emissions that assumes that there would be no major changes in policies on mitigation.
- carbon budget.** The amount of carbon (or emissions, expressed as *carbon dioxide equivalent*) allowed to be released over a number of years, by a given party or parties.
- carbon–climate feedback.** See *feedback*.
- carbon cycle.** The term used to describe the movement of carbon in various forms (for example, as carbon dioxide or methane) through the atmosphere, ocean, plants, animals and soils.
- carbon dioxide equivalent (CO<sub>2</sub>-e).** A measure that allows for the comparison of different *greenhouse gases* in terms of their *global warming potential*.
- carbon dioxide equivalent concentration.** The concentration of carbon dioxide (measured in parts per million) that would lead to the same amount of *radiative forcing* as a given mixture of carbon dioxide and other *greenhouse gases*.
- carbon dioxide equivalent emissions.** The amount of carbon dioxide emissions that would cause the same integrated *radiative forcing*, over a given time horizon, as an emitted amount of a well-mixed *greenhouse gas*. The equivalent carbon dioxide emission is obtained by multiplying the emission of a well-mixed greenhouse gas by its *global warming potential* for the given time period.
- carbon dioxide fertilisation.** Increasing plant growth or yield by elevated concentrations of atmospheric carbon dioxide.
- carbon price.** The price at which *emissions permits* can be traded, nationally or internationally.
- carbon sink or reservoir.** Parts of the *carbon cycle* that store carbon in various forms.

**Clean Development Mechanism (CDM).** A flexibility mechanism under the Kyoto Protocol that allows *Annex I countries* to meet part of their obligation to reduce emissions by undertaking approved emissions reduction projects in developing countries. Emissions reductions under the CDM can create tradable permits offset credits, called certified emission reductions or CERs.

**climate change.** A change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

**climate sensitivity.** A measure of the *climate system's* response to sustained *radiative forcing*. Climate sensitivity is defined as the global average surface warming that will occur when the climate reaches equilibrium following a doubling of carbon dioxide concentrations.

**climate system.** A highly complex system consisting of the atmosphere, the water cycle, ice, snow and frozen ground, the land surface and plants and animals, and the interactions between them.

**CO<sub>2</sub>-e.** See *carbon dioxide equivalent*.

**commitment period.** The period in which *Annex B countries* are required to meet their emissions reduction commitments. The first commitment period is 2008 to 2012. The dates of the second commitment period have not yet been determined.

**committed warming.** Warming of the climate which, due to the thermal inertia of the ocean and slow processes in ice sheets, biological sinks and land surfaces, would continue even if the atmospheric composition were held fixed at today's values.

**contraction and convergence.** A model for allocating a global emissions budget among nations. Allocations of emissions entitlements start at current emissions levels, and converge over time to equal per capita allocations in all countries. At the same time, the global emissions budget, and thus the global per capita average, contracts toward lower levels.

**deforestation.** Conversion of forest to non-forested land.

**direct emissions.** Emissions from sources within the boundary or control of an organisation's or facility's (or individual's) processes or actions. They can include emissions from fuel combustion (for example, in transport) and non-combustion emissions arising from physical or chemical processes (for example, in agricultural production or industrial manufacturing).

**ecosystem.** A distinct system of interacting living organisms, together with their physical environment. The extent of an ecosystem may range from very small spatial scales to, ultimately, the entire earth.

- El Niño – Southern Oscillation.** A coupled fluctuation in the atmosphere and the equatorial Pacific Ocean that has a large influence on Australia's climate.
- emissions (or carbon) intensity.** A measure of the amount of carbon dioxide, or other *greenhouse gases*, emitted per unit of, for example, electricity, energy output or kilometre of travel.
- emissions limit or emissions cap.** A limit on the number of tonnes of *greenhouse gases* that can be emitted under an *emissions trading scheme*. The limit could apply to the whole economy, or to the sectors covered under the scheme.
- emissions permit.** See *permit*.
- emissions trading scheme.** A market-based approach to reducing emissions. An emissions trading scheme places a limit on emissions allowed from all sectors covered by the scheme. It allows those reducing *greenhouse gas* emissions to use or trade excess emissions *permits* to offset emissions at another source. Also referred to as a 'cap and trade scheme'.
- energy efficiency.** The ratio of energy required to produce a certain level of a service, such as kilowatt hours per unit of heat or light.
- energy intensity.** A measure of the amount of energy supplied or consumed per unit of, for example, gross domestic product or sales.
- enteric fermentation.** Part of the digestive process of ruminant animals, such as cows and sheep, that results in the release of methane.
- evapotranspiration.** The sum of evaporation and plant transpiration from the earth's land surface to the atmosphere.
- exposure.** The nature and degree to which a system is exposed to significant climatic variations.
- feedback.** An interaction mechanism between processes, where the result of an initial process triggers changes in a second process and that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.
- fluorinated gases.** Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>). See *greenhouse gas*.
- forcing.** An induced change to a system.
- geo-engineering.** Technological efforts to reduce global warming by stabilising the *climate system* through intervention in the energy balance of the earth.
- geosequestration.** Injection of carbon dioxide directly into underground geological formations.

**global warming potential.** The index used to translate the level of emissions of *greenhouse gases* into a common measure in order to compare the relative *radiative forcing* of different gases without directly calculating the changes in atmospheric concentrations.

**greenhouse effect.** The effect created by *greenhouse gases* in the earth's atmosphere that allow short-wavelength (visible) *solar radiation* to reach the surface, but absorb the *long-wavelength radiation* that is reflected back, leading to a warming of the surface and lower atmosphere.

**greenhouse gas.** Any gas that absorbs infrared radiation in the atmosphere. This property causes the *greenhouse effect*. With the exception of Chapter 2, where a wider range of greenhouse gases are discussed, the term 'greenhouse gases' in this report relates to those gases covered by the Kyoto Protocol, which are carbon dioxide, nitrous oxide, methane, sulphur hexafluoride, perfluorocarbons (PFCs) and hydrofluorocarbons (CHFCs).

**ice sheet.** A mass of land ice that is sufficiently deep to cover most of the underlying bedrock, so that its shape is mainly determined by the flow of the ice as it deforms internally and/or slides at its base.

**indirect emissions.** Emissions that are a consequence of the activities of an organisation (or individual) but originate from sources owned or controlled by another. Indirect emissions can refer to the emissions attributable to the purchase of electricity, heat or steam from another party, and also from activities such as outsourcing and waste disposal.

**intertemporal flexibility.** The ability to use *emissions permits* at different points in time, made possible through the flexibility mechanisms of hoarding and lending.

**Kyoto Protocol.** An agreement adopted under the *United Nations Framework Convention on Climate Change* in 1997. It entered into force in 2005.

**long-lived greenhouse gases.** A term used to identify the selection of *greenhouse gases* covered by the Kyoto Protocol to distinguish them from ozone and water vapour, both of which are removed from the atmosphere relatively quickly.

**long-wavelength radiation.** Thermal radiation, or heat, emitted by the earth's surface, the atmosphere and the clouds. It is also known as 'infrared radiation'.

**Marrakesh Accords.** A series of agreements signed in Morocco in 2001 on the rules of meeting the targets set by the *Kyoto Protocol*.

**mitigation.** A reduction in the source of, or enhancement of the sinks for, greenhouse gases.

- Montreal Protocol.** The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in 1987. It controls the consumption and production of chemicals that destroy stratospheric ozone, such as chlorofluorocarbons.
- offsets.** Reductions or removals of greenhouse gas emissions that are used to counterbalance emissions elsewhere in the economy.
- overshoot scenario or profile.** A mitigation scenario where concentrations of a *greenhouse gas* (or a mix of greenhouse gases) peak at a higher atmospheric concentration than the eventual target, and then reduce over time to achieve *stabilisation*.
- passenger-kilometre.** A measure of passenger transport activity, equal to one passenger carried one kilometre. For example, two individuals in a car travelling 50 kilometres is equal to 100 passenger-kilometres.
- peaking scenario or profile.** A mitigation scenario where concentrations of a *greenhouse gas* (or a mix of greenhouse gases) stabilise or peak, and then continue to reduce.
- permit or emissions permit.** A certificate created under an *emissions trading scheme* that enables the holder to emit a specified amount of *greenhouse gases*, generally one tonne of *carbon dioxide equivalent*.
- price ceiling.** An upper limit on *carbon prices*. Once the price ceiling is reached, an unlimited amount of permits are issued at that price.
- floor price.** A lower limit on *carbon prices*. When the floor price is reached, authorities would intervene to reduce the supply of permits, in order to keep prices at or above the floor.
- primary energy.** Energy in the forms obtained directly from nature, for example coal, natural gas or solar energy.
- radiative forcing.** A measure of the influence that a factor has on the energy balance of the climate system. Positive forcing tends to warm the surface, while negative forcing tends to cool it.
- reference case.** In the Review's modelling, the evolution of the global and Australian economies and associated greenhouse gas emissions to the end of the current century in the absence of climate change.
- reforestation.** Replanting of forests on lands that once contained forests but were converted to some other use.
- secondary market.** In the context of an emissions trading scheme, a financial market for trading of permits, whether by auction or some other method of allocation. It may also include markets in physical or financial contracts for the future purchase or sale of permits (forward contracts).

**sensitivity.** With respect to the *climate system*, the degree to which the system is affected, either adversely or beneficially, by climate-related stimuli. With respect to modelling, a sensitivity analysis may be used to assess how the variation of model assumptions affect the output of that model.

**sequestration.** Removal of carbon from the atmosphere by, and storage in, terrestrial or marine reservoirs.

**severe weather event.** An event that is rare within its statistical reference distribution at a particular place. The characteristics of what is called 'severe weather' may vary from place to place. An 'extreme climate event' is an average of a number of weather events over a certain period of time—an average that is itself extreme (for example, rainfall over a season).

**sink.** See *carbon sink*.

**solar radiation.** Electromagnetic radiation emitted by the sun. It is also referred to as 'short-wavelength radiation'.

**stabilisation.** In the *climate change* context, keeping constant the atmospheric concentrations of one or more *greenhouse gases* (such as carbon dioxide) or of a *carbon dioxide equivalent concentration* of a mix of greenhouse gases.

**storm surge.** A temporary increase, at a particular location, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). A storm surge is the excess above the level expected from the tidal variation alone at that time and place.

**stratosphere.** The highly stratified layer of the atmosphere above the *troposphere* extending from about 10 km (ranging from 9 km at high latitudes to 16 km in the tropics on average) to about 50 km in altitude.

**sunspot cycle.** Periods of high activity observed in numbers of sunspots (small dark areas on the sun), as well as radiative output, magnetic activity and emission of high-energy particles.

**temperature reference point** or **baseline.** Unless otherwise specified, temperature changes discussed in this report are expressed as the difference from the period 1980–99, expressed as '1990 levels' in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. To compare temperature increases from 1990 levels to changes relative to pre-industrial levels, 0.5°C should be added.

**thermal expansion.** In connection with sea level, the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence to sea-level rise.

**thermohaline circulation.** Large-scale circulation in the ocean driven by high densities at or near the surface, caused by cold temperatures and/or high salinities, in addition to mechanical forces such as wind and tides.



**threshold** or **tipping point**. The point in a system at which sudden or rapid change occurs, which may be irreversible.

**tonne-kilometre**. A measure of freight activity, equal to one tonne of freight carried one kilometre. For example, 20 tonnes carried 5 kilometres is equal to 100 tonne-kilometres.

**trade-exposed, emissions-intensive industries**. Industries with product prices that are set by world markets and that produce significant emissions during their production processes.

**transaction costs**. Costs associated with a market exchange (which may include indirect costs of market participation, such as information gathering).

**transition countries**. Countries in central and eastern Europe and the former Soviet Union defined in the *United Nations Framework Convention on Climate Change* and the *Kyoto Protocol* as 'undergoing the process of transition to a market economy'.

**troposphere**. The lowest part of the atmosphere, from the surface to about 10 km in altitude at mid latitudes (ranging from 9 km at high latitudes to 16 km in the tropics on average), where clouds and weather phenomena occur.

**ultraviolet radiation**. The high-energy, invisible part of the spectrum of light emitted by the sun. The majority of ultraviolet radiation is absorbed by the layer of ozone in the *stratosphere*.

**United Nations Framework Convention on Climate Change (UNFCCC)**. The international treaty that sets general goals and rules for confronting *climate change*. It has the goal of preventing 'dangerous' human interference with the *climate system*. Signed in 1992, it entered into force in 1994, and has been ratified by all major countries of the world.

**upstream point of obligation**. Designating the point of obligation at a point higher or earlier in the supply chain. For example, the obligation for emissions from petrol can be placed upstream at the point of excise tax collection.

**utility**. Personal satisfaction or benefit derived by individuals from the consumption of goods and services.

**vector-borne disease**. A disease that is transmitted between hosts by a vector organism (such as a mosquito or tick—for example, dengue virus).

**volumetric control**. The imposition of a restriction on the amount of something allowed. For example, a cap and trade **emissions trading scheme** sets a limit on the amount of emissions that may be released over a given period of time without incurring a penalty. By contrast, a price control policy would set the cost of emissions or permits, but not the amount.

## Sources

- IPCC 2007, *Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor & H.L. Miller (eds), Cambridge University Press, Cambridge and New York.
- IPCC 2007, *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (eds), Cambridge University Press, Cambridge.
- IPCC 2007, *Climate Change 2007: Mitigation of climate change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds), Cambridge University Press, Cambridge and New York.
- IPCC 2007, *Climate Change 2007: Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Core Writing Team, R.K. Pachauri & A. Reisinger (eds), IPCC, Geneva.
- IPCC 2007, *Climate Change 2007: Synthesis report. An assessment of the Intergovernmental Panel on Climate Change*, A. Allali, R. Bojariu, S. Diaz, I. Elgizouli, D. Griggs, D. Hawkins, O. Hohmeyer, B. Pateh Jallow, L. Kajfez-Bogataj, N. Leary, H. Lee & D. Wratt (eds), Cambridge University Press, Cambridge.
- Melbourne Water 2006, *Port Phillip and Westernport Region, Flood Management and Drainage Strategy*, Melbourne Water, Melbourne.
- National Emissions Trading Taskforce 2007, *Final Framework Report*, submission to the Garnaut Climate Change Review, 2008.
- Prime Minister's Science, Engineering and Innovation Council 2007, *Climate Change in Australia: Regional impacts and adaptation—managing the risk for Australia*, Independent Working Group, Canberra.

## Index

- Note:** Page numbers in **bold** text denote boxed text; those in *italics* denote glossary definitions. References to figures, tables and endnotes are indicated by *fig*, *tab* and *n* after the page number.
- 450/550 mitigation scenarios
    - description 86
    - feasibility of reaching international agreement on 212–13
    - greenhouse gas concentration projections 86
    - likelihood of extreme climate outcomes 101
    - modelling results
      - 450 backstop technology 575–76
      - global emissions changes over 2001: 205–06
      - per capita emissions, 2012–2050: 208
      - purchases of foreign permits (450 and 550) 571, 575
      - sources of emissions (450 and 550) 574, 577
      - sources of mitigation (450 and 550) 572, 577
      - total Australian emissions 571, 575
      - summary of projected climate change 87–96
    - 450 case *see* 450/550 mitigation scenarios
    - 550 case *see* 450/550 mitigation scenarios
    - 2020 targets *see* interim targets
  - abrupt climate change 96–97, 608
  - adaptation
    - adaptation challenges
      - buildings in coastal settlements 378–79
      - ecosystems and biodiversity 379–80
      - emergency management services 381
      - irrigated agriculture 377–78
      - urban water supply infrastructure 378
    - attitudinal aspects 14
    - community protection as non-government responsibility 363–64
    - cost–benefit impact 13–14
    - defined 302, 608
    - role of food markets 375–76
    - role of insurance markets 370–73
    - see also* agency barriers; climate information; information barriers
  - Adaptation Fund 224
  - adaptation policy
    - creation and dissemination of climate information 366–69
    - defined 302, 303
    - funding climate research 367–68
    - intervening to prevent ecosystem collapse 379–80
    - liberalising food markets 375–76
    - preventing inequitable responses 376
    - promoting insurability 372–73
    - Review’s institutional proposals 366–69
  - adaptation technologies
    - Australian early research 429
    - current demonstration and commercialisation programs 434–36
    - market failures in developing 426
  - adverse selection 407
  - aerosols
    - and fossil fuels 89
    - defined 29, 608
    - in geo-engineering 49
    - influence on climate system 29, 29–30, 38, 45, 85, 108
  - agency barriers 404
  - agriculture
    - adaptation to climate change 12
    - Australian early research 429
    - Australia’s emissions, relative to OECD countries 167–70
    - barriers to a low emissions future 558–60
    - economic impact of climate change on 259
    - effect of emissions price on 393
    - existing mitigation policies 535
    - impact of climate change on 129, 534–35, 535*tab*
    - in an emissions trading scheme 330
    - potential for reducing emissions 538, 542–43*tab*
    - projected future emissions 537–39, 541, 547–48
    - projected productivity and composition of sector 539–40
    - recent changes 532–33
    - transaction costs of including in emissions trading scheme 540, 544–45
  - air traffic emissions 234
  - albedo effect 29, 49, 608
  - algae, in carbon-cycle 35, 48
  - algal biofuels 432, 495, 552
  - algal biosequestration 424, 432, 567–68, 578
  - alpine tourism 134–35
  - alumina production 497
  - aluminium industry 497
  - Annex B countries/parties 187*n*2, 198, 608
  - Annex I countries/parties 174, 175, 201, 206–07, 608
  - Antarctic ice melt 94
  - anti-methanogen technology 424, 542

- appliances
  - energy efficiency rating 413
  - minimum performance standards 417–18
- Arctic warming
  - observed 76–77*fig*, 78, 82
  - projected 89, **95**
  - sea-ice decline 76, 82, 83, 271
- Asia–Pacific Economic Cooperation (APEC) 176
- Asia–Pacific geopolitical stability 145–50
- Asia–Pacific Partnership on Clean Development and Climate 176, 219
- atmosphere
  - accumulation of greenhouse gas
    - concentrations in 25–26
  - as component of climate system 27
  - changing temperature over time 25–26, 78
  - components and temperatures 24, 27, 28
  - natural greenhouse effect of 24
- Australia
  - as highest per capita OECD emitter 293
  - as laggard in mitigation efforts 292–93
  - as projected low-emissions economy 565–78
  - emissions entitlement 571
  - emissions reduction targets 209–11, 278–81, 307–08
  - policies to mitigate climate change 177–79
  - policy leadership role 223, 302
  - potential for backstop technology 567–68, 571
  - preferred climate change policy 310–11
  - projected effects of mitigation
    - on industry sectors 571–74
    - on inflation 568–70
    - on terms of trade and comparative advantage 576–78
  - ratification of Kyoto Protocol 180
- Australian Capital Territory (ACT) 413
- Australian Centre for International Agricultural Research (ACIAR) 226–27, **227**
- Australian Community Climate and Earth System Simulator (ACCESS) **366**
- Australian climate change policy research institute (proposed) xxxiii, 366*fig*, 368–69
- Australian Solar Institute 435
- Australia's International Forest Carbon Initiative **238**
- aviation emissions 234, 360*n5*, 507, 523, 525
  
- backstop technologies 251, 516, 567–68
- Bali Roadmap 175, 280, *608*
- Bayesian decision theory 8
- Benalla bushfire blackouts **447**
- benefits of mitigation xxiii–xxiv, 14–18, 264–68, 301–2
  
- biochar 48, 424, 481, **552**, 553, *609*
- biodiesel **552**
- biodiversity, climate change impact on 101, 141–44, 377
- bioenergy 551–54
- biofuels 541, 542–43*tab*, 551–53, **552**
- biomass 35, 48, 156, 165, 481, 542, 552, 554
- biosequestration
  - algal 424, **432**, **495**, 552, 567–68, 578
  - Australia's potential xxxii, 164–65, 542, **557**, 578, 582
  - barriers 582
  - defined *609*
  - effect of Kyoto Protocol on uptake 558
  - importance to emissions mitigation 559, 582
  - see also* soil sequestration
- bounded rationality 408
- Brazil, policies to mitigate climate change 180
- brown coal electricity generation 398
- building and construction industry **259**
- Building Australia Fund 451, 457
- Building Code of Australia 417
- buildings
  - impact of climate change on *128tab*, 137–39, *138tab*, 376–77, **405**
  - minimum performance standards 417–18
- bushfires
  - emergency management 377
  - impacts 134, **135**, 139, 262, 559
  - liabilities for emissions 557
  - observed increase 112
  - projections for Australia 118
- BushTender project **381**
  
- California
  - energy efficiency policies 416
  - Renewable Energy Transmission Initiative 450
- Canada, emissions reduction targets 177
- cap and trade schemes **178**, 195–97, 309
- carbon accounting, for agriculture and forestry xxxii, 165, 558, 582
- carbon budget *609*
- carbon capture and storage
  - and future of coal industry 392, 399, 438
  - capture from the air 48, 567–68
  - in Australia's national interest 431–32, 567
  - investment in 219, 223, 399, 438
  - modelling of 485–89, 496, 499, **583**
  - research on 432, 500
  - scale of the task 495
- carbon cycle
  - carbon–climate feedbacks 37
  - carbon sinks and 35–36
  - changes since 1750: 36
  - defined 35, *609*
  - future reduced absorptive capacity *44fig*

- carbon dioxide
  - as greenhouse gas 24, 31
  - as part of carbon cycle 35–36
  - carbon intensity of energy use 56
  - concentration in atmosphere 25–26, 33, 45
  - contribution to atmospheric warming 30*fig*, 37
  - emissions 31
  - from fossil-fuel use 55–58
  - long lifetime 32–33, 43
  - OECD vs non-OECD countries 56–57
  - projected growth to 2030: 62–63
  - recent accelerated growth 55–58
  - removal by soil 548–49
  - removal from air 48, 567–68
- carbon dioxide equivalent (CO<sub>2</sub>-e) 35, 37, 609
- carbon dioxide transportation 453–55
- carbon intensity of energy 57, 61, 611
- 'carbon leakage' problem 231–32
- carbon plantings 542–43*tab*, 552, 554–56
- carbon sequestration *see* biosequestration; geosequestration
- Carbon Sequestration Leadership Forum 219
- carbon sinks
  - defined 35–36, 609
  - rate of carbon storage over time 36
- carbon taxes
  - advantages 196
  - border adjustments to compensate domestic industries 233–34
  - limitations 309
- catastrophic events
  - examples 99–101, 118
  - likelihood 101–2, 271–72
- catastrophic fire weather 118
- cattle industry *see* livestock industry
- Centre for Australian Weather and Climate Research 367
- China
  - energy intensity 57–58, 65
  - mitigation efforts 179, 293
  - projected energy consumption growth 65–66
  - projected share of global emissions 65
  - projections of emissions growth 64, 65–66
- chlorofluorocarbons (CFCs)
  - accumulation in atmosphere 34
  - and the Montreal Protocol 34
  - as a greenhouse gas 31, 34
  - sources of emissions 32*tab*
- Clean Air Act (US) 178
- Clean Development Mechanism (CDM) 174–75, 610
  - international trade in offset credits under 229–30, 341
  - limitations and flaws 182, 183, 229–30
- Clean Technology Fund 219
- climate–carbon feedbacks
  - defined 37
  - uncertainty in projecting 98–99
- climate change
  - abrupt 96–97, 608
  - as diabolical public policy challenge xviii–xxi, 287–89
  - Australia's vulnerability 124–25
  - challenge for insurance markets 370–73
  - definitions 27, 610
  - extreme outcomes 97–99
  - high-consequence outcomes 99–101
  - high risk from xvii
  - human impact on 26–30, 82–83
  - impact of aviation on 507
  - impact on buildings 137–39, 405, 462
  - importance of rate of temperature change 39
  - income distribution effects 400
  - public attitudes to xviii–xix
- climate change (Australia)
  - observed impact
    - air and surface temperature 106–07
    - bushfires 112
    - cyclones and storms 111–12
    - drought 108–09
    - effect of El Niño 110–11
    - effect of Southern Annular Mode 111
    - heatwaves 112
    - ocean temperatures 107
    - rainfall 107–08
    - streamflows 109
  - projected impact
    - direct vs indirect 121
    - in the 450 and 550 cases 127–28*tab*
    - no-mitigation vs global mitigation comparisons 125–28, 127–28*tab*
    - on agriculture 125–28, 127–28*tab*, 129
    - on buildings in coastal settlements 137–39
    - on bushfires and heatwaves 117–18
    - on critical infrastructure 135–39
    - on cyclones and storms 117
    - on dryland cropping: wheat 131–33
    - on ecosystems and biodiversity 141–44
    - on geopolitical stability in Asia–Pacific region 145–50
    - on human health 139–41
    - on irrigated agriculture 129–31
    - on natural resource–based tourism 133–35
    - on rainfall 117
    - on resourced-based industries and communities 128–35
    - on temperatures 117
    - on terms of trade 145
    - state and territory impacts 126*fig*

- climate change (global)
  - observed impact
    - air and surface temperatures 75, 76, 77
    - determining human impact on 82–83
    - ice caps and ice sheets 81–82
    - ocean acidity 80
    - rainfall 81
    - regional patterns 76–77
    - sea level 79–80
    - severe weather changes 82
  - projected impact
    - carbon cycle 95–96
    - centrality of temperature changes 84, 87
    - confidence in climate models 84–85
    - heatwaves 95
    - ice-sheet melting 94, 120
    - impact of current emissions 85
    - impact of past vs current actions 85
    - ocean acidification 96
    - rainfall 92–93
    - risk and uncertainty in 96–101
    - sea level 93–94
    - snow and ice 95
    - storms 96
    - temperature 89–92, 247*tab*
    - tropical cyclones 96
    - use of multiple models to assess 87
- climate change mitigation
  - calculating costs and benefits xxiii–xxv, 1–22, 264–68
  - case for government intervention 303
  - conceptual aspect 302–5
  - costs of delay 2–3
  - global goals 42
  - global vs single country action xxvii, 25, 285–87
  - market vs non-market benefits 9–12, 262
  - methods and pathways 42–48
  - preferred approach for Australia 308–13
  - see also decision-making methodology; emissions trading scheme for Australia; emissions trading schemes; international agreement (post-Kyoto)
- climate change policy see climate change mitigation
- climate-induced migration 149–50
- climate information
  - creation and dissemination for adaptation 365–69
  - improving communication of 369
  - limits to quantity, quality and availability 369
  - Review’s institutional proposals 366–69
- climate models see modelling (climate change)
- climate outcomes
  - defined 83
  - emissions scenarios/cases 85–86
  - high-consequence 99–101
- climate science
  - atmospheric changes 25–26
  - carbon–climate feedbacks 36–37
  - carbon cycle 35–37
  - changes in greenhouse gas concentrations 25–26
  - climate sensitivity 38
  - climate system variability 39–40
  - definitions of climate change 27
  - effect of greenhouse gases on energy balance 37–38
  - factors influencing global warming 29–30
  - geo-engineering 49
  - greenhouse gas accumulation in atmosphere 32–36
  - greenhouse gas stabilisation 43–48
  - greenhouse gases and temperature rise 37–38
  - linking emissions and climate change 30–42
  - natural greenhouse effect 24
  - natural vs human influences 24–26
  - need for strengthened research and modelling in Australia 366–69
  - radiative forcing 37
  - Review’s recommendations 366–69
  - severity of climate change on Australia 125–28
  - uncertainty in 2, 23, 84–85, 365
- climate sensitivity
  - defined 38, 610
  - influence on temperature outcomes 89, 246, 263, 271
  - IPCC best-estimate 38, 89
  - use in Review scenarios 124*tab*
- climate system
  - climate variability 39, 75, 83
  - components 27
  - defined 610
  - energy balance 27–29, 38
  - inertia in 42, 46
  - modelling of 84
  - slow response of 42, 91
  - tipping points in 97
  - warming of 29–30, 78
- climate variability
  - and agriculture 129, 131, 133, 259
  - and insurance markets 370–71
  - changes in 41*fig*, 97
  - defined 39
  - large-scale patterns 39, 39, 111
  - relationship to climate change 27
  - severe weather events 40, 83, 111, 117

- Club of Rome 5, 69
- CO<sub>2</sub> *see* carbon dioxide
- CO2CRC project **495**
- coal
- as dominant Australian energy source 158–59
  - Australia's high emissions intensity 159–60
  - long-term future 392, 399, 438, 493–96, **583**
  - near-zero emissions technologies 223, 399, 482, 489, 493, **494–95**
- Coal 21 Fund 438
- coal consumption
- Australian electricity generation 159, 493
  - China 57–58
  - increases in 57–58
- coal industry and regions, structural adjustment assistance for 396–99
- coastal settlements
- impact of climate change on 137–39
  - minimising impacts through planning 461–62
  - sea-wall provision **462**
- commercialisation *see* demonstration and commercialisation
- commitment period, defined 610
- committed warming
- defined 88, 610
  - IPCC estimates 88
- compensatory payments
- case against 315–16
  - for coal communities 396–99
  - for low-income households xxxii, 387–88, 394–96, 569
- concentration goals
- 450 ppm 42–43, 212–13, 279
  - 550 ppm 42–43, 212–13, 279
  - argument for 400 ppm 42–43
  - Bali numbers **280**
  - choice between 450 and 550: 268–70, 271–72, 595–96
  - concept 193–94
  - modelling of 193–94, 246–47, 250
  - reaching agreement on 212–13
  - relationship to Australian emissions targets 278–81
  - relationship to global emissions targets 280
  - relationship to impact goals 193
  - setting global goals 279
- concentration profiles *see* concentration goals
- concentration targets
- for stabilising emissions 42–45, 193–94
  - modelling of 193–94, 246–47, 250
  - overshooting 45–46, 47–48
  - overshooting profiles 45–46
  - peaking profiles 46–47
  - stabilisation scenarios (*see* 450/550 mitigation scenarios)
- congestion charges 457–58
- conservation forests 542–43 *tab*, **557**
- construction **259**
- Consultative Group for International Agricultural Research 226–27, **227**
- 'contraction and convergence'
- as version of the per capita emissions approach 203–05
  - assumptions used in modelling **206–07**
  - defined 610
- coordination externalities 446, 456
- 'Copenhagen compromise' 282–83, 294–97
- Copenhagen conference *see* international agreement (post-Kyoto)
- coral reef destruction 100, 142, **143–44**, 271
- cost-benefit analysis
- methodological overview xxiii–xxv, 1–21
  - social discount rate in 20
  - types of costs/benefits 8–13, 253, 258–62, **259–60**
- costs of unmitigated climate change 253–63, 254–57 *tab*
- avoidance of non-market costs under 450 and 550: 270–71
  - comparisons with earlier estimates 260
  - costs in 22nd century 262–63
  - methodology 3–7, 247–50
- critical infrastructure
- economic effects of climate change 258
  - impact of climate change on 135–39
  - impacts criteria 137 *tab*
- cryosphere changes 81–82
- cycling 519–22
- cyclones 111–12, 117
- Darwin, projected hot days 117
- deaths, temperature-related 128 *tab*, 141–42
- decision-making methodology
- assessing non-market benefits 11–13
  - calculating benefits of mitigation 9–13
  - calculating costs of mitigation 3–7
  - confronting risk and uncertainty 7–9, 300–302
  - effect of adaptation on costs and benefits 13–14
  - framework for climate change policy 302–05
  - measuring mitigation benefits against climate change costs xxiii–xxiv, 14–18, 300–02
  - valuing future vs present welfare 18–21
  - see also* modelling (economic effects)
- defence spending **260**
- deforestation emissions 235, **237**
- delay, costs of xxviii, 2–3, 287–89
- demonstration and commercialisation
- current programs 434–37
  - defined 425
- dengue virus 147

- developed countries
  - need for immediate leadership from 185
  - need for International Low-Emissions Technology Commitment 221–23, 429
- developing countries
  - business-as-usual emissions targets for 199
  - differentiated emissions targets for 185, 198–200
  - emissions entitlements under 450 and 550 scenarios 205–11
  - energy intensity 56–57
  - energy intensity of economic activity 56–57
  - growth in CO<sub>2</sub> emissions 56–58
  - land-use change and forestry emissions 235–37
  - need for financial and technological incentives 18
  - need for more active abatement effort from 185
  - one-sided emissions targets for 198–200
  - role in advancing climate change abatement 185–86
- disclosure schemes 410
- discount rate 19–21
- distribution of income 387–89
  - see also* distributive efficiency
- distributive efficiency
  - assistance through social security and tax 394–95
  - dual rationale for government assistance 396–99, **397**
  - household compensation package xxxii, 387–88, 394–98, 569
  - role for government 393–99
- domestic appliances 417–18
- droughts
  - and agriculture 459, 533
  - as severe weather events 40
  - causes 81, **108–9**, 110
  - defined **108**
  - global projections 93
  - impacts 125, 133, 149, 377
  - in Australia 106, 108–9
  - water supply infrastructure and 458–59
- dryland cropping: wheat 131–33
- early movers
  - matched funding 437–41
  - spillovers from 433–34
- early research *see under* research and development
- economic growth
  - and use of fossil fuels 4–5
  - growth rates 268, 269, 570
  - resource limits as constraint 69–71
- ecosystems
  - defined 610
  - impact of climate change on 141–44, 377
  - need for adaptive measures 377–78
- education and training programs 410–11
- effective adaptation *see* adaptation
- El Niño – Southern Oscillation
  - and tropical cyclones 117
  - as extreme climate outcome 101–2, 271
  - as large-scale pattern of variability **39**
  - changes over time 97–98
  - defined 97, 110, 611
  - effect of climate change on 97–98, 113, 117
  - impact on Australia 39, 108–9, **109**, 110–12, 133
  - relationship to drought **109**
  - temporal variability 97–98
  - uncertainty concerning thresholds 98, **109**
- electricity costs, future projections 490
- electricity distribution infrastructure
  - feed-in tariffs 452
  - positive externalities of embedded generation 452
- electricity emissions 160
- electricity generation
  - dependence on coal 159, 493
  - dependence on water 477
  - effect of low-emissions coal technology 493
  - greenhouse gas emissions from 160
  - impact of transformed energy sector on 491–93
  - in low-emissions economy 572–74, **583**
  - non-coal energy options 474–77
  - projected technology shares 485–87, 489
  - retrofitting existing plants with new technologies 481, 500
- electricity prices 572–73, 575
- electricity supply, new technologies 448
- electricity transmission infrastructure
  - barriers to optimal scale 449
  - current adequacy 447–48
  - effect of damage to **447**
  - interconnectors as public goods 446–47
  - market failures in network extensions 448–49
  - need for excess capacity 446–47
  - role for national transmission planner 449–51
- emergency management services 381
- emissions entitlements
  - for Australia 209–11, 571, 575
  - implications for Australia 210–11
  - national allocations using ‘contraction and convergence’ **206–7**
  - need for an internationally tradable system 196



- per capita emissions proposal xxiv, 200–205
- principles for allocating across countries 200–205
- projected allocations 209–10
- see also* international trading in emissions entitlements
- emissions intensity 611
  - agriculture 168–70
  - electricity 160
  - energy 157–59
- emissions limit, defined 611
- emissions pathways 44–47, 86, 91, 113
- emissions price
  - distributive effects on households 387–89
  - effect on coal-based regions 391–93
  - effect on industry 390–93
  - effect on inflation 568–69
  - effect on innovation 567–68
  - effect on use of low-emissions products 567–68
  - pass-down effects 386–87
  - regressive effects 388–89
  - spatial variability of effects 388–89
- emissions projections scenarios
  - for Garnaut Review 59–62
  - IPCC *Special Report on Emissions Scenarios* 58, 62–64, 85, 87–88, 113, 183, 261
  - post-SRES 58
- emissions reduction targets (or trajectories)
  - approaches 194
  - Bali negotiations 280
  - conditional and unconditional, for Australia 278–81
  - Kyoto Protocol 174, 180–81
  - one-sided for developing countries 198–200
  - see also* interim targets
- emissions taxes *see* carbon taxes
- emissions trading scheme for Australia
  - accounting and tax issues 334
  - auction vs free allocation of permits 330–31
  - coverage 326–27, 358*tab*, 536
  - deferred payment for permit purchases 333–34
  - domestic offsets from non-covered sectors 327, 358*tab*
  - emissions limit and changes to the limit 325–26, 358*tab*
  - emissions monitoring, reporting and verification 328
  - guiding principles 323–24
  - impact on energy market 478
  - impact on household meat consumption 540, 545–48
  - independent carbon bank 336, 351–52, 352–53*tab*
  - institutional arrangements 351–53
  - international linking 337–41, 339–40, 359*tab*
  - intertemporal use of permits 334, 335, 337, 359*tab*
  - limits on international offsets 340–41
  - linking with offset markets 340–41
  - means for lowering costs of meeting targets 334–41
  - objective 322–23
  - pass-through of permit value to price of goods and services 332–33
  - penalties for non-compliance 328, 359*tab*
  - permit issue and release 330–34, 358*tab*
  - point of obligation 327–28, 329–30, 358*tab*, 615
  - price ceilings and floors 334–35, 359*tab*
  - projected impact on agriculture 536, 539–40
  - projected impact on forestry 540–41
  - projected impact on gas industry 498
  - projected impact on transport system 507–08
  - Review's preferred design 358–59*tab*
  - role of Mandatory Renewable Energy Target (MRET) xxxii, 353–56, 355*tab*, 356
  - rules 323–24
  - sector-specific issues 328–30
  - tradability of permits 324, 358*tab*
  - trade-exposed, emissions-intensive industries and 341–50, 346–47, 359*tab*
  - transaction cost of including agriculture in 559
  - transition from Greenhouse Gas Reduction Scheme to 356–57
  - transition period (2010 to end 2112) 350–51, 358*tab*
  - transitional assistance arrangements 341–50, 346–47
  - use of revenue from permit sales xxxii–xxxiv, 352*tab*, 388, 395
  - voluntary market for emissions reductions 357
  - see also* emissions price
- emissions trading schemes
  - as preferred policy for Australia 310–11
  - as superior to carbon tax 311
  - avoidance of compensatory payments 315–16
  - baseline and credit schemes 309–10
  - cap and trade schemes 309
  - dangers of compromising with design 314–15
  - defined 309–10, 611
  - economic impact of 311–13
  - effect on technological development 425–26
  - hybrid schemes 310
  - necessary rules for 311
  - role of public information programs 408–9

- emissions trajectory *see* emissions pathways; emissions reduction targets; interim targets
- Energy Efficiency Opportunities program 410–11
- energy efficiency
  - California 416
  - defined **404**, 611
  - effect of bounded rationality on 408
  - effect of information asymmetry on 407
  - potential for 405
  - role of government in 405–06
  - role of public information programs 408–09
- energy efficiency ratings 413
- Energy Innovation Fund 435*tab*
- energy intensity of economic activity
  - Australia compared with OECD countries 158
  - China 57–58
  - defined 611
  - OECD compared with non-OECD countries 56–57
- energy prices
  - effect on CO<sub>2</sub> emissions 68–69
  - impact on low-income households 389–90
  - trends 1970–2008: 67
- energy research and development
  - case for international public funding 218–23
  - falling levels 218
  - recent initiatives 219, **219**
  - see also* International Low-Emissions Technology Commitment
- energy sector, Australia
  - character and recent developments 469–72
  - fuel options 474–77
  - future transformation
    - economic impacts 490–99
    - forces driving 472–78
    - phases in 478–82
    - risks facing 499–501
    - technology scenarios 488–89
  - impact of emissions trading scheme 478
  - modelling the transformed sector 482–89
- energy service contracting 410–11
- Energy Technology Innovation Strategy (Victoria) 435*tab*
- enforcement mechanisms 238–39
- enteric fermentation emissions 163, 611
- equity
  - distributive efficiency **393**
  - in allocating emissions entitlements 202
  - in income distribution 19
  - main guarantors 385–86
  - see also* distributional efficiency; structural adjustment
- European Union
  - 450 ppm CO<sub>2</sub>-e stabilisation target 43
  - global mean warming target 192
  - policies to mitigate climate change 177
- evapotranspiration 129, 611
- externalities
  - early mover contributions to 433–34
  - from early research 428
  - from embedded electricity generation 452
  - from new transport infrastructure 456
- extreme climate outcomes
  - assessing the risk of 96–99
  - evaluating likelihood of 101
  - tipping points 96–97
- feed-in tariffs 452
- fire weather 118
- first-mover disadvantage 448
- fluorinated gases 34–35, 611
- food production *see* agriculture
- food security, Asia-Pacific region 146, **147**
- forest and wooded land
  - Australia vs OECD 164, 555
- forest sinks 535, 541
- forestry
  - afforestation and reforestation 550, 608, 613
  - conservation forests 557
  - impact of emissions trading scheme on 536, 539, 540–41
  - impact of mitigation on 535–36
  - inclusion in in emissions trading scheme 330
  - plantation and production forests 550–51
  - potential for reducing emissions 542–44*tab*
  - projected future emissions 539
- fossil fuels
  - constraints on consumption 4–5, 68–69
  - consumption growth 5
  - growth of CO<sub>2</sub> emissions from 55–58
  - resource availability 4–5, 70–71
  - role in Australia's electricity generation 159
  - role in Australia's primary energy consumption 158
- France, nuclear energy research 433
- free-rider problem
  - in electricity network extensions 448
  - solutions 288
  - see also* prisoner's dilemma
- freight transport 522–25
- fuel prices 389
- fugitive emissions 329
- future vs present utility 18–21

- Garnaut Review projections  
 comparison with existing projections 62–64  
 Garnaut-Treasury reference case projections 59–62  
 impact of China **65–66**  
 methodology and assumptions 59–62  
 of CO<sub>2</sub>-e emissions 61–64, 69–71  
 of country shares in global output 61  
 of GDP and GDP per capita 60–61  
 of global population 59–60  
 of resource availability 69–71  
 Platinum Age projections xxv, 59, 61–62, 63  
 gas transmission infrastructure 453–54  
 gasification **552**  
 Generation IV International Forum 219  
 geo-engineering  
 advantages and disadvantages 49  
 defined *611*  
 proposals 49  
 geopolitical stability in Asia-Pacific  
 climate refugees 149–50  
 food security 146  
 humanitarian disasters 148  
 impact of climate change on **260**  
 infectious diseases 147  
 sea-level rise 148–49  
 severe weather events 147–48  
 water availability **147**  
 geosequestration  
 and coal 392, 481–82, **495**  
 Australia's suitability **432**, 578  
 defined *611*  
 infrastructure needs 453–54  
 role of government in 454–55  
 technologies **495–96**, 581–82  
 geothermal technology 219, 273*n*2, 424, 481, 578, 581  
 glaciers  
 melting of Himalayan 99, **147**  
 observed changes 81–82  
 Global Environment Facility 218  
 Global Integrated Assessment Model (GIAM) 248  
 Global Trade and Environment Model (GTEM) 248  
 global warming potential  
 defined 35, *612*  
 goals *see* concentration targets; emissions reduction targets; impact targets  
 Great Barrier Reef xxvii, 46, 125, 126*fig*, 127*tab*, **143–44**, 262, 271  
 Green Car Innovation Fund 435*tab*  
 green credits 395–96  
 Green Leases 415  
 Greenhouse Development Rights framework 202  
 greenhouse effect  
 and the climate system *28fig*  
 defined 24, *612*  
 greenhouse gas  
 accumulation in atmosphere 32–35  
 linking emissions and climate change 30–31  
 changes in concentration over time 25, 32–35, 37–38  
 defined *612*  
 effect on energy balance 28–30, 37–38  
 global warming potential 35, *612*  
 lifetime in atmosphere 32, 43–44  
 projected concentrations 86, 246  
 radiative forcing 37  
 sources 31–32*tab*  
 greenhouse gas emissions (Australia)  
 emissions profile 153–65, 573*figs*  
 energy emissions 156–59  
 from electricity generation 160  
 future growth 155–56  
 industry emissions profiles  
 agriculture 167–70  
 mining and manufacturing, by sector 167  
 sectoral shares 165–66  
 international comparisons 153–54, 156–65, 168–70  
 livestock emissions 163  
 other stationary energy 498–99  
 per capita 153–54  
 recent growth trends 155  
 transport emissions 161–62, 505  
 greenhouse gas emissions (global)  
 from fossil fuel use 55–58  
 major emitting countries 54–55  
 no-mitigation projections 59–64, 69–71  
 projected country shares 64, 65*tab*  
 projected growth, China **65–66**  
 SRES and post-SRES projections 58  
 urban transport, by mode *520fig*  
 Greenhouse Gas Reduction Scheme (NSW) 356–57  
 greenhouse gas stabilisation *see* stabilisation (of greenhouse gas concentrations)  
 greenhouse gas stabilisation targets *see* emissions pathways; emissions reduction targets; interim targets  
 Greenland, melting of ice sheet 94, 102*tab*  
 Group of Eight (G8) 176  
 Guidelines for National Greenhouse Gas Inventories (IPCC) 163, 532, 536, 550–51

- hailstorms, projections for Sydney 117
- health
  - economic effects of climate change 254–57 *tab*, 258
  - impact of climate change on 123*tab*, 139–41, 147
  - main health risks in Australia 139
  - non-market impact of climate change 11
- heatwaves
  - as severe weather events 40
  - frequency and intensity 82, **95**, **112**
  - impacts on health 139
  - projections for Australia 117
- high and extreme fire weather 118
- high-consequence climate outcomes 99–101
- high-speed rail 523–24
- historical responsibility 202
- hot rocks (geothermal) technology 219, 273*n*2, 424, 482, 578, 581
- Hotelling curve 7, 20, 273
- household appliances
  - energy efficiency rating 413
  - minimum performance standards 417–18
- households
  - compensation package for xxxiii, 387–88, 394–96, 569
  - effect of information barriers 407–09
  - energy-efficiency advice and audits 411–12
- houses
  - energy efficiency rating 413
  - see also* coastal settlements
- human health *see* health
- human-induced climate change
  - assessing 26–27, 82–83
  - Australia 106
  - effect on energy balance of climate system 28–30
- humanitarian disasters 148
- hurricanes 82
- hybrid policies for emissions control *see* cap and trade schemes
- hybrid vehicles 513, **519**
- hydroelectricity 476–77
- hydrofluorocarbons 34
  
- ice caps and ice sheets
  - observed changes 81–82
  - projected changes 94, 102*tab*
- impact goals 192
- India
  - conflicts with neighbours over water **147**
  - policies to mitigate climate change 179
- Indian monsoon 99–100
- Indigenous communities 389, 557
  
- Indonesia
  - linking with Australian emissions trading scheme **340**
  - regional partnership with Australia **237–38**
- infectious disease 147
- information barriers
  - disclosure schemes as curb 412
  - education and training as curb 410–11
  - effect on household demand for energy 389
  - energy advice and audits as curb 412
  - in adoption of energy efficient technologies 404
  - information asymmetry and adverse selection 407
  - mandatory disclosure as curb 412–13
  - public information as curb 408–09
  - undersupply of information 406–07
- infrastructure
  - impact of climate change 135–39, 258
  - impacts criteria 137*tab*
- innovation
  - Australia as beneficiary of global 567
  - impact of emissions pricing 566–67
  - innovation chain 424–25
  - innovation policy 426–27
  - see also* demonstration and commercialisation; research and development
- insurance markets 370–73
- insurance value of mitigation 10–11, 271–72
- interim targets 282–85
  - modelling of 294–97
  - revision of 289–90
- International Adaptation Assistance Commitment (proposed), 224–25, 227, 239
- international agreement (post-Kyoto)
  - allocation of emissions entitlements across countries 200–05
  - arguments for interim targets 288–90
  - Australia's role, relevance and responsibilities xxx–xxxi, 277–81, 291–94, 307–08, 342–43
  - based on internationally tradable emissions entitlements 196–97, 227–30
  - benefits of a comprehensive agreement 285–87
  - conditional and unconditional interim targets 282–83
  - defining global goals (impact, concentration, emissions) 192–94
  - developed country leadership 185, 307
  - developing country targets 198–200
  - enforcement mechanisms 239

- entitlements based on per capita emissions 202–05
- feasibility of agreeing on 550 or 450 target 212–13
- graduated levels of national emissions commitments 198–200
- implications of failure 579
- incorporating international aviation and shipping 234
- incorporating land-use change and forestry 234–37
- international public funding for adaptation 223–26
- international public funding for mitigation 218–23
- joint agricultural research to assist developing countries 226–27
- modelling a ‘Copenhagen compromise’ 282–85, 294–97
- moving from 550 to 450 290
- overcoming free-rider problem 288–89
- policy-making challenges 281–82
- price-based vs quantitative national commitments 195–97
- role for international offsets 341
- sectoral agreements for emissions-intensive industries 230–32
- trade policy aspects 232–34
- international emissions permit trading 174–75
- International Low-Emissions Technology Commitment (proposal) 221–23, 429
- international mitigation and adaptation efforts as a ‘prisoner’s dilemma’ 184
- funding of adaptation measures **224**
- inadequate funding for mitigation 218–19
- International Adaptation Assistance Commitment (proposed), 224–25, 227, 239
- multilateral
  - Asia–Pacific Economic Cooperation (APEC) 176
  - Asia–Pacific Partnership on Clean Development and Climate 176
  - Bali Roadmap 175
  - Group of Eight (G8) 176
  - Kyoto Protocol 174–75
- unilateral
  - Australia 177
  - Brazil 180
  - Canada 177
  - China 179
  - European countries 177
  - India 179
  - Korea 177
  - New Zealand 177
  - Papua New Guinea 180
  - South Africa 180
- projected inadequacy for achieving stabilisation targets 183–84
- role of unilateral and regional action 186–87, **238–39**
- ways to accelerate progress 185–87
- international tourism **259**
- international trade
  - effect of climate change on Australia’s 145
- international trading in emissions entitlements
  - benefits and risks 227–28
  - options for 229
  - trade in offset credits 229–30
  - under Australian mitigation 571, 575
- IPCC (Intergovernmental Panel on Climate Change)
  - asserts global warming is ‘unequivocal’ 75
  - Bayesian approach 9
  - default values 165
  - emissions projections (scenarios) 58, 62–64, 85, 87–88, 113, 183, 261
  - radiative forcing from aviation 234, 507
  - treatment of uncertainty 9
  - underestimate of growth of emissions 261
- IPCC Fourth Assessment Report
  - changes to El Niño – Southern Oscillation 98
  - conclusions from 26, 75
  - definitions of climate change 27
  - estimate of climate sensitivity 38, 89, 246, 271–72
  - estimate of committed warming 88
  - estimates of global emissions 53–54
  - estimates of land-use change and forestry emissions 235
  - estimates of sea-level rise 93–94
  - estimates of temperature increases 261
  - global mitigation 405
  - human impact on climate 26
  - Review’s treatment of 24, **87**, 121
  - stabilisation scenarios 206, 211
  - temperature baselines **87**
- IPCC *Guidelines for National Greenhouse Gas Inventories* 163, 532, 536, 550–01
- IPCC *Special Report on Emissions Scenarios* 58, 62–64, 85, 87–88, 113, 183, 261
- Ireland, agricultural emissions 163–64
- irrigated agriculture
  - impact of climate change on 127 *tab*, 129–31, 377
  - need for adaptive changes 377

- Japan
  - Clean Technology Fund 219
  - contracts for vending machines 415
  - nuclear energy research 433
  - policies to mitigate climate change 177
- Jatropha curcas* **552**
- Joint Implementation (Kyoto Protocol) 174–75
- Kakadu xxvii, 126*fig*, 142, **259**
- kangaroos, for meat production 540, 547–48
- knowledge externalities 433–34
- Korea 177
- Kyoto Protocol
  - and global warming potential 35
  - as basis for new international action 185
  - emissions budgets for Annex I countries 201
  - enforcement mechanism 239
  - ‘flexibility where’ mechanisms 174–75
  - ratification by Australia 180
  - non-ratification by US 178, 180, 181, 182
  - omission of harvested wood emissions 550
  - progress towards reaching targets 180–82
  - technology transfer 218
  - see also* Clean Development Mechanism (CDM); international agreement (post-Kyoto)
- land management
  - in emissions trading scheme 330
- land use
  - inclusion in emissions trading scheme 330
  - land-use zoning 461
  - potential for reducing emissions **542–44**, 548–50
  - reliability of emissions measurement 558
  - types and areas 554*tab*
- land-use change
  - emissions accounting rules 558–59
  - emissions from 235–37, 541
- Latrobe Valley 398, 493
- Least Developed Countries Fund **224**
- Lieberman-Warner Climate Security Act (US) **178**
- livestock industry
  - impact of climate change on 547
  - sheep and cattle emissions 163–64, 540, 544–45
- local government planning 460
- low-emissions products
  - minimum performance standards 415–16
  - principal-agent problems in uptake 413–15
- low-emissions technologies
  - Australian early research 428–29
  - current demonstration and commercialisation programs 434–36
  - defined 442n1
  - need for specialist Australian research body 430
- low-emissions vehicles
  - cost competitiveness 513, **519**
  - modelling transition to 515–16, 518
  - price distortions on 526–27
  - projected takeup 390, 508, 515–16, 518, 524
  - types and emissions from **519**
- Low Emissions Technology Demonstration Fund 435*tab*
- low-income households
  - impact of emissions price on 387–90
  - subsidised energy-efficiency audits 412
  - targeted assistance for 395–96
- Major Economies Meeting on Energy Security and Climate Change 176
- malaria 147
- mallee eucalypts 553
- Mandatory Renewable Energy Target (MRET) xxxii, 354–56
- manufacturing industry
  - emissions 166–67, 573*fig*
  - impact of mitigation 266
- marginal elasticity of utility of consumption 19
- market-based policy mechanisms
  - argument against exemptions 314–17
  - argument against supplementary regulation 317–18
  - with measures to correct market failures 318
- market failures
  - climate change risks as 299
  - government role in correcting 318, 426–27, **427**, 454–56
  - in commercialisation of innovation 433–34
  - in early research phase of innovation chain 426, 428–29
  - in provision of infrastructure 445–46, 455–56
  - see also* agency barriers; information barriers; network infrastructure
- market uptake 425
- Marrakesh Accords 537, 558–59, 612
- marsupials 547–48

- matched funding  
 as compensation for early-mover spillovers 437–38  
 criteria 439–40  
 funding sources 438–39  
 mechanisms for 437*tab*  
 private and social rates of return 440–41
- meat prices and consumption 540, 545–48
- metals, availability 70–71
- methane  
 accumulation in atmosphere 33  
 and carbon cycle 35  
 and radiative forcing 30*fig*, 37  
 and stratospheric water vapour 34  
 as a greenhouse gas 24, 31  
 carbon-climate feedbacks 37, 98  
 concentration in atmosphere 24, 26*fig*, 33  
 emissions from livestock 163, 540, 544–45  
 global emissions of 53  
 lifetime in atmosphere 32, 43, 45  
 abatement options 559  
 projected emissions 61  
 sources of emissions 31*tab*, 163, 329  
 warming influence 45, 91
- Methane to Markets Partnership **219**
- minerals, availability 70–71
- minimum performance standards  
 and principal-agent problem 415–16  
 criteria 416  
 for appliances 417–18  
 for buildings 417–18
- mining  
 economic effects of climate change 258  
 emissions from 167, 573*fig*  
 impact of mitigation 266
- mitigation  
 case for government action 252, 303  
 defined 612  
 net benefits of xxiii–xxv, 14–18, 264–68  
 science of 42–48  
*see also* climate change mitigation
- mitigation potential 405
- modelling (climate change)  
 Australian Community Climate and Earth System Simulator (ACCESS) **367**  
 confidence in the models 84–85  
 key role of temperature change 84, 87  
 problems and uncertainties in 84–85  
 use of multiple models 84
- modelling (economic effects)  
 limitations 305–06  
 methodology  
 assumptions about technology 250–51, 306, 488–89, 511, 515–16, 579, 580–82
- assumptions for ‘Copenhagen compromise’ and ‘waiting game’ scenarios **294–95**  
 comparing costs of climate change and mitigation 14–18, 247–50, 252  
 discount rates 269–70  
 Garnaut/Treasury reference case 59–62  
 inclusion of Type 2 costs of climate change **259–60**  
 mitigation scenarios (450 and 550) 246  
 modelling long-term costs and benefits 249–50  
 modelling the mitigation scenarios 250–52, 268–72  
 models used **248**  
 types of costs (quantifiable and non-quantifiable) 247, 249–50
- results  
 agriculture and forestry 537–41  
 alternative technology scenarios 306  
 carbon prices 251, 296  
 comparison of 450 and 550 scenarios 268–72  
 concentration goals 193, 246–47, 250  
 ‘Copenhagen compromise’ 282, 294–96  
 cost of unmitigated climate change 253–63, 254–57*tab*  
 costs of meeting interim targets 295–96  
 costs of mitigation (gross and net) 264–68  
 distributional effects of emissions price 387–89  
 emissions allocations under a per capita approach 205–11  
 energy sector 482–87  
 ‘enhanced technology’ scenario **583**  
 expanded Mandatory Renewable Energy target **356**  
 nuclear energy 488  
 sectoral share of emissions reductions 571–74  
 trading of emissions entitlements 571, 575  
 transport sector 511–16
- Monash Multi Regional Forecasting (MMRF) model **248**
- monsoons 99–100
- Montreal Protocol 33, 34, 613
- Murray-Darling Basin  
 and Southern Annular Mode 111  
 competition for water 532  
 decrease in streamflow 109  
 impact of climate change on 122*tab*, 125, 126, 127*tab*, 129–31, 258  
 possibility of a wetter Basin **131**

- National Electricity Market 446–47, 464*n*1
- National Greenhouse and Energy Reporting Act 2007* **328**
- National Low Emissions Coal Fund 435*tab*
- natural resource-based tourism 127*tab*, 133–35
- network infrastructure
  - market failure in 445–46, 455–56
  - see also carbon dioxide transportation;
  - electricity distribution infrastructure;
  - electricity transmission infrastructure;
  - gas transmission infrastructure; transport infrastructure; urban infrastructure; water supply infrastructure
- New South Wales
  - Greenhouse Gas Reduction Scheme 356–57
  - projected climate change impact 126*fig*
- New Zealand
  - agricultural emissions 163–64
  - linking with Australian emissions trading scheme **339**
  - mitigation policies 177
- Ningaloo Reef xxvii, 11, 125, 133
- nitrous oxide
  - and radiative forcing 30*fig*, 37
  - as a greenhouse gas 24, 31, 33
  - concentration in the atmosphere 25–26, 33
  - global emissions 54
  - lifetime in the atmosphere 43
  - mitigation and measurement 543 *tab*, 544, 550, 558
  - sources of emissions 31*tab*, 544, 550
- Northern Territory
  - projected climate change impact 126*fig*, 141, 142
  - tourism 134
  - savanna fires 557
- nuclear energy
  - demand for 475
  - in Australia 476
  - modelling of 477, 488
  - research 433
- oceans
  - acidification 80, **96**, 100
  - and carbon–climate feedbacks 98
  - and El Niño – Southern Oscillation 98
  - and geo-engineering 49
  - and precipitation 81, 92, 115
  - as a carbon sink 35–37
  - as part of carbon cycle 35–37, 43, 95, 98
  - as part of climate system 27–28, **39**
  - observed changes 79–80
  - sea level (see sea-level rise)
- warming
  - around Australia 107
  - inertia in 42, 91
  - projected 89
  - slow rate of stabilisation 42, 91
- OECD countries
  - carbon intensity of energy use 56
  - growth in CO<sub>2</sub> emissions 56–57
- offset credits 229–30
- oil
  - impact of high prices on Australian transport system 506–10
  - impact of high prices on global emissions 67–69
  - prices, 1970 to 2008: 67–68
  - resource supply limits 70–71
- outer suburban households 390, 396
- overshooting 46–48, 613
- ozone
  - as a greenhouse gas 24, 31
  - stratospheric ozone 27, 30*fig*
  - and Montreal Protocol 33
  - destruction by CFCs 34
  - success in combatting depletion 33, 184
  - tropospheric ozone
    - accumulation in atmosphere 35
    - and precursor species 35
    - sources 32*tab*
- Pacific countries
  - impact of sea-level rise 149
- Papua New Guinea
  - and Australian emissions trading scheme **340**
  - deforestation emissions **238**
  - impact of sea-level rise 149
  - policies to mitigate climate change 180
  - regional partnership with Australia **237–38**
- passenger transport 504*tab*, 518–22, 523–24, 525
- peaking profile 47, 613
- per capita emissions entitlements
  - advantages 202–05
  - ‘contraction and conversion’ approach 203–05, **206–07**
  - implications for Australia 204–05, 209–11
  - modelling national emissions allocations under 205–11
- Perth
  - TravelSmart **409**
  - water supply 109, 110*fig*, 136
- Pew Center Pocantico Dialogue 201
- pipeline system fugitive emissions
  - in emissions trading scheme 329



- 'Platinum Age'
  - defined 21*n1*
  - projections xxv, 59, 61–62, 63
- price-based emissions control
  - arguments for and against 195–97 (*see also* carbon taxes)
- primary energy, Australia 158–59
- primary energy consumption
  - Australia, by sector 159
- principal–agent problems
  - contractual relationships as solution 415
  - defined 404
  - households and rising energy prices 389–90
  - in adoption of energy efficiency 404
  - in uptake of low-emissions products 413–15
  - mitigated through minimum performance standards 415–16
  - typology 414*tab*
- prisoner's dilemma xviii, 184, 288–89
  - defined 187*n7*
- projections *see* emissions projections
- scenarios
- public goods
  - electricity transmission interconnectors as 446–47
  - research and information 220, 365, 406–07, 428
  - road, bicycle and walking infrastructure 456
- public-housing renters 396
- public information programs 408–09
- public transport 390, 396, 510, 519–21
- quantity- and price-based emissions control 195–97
- Queensland, projected climate change impact 126*fig*, 128*tab*
- Queensland Future Growth Fund 435*tab*
- radiative forcing
  - and climate sensitivity 38
  - defined 37, 613
  - from aviation 507
  - of long-lived greenhouse gases 37–38
- rail transport 505, 511–13, 521, 523–24
- rainfall
  - and drought 108–09
  - and inflow into river systems 129
  - effect on streamflows 109
  - observed changes in (Australia) 108–09
  - observed changes in (global) 81
  - projections for Australia 115–16
  - temporal variations 116
- rapid climate change *see* abrupt climate change
- rate of pure time preference 19
- reference case
  - defined 613
  - Garnaut-Treasury reference case projections 59–62
- reforestation 330
- refrigerators and freezers, performance standards 418
- refugees 147–50
- regional industries
  - structural adjustment assistance for 396–99
  - vulnerability of 400
- regional partnerships 237–38
- regulatory and legal spillovers 434
- renewable energy
  - and electricity generation 354–56, 476–77, 485–87
  - Australia's opportunities 478, 481–82, 578
  - future demand for 69
  - growth in consumption 68
  - investment in 219, 472
  - Mandatory Renewable Energy Target (MRET) xxxii, 317, 472, 354–56
  - national targets 177, 179, 180, 354–56
  - projected future use 485–87, 489, 498, 581, 583
  - research and development 219, 239*n1*, 435*tab*
  - see also* geothermal; hot rocks; solar energy; tidal power; wave power; wind power
- Renewable Energy and Energy Efficiency Partnership (REEEP) 219
- Renewable Energy Development Initiative 435*tab*
- Renewable Energy Fund 435*tab*
- Renewable Energy Transmission Initiative (California) 450
- rent-seeking 297, 310, 315, 322, 331
- research and development
  - early-mover spillovers 433–34
  - early research
    - additional funding for 430
    - Australian funding levels 428–29
    - defined 425
    - ensuring optimal levels 428–30
    - funding criteria 431–33, 432
    - new institutions for 430
  - market failures in 426–28, 433–34
  - technological lock-in barriers 441–42
  - see also* demonstration and commercialisation; energy research and development
- resource limits
  - on fossil fuel use 4–6
  - to growth 69–71

- risk
  - assessment of 96–101
  - defined 7
  - extreme climate outcomes 96–101
- road and bridge maintenance **259**
- Ross River virus 147
- Rural R&D Corporations program 436
- savanna, mitigation potential 543*tab*, 557
- science of climate change *see* climate science
- sea-level rise
  - accelerated 94
  - historical rates of 94
  - ice-melt contribution to 80, 93, 94
  - impact on Asia–Pacific region 148–49
  - impact on ecosystems 142
  - IPCC projections 93–94
  - observed changes in global 79–80
  - thermal expansion contribution to 79–80, 93
- sea walls **462**
- sequestration
  - bringing emissions below natural level of 47–48
  - defined 614
  - technologies 495
  - see also* biosequestration; geosequestration; soil sequestration
- severe weather events
  - as security challenge in Asia–Pacific 147–48
  - defined 40, 614
  - implications for insurance markets 371, 400
  - observed global changes 82
- sheep and cattle *see* livestock industry
- shipping 234, 505, 512–13, 524–25, 526
- 'shocks'
  - defined 302
  - mitigation and adaptation 303*tab*
- skills spillovers 434
- social acceptance spillovers 434
- social security and tax systems 394–95
- soil carbon 548, 550
- soil management, mitigation potential 543*tab*, 548–50
- soil sequestration 548–49
- Solar Cities (program) 435*tab*, 481
- solar energy 424, 478, 481, 482, 578, 581
- solar radiation 29, 614
- South Africa, national climate change policy 180
- South Australia, projected climate change impact 126*fig*
- South-North Dialogue 201
- Southern Annular Mode
  - effect on Australian rainfall **109**, 111
  - effect on southern hemisphere climate **39**
- Southern Oscillation Index *see* El Niño – Southern Oscillation
- Special Report on Emissions Scenarios* (IPCC) 58, 62–64, 85, 87–88, 113, 183, 261
- species extinction 101, 141–42, 271
- spillovers
  - from early movers 433–34
  - from early research 428
- stabilisation (of greenhouse gas concentrations)
  - Article 2 (UNFCCC) 42
  - defined 614
  - European Union target (*see* 450/550 mitigation scenarios)
  - feasibility of targets 45–47
  - overshooting profiles 46–48
  - stabilisation scenarios (*see* 450/550 mitigation scenarios)
  - targets 42–43
  - UNFCCC objective 42
- stabilisation targets *see* concentration goals
- Stern Review
  - discount rate 19
  - economic impact of climate change 263
  - effect of climate change on global GDP 260
  - emissions projections 58
- stratosphere 27, 614
- stratospheric ozone *see* ozone
- streamflows **108**, 109, 377
- structural adjustment assistance
  - coal-generation regions 396–99, 493
  - equity plus efficiency rationale for 396–97
  - inadequate arguments for **397**
  - through social security and tax systems 394–95
- sulphate aerosol emissions 85
- support sector externalities 434
- Sydney, projected hailstorms 117
- 'syngas' **552**
- tailored information 408–10
- targeted assistance *see* structural adjustment assistance
- targets *see* concentration goals; emissions reduction targets
- tariffs 233–34
  - see also* feed-in tariffs
- tariffs on vehicles 526
- Tasmania, projected climate change impact 126*fig*
- technological lock-in 441
- technology
  - effect of carbon price on 425–26
  - modelling assumptions about 250–51, 306, 488–89, 511, 515–16, 579, 580–82

- see also* biosequestration; energy research and development; research and development; technology transfer; zero-emissions coal
- technology transfer
  - international initiatives 218–19
  - near-zero emissions coal technologies 223
  - under International Low-Emissions Technology Commitment 223
  - under UNFCCC and Kyoto Protocol 218
- temperature increases
  - committed warming 88, 610
  - global mean temperatures, post-2030: 88–89
  - observed (global) 75, 76, 77
  - positive feedback effects 263
  - relationship to changes in climate system 87
- temperature projections
  - extreme responses to stabilisation targets 89
  - for Australia 113–14
  - post-2030 88–89
  - post-2100 91
  - short-term responses to stabilisation targets 91
  - spatial variation 89
- temperature reference point 87, 614
- temperature-related deaths 141–42
- terms of trade
  - climate change impact on Australia's 145, 258
  - climate change impact on other countries' 258
  - economic effects of climate change 258
  - effects of mitigation on 266, 570, 576
- thermal expansion
  - contribution to sea-level rise 79–80, 93
  - defined 614
- thermohaline circulation
  - defined 614
- thresholds *see* tipping points
- Tibetan glaciers 147
- tidal power 448
- tipping points
  - defined 96–97, 615
  - for extreme and high-consequence outcomes 101–2
- tourism 133, 134–35, 143–44
- trade-exposed, emissions-intensive industries 615
  - adjustment assistance 295, 297, 316–17, 344–50, 346–47
  - sectoral agreements for 230–32, 342–43
- trade policy 232–34
- transition economies *see* developing countries
- transport
  - current role and structure 504–05
  - emissions 161–62, 505
  - future developments
    - causes of the transformation 505–11
    - economic modelling of 511–16
    - emissions reductions 512–14, 517, 522
    - expected cost of transition 525–26
    - fuel-efficient vehicles 506–07, 513–14, 518, 519, 523–25
    - fuel substitution 508, 519, 523–24
    - impact of carbon price 507–08, 512
    - mode shift 509–10, 517, 518–21, 522–23
    - public transport 390, 396, 510–11, 519–22, 520*fig*
    - role of governments in 510–11, 518–22, 523–24, 526–27
    - transport demand 509, 518–22, 523–24
  - in emissions trading scheme 329
  - information about options 409
  - transport sector typology 504*tab*
  - transport energy intensity of the economy 161
  - transport infrastructure
    - biases in expenditure on 456–57
    - need for coordinated long-term planning 458
    - prices for transport use 457–58
    - role of governments 456, 510–11, 522, 526
- TravelSmart 409
- Treasury *see under* Garnaut Review projections
- tropical cyclones
  - Australia 111–12
  - economic effects of climate change 258–59
  - projections 117
- tropical deforestation 235
- tropical storms
  - global projections 96
  - observed changes 82
- troposphere 27, 615
- tropospheric ozone *see* ozone
- uncertainty
  - and extreme climate outcomes 97–99
  - and insurance value of mitigation 10
  - and the delusion of delay 287
  - climate–carbon feedbacks 98–99
  - climate sensitivity 24
  - defined 8–9
  - future technologies 581
  - in climate change modelling 84–85
  - in climate science 24
  - in decision making 7–9, 300–02
  - in operations of mitigation regime 580
- United Kingdom
  - Carbon Trust 410
  - Clean Technology Fund 219

- United Nations Framework Convention on Climate Change (UNFCCC) 175
  - Article 2 42
  - capacity-based emissions entitlements 201
  - definition of climate change 27
  - emissions reduction goal 212
  - goal for global mitigation 42
  - principle of 'common but differentiated responsibility' 221
  - stabilisation objective 42
- United States
  - Clean Technology Fund 219
  - need for a credible long-term target 185
  - non-ratification of Kyoto Protocol 178, 180
  - policies to mitigate climate change 177, **178**
- urban densities 510–11, 526
- urban planning 460–63
  - adaptation measures 378, 460–61
- US Energy Information Administration 58
- US Environmental Protection Agency **178**
- utility, present vs future 18–21
  
- vested interests xxi, 314–16, 580
  - see also* rent-seeking
- Victoria, projected climate change impact 126*fig*
  
- walking and cycling 518–22
- waste emissions 329
- water availability in Asia 145, **147**
- water efficiency 404
- water markets
  - needed reforms 459
  - Review's proposals for distortion removal 374–75
  - role in adaptation 373–75
- water supply infrastructure
  - adequacy of current arrangements 459
  - future electricity demand 477–78
  - impact of climate change on 135–36
  - need for adaptive measures 378
- water vapour
  - accumulation in atmosphere 36
  - as a greenhouse gas 32
- West Arnhem Land Fire Abatement project 557
- Western Australia, projected climate change impact 126*fig*
- wheat crops 131–33
- wind power 354, **356**, 431–32, 448, 481, 585
- World Trade Organization 231–33
  
- zero-emissions coal technologies 493–96, **494–95**