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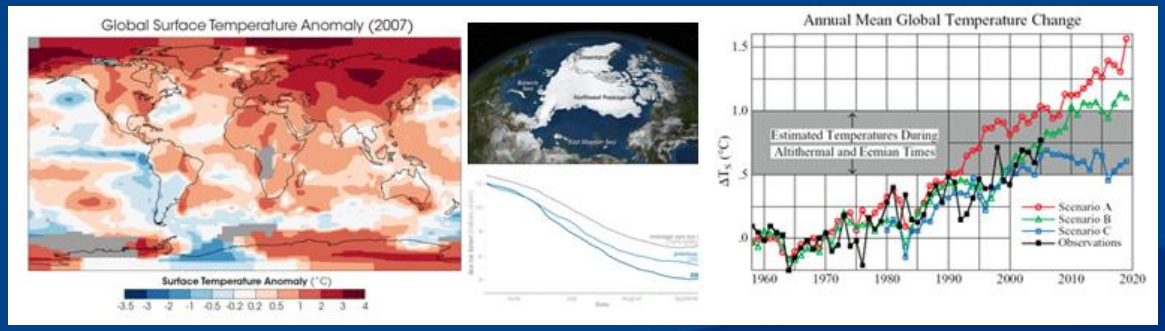

Climate Change Q&A **Seminar #5**

Will it cost the Earth to avoid climate change?

Professor Barry W. Brook

Sir Hubert Wilkins Chair of Climate Change

Director, Research Institute for Climate Change and Sustainability

School of Earth and Environmental Sciences

The University of Adelaide

Email: barry.brook@adelaide.edu.au

Climate Change Q&A

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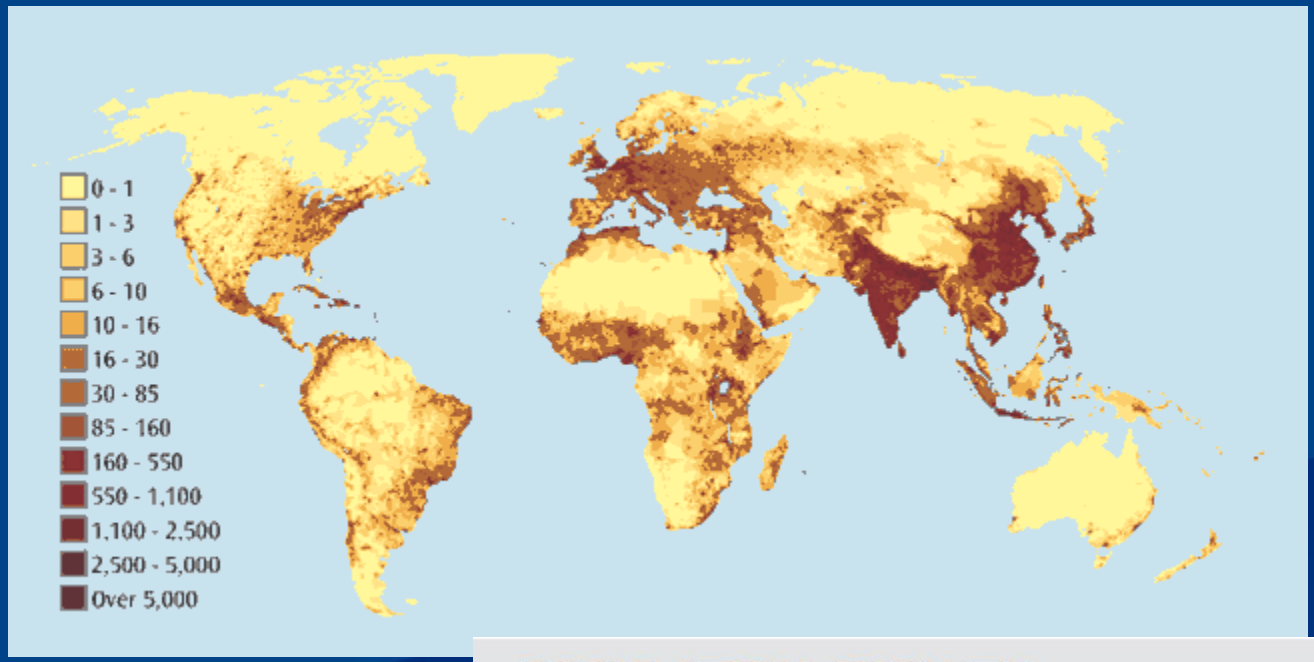
6 lectures – step-by-step guide to the key questions

- 8 Aug: Is the Earth really warming?
- 22 Aug: Natural vs Human causes
- 5 Sept: Future climate change scenarios?
- 19 Sept: Are impacts being overstated?
- **10 Oct: Will it cost the Earth to avoid this?**
- 24 Oct: Greenhouse denial: the 'pretend debate'

- Let’s wait and see
- Kyoto is a big effort for almost nothing
- Why should Australia do something when China and India are the problem?
- Climate change mitigation will ruin the economy
- Population is the problem
- Carbon offsets don’t work
- We cannot upscale renewable energy
- Technology will fix the problem
- We can geo- or bio-engineer our way out of the problem
- Carbon capture and storage doesn’t work



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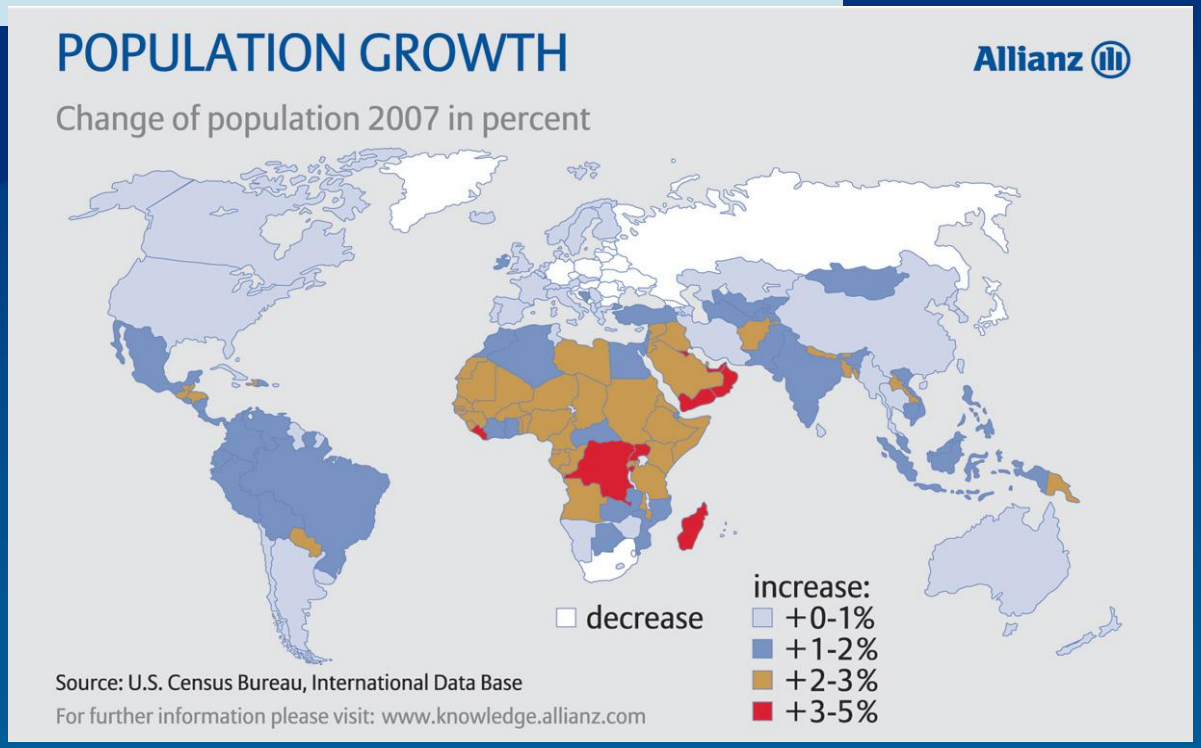
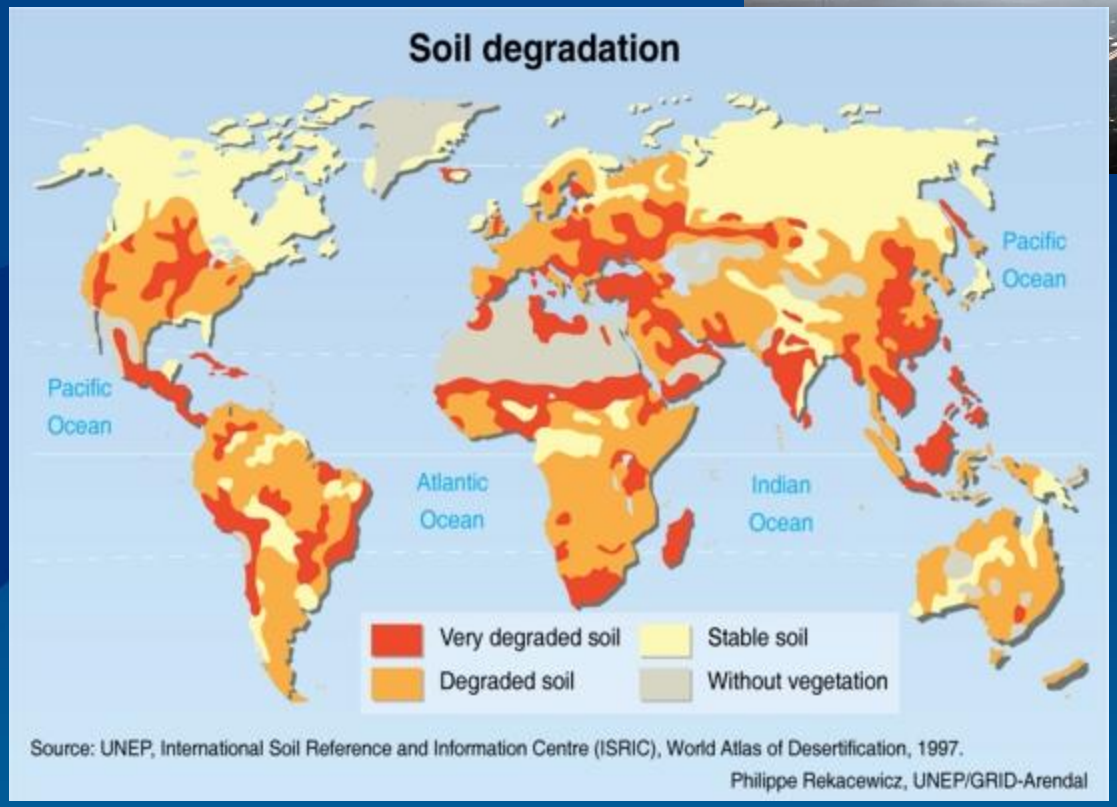
SUB CRUCE LUMEN




Soil degradation
Pacific Ocean
Pacific Ocean
Atlantic Ocean
Indian Ocean
Very degraded soil
Degraded soil
Stable soil
Without vegetation
Source: UNEP, International Soil Reference and Information Centre (ISRIC), World Atlas of Desertification, 1997.
Philippe Rekacewicz, UNEP/GRID-Arendal

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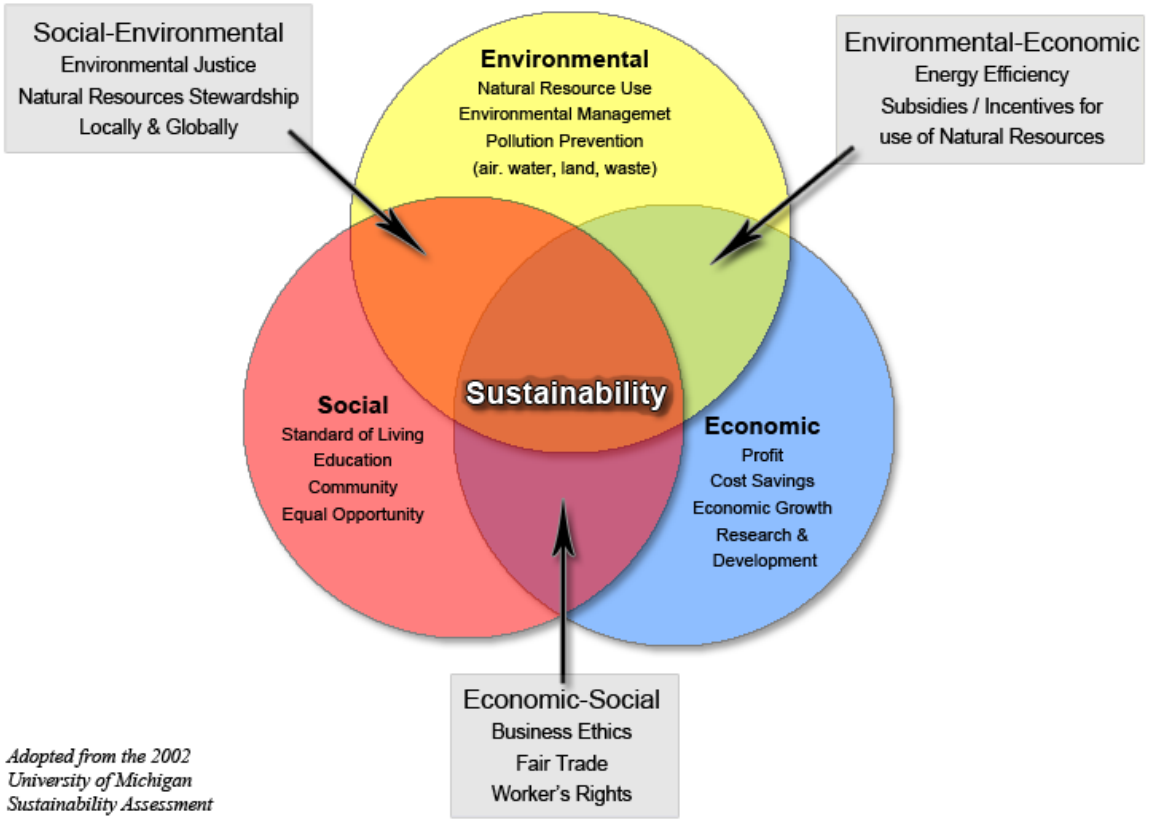
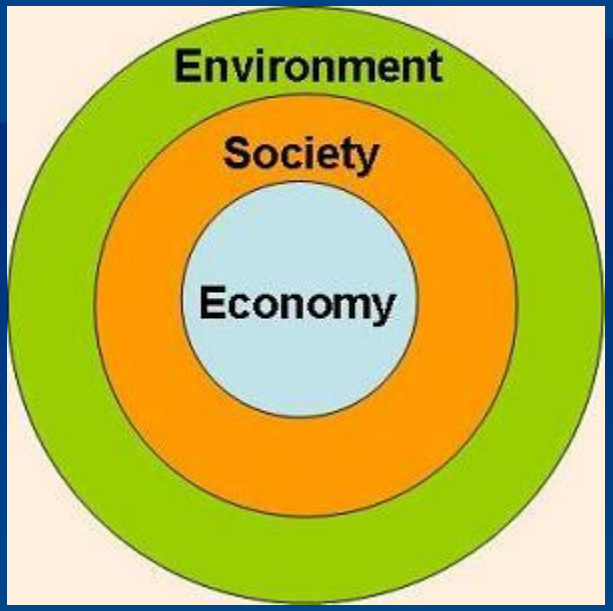
The Three Spheres of Sustainability



Adopted from the 2002 University of Michigan Sustainability Assessment

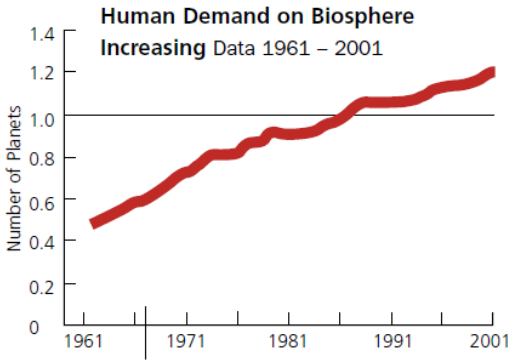


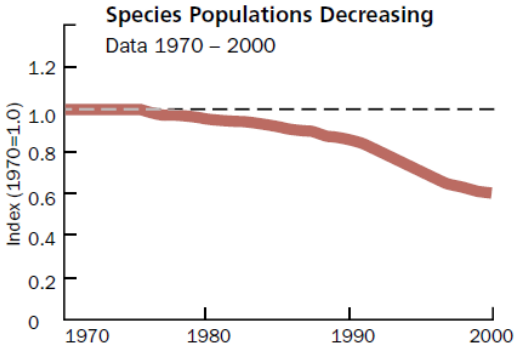
Humanity's Ecological Footprint

Humanity's Ecological Footprint is shown here in number of planets, where one planet equals the total biologically productive capacity of the Earth in any one year. In 2001, humanity's Ecological footprint was 2.5 times larger than in 1961, and exceeded the Earth's biological capacity by about 20%.

Living Planet Index

The Ecological Footprint measures the amount of nature available for human populations, but makes no assessment of what is required to be set aside for plants, animals and other species.





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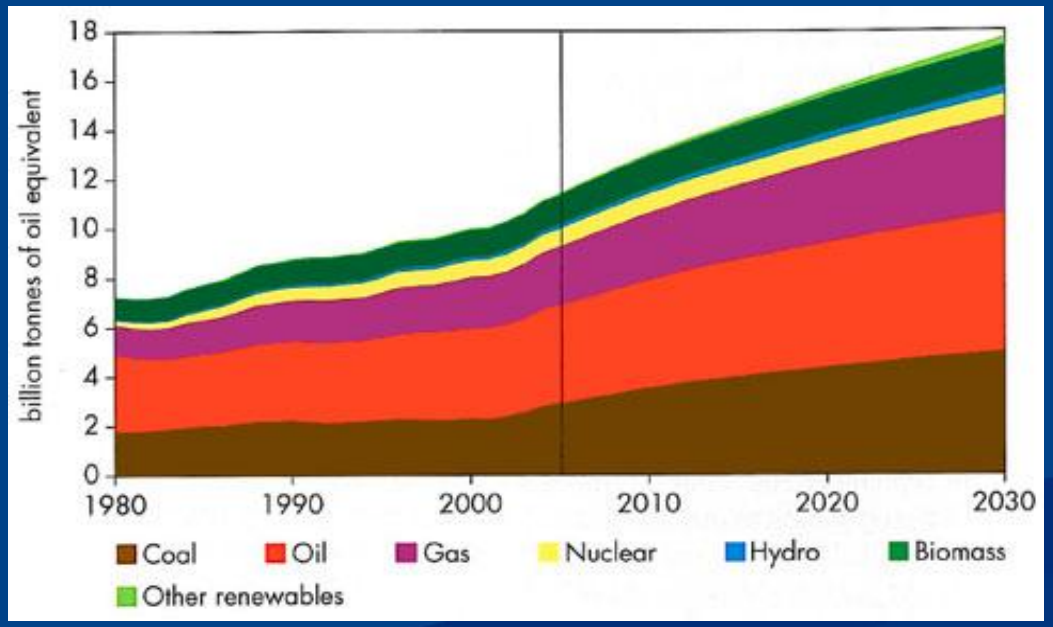
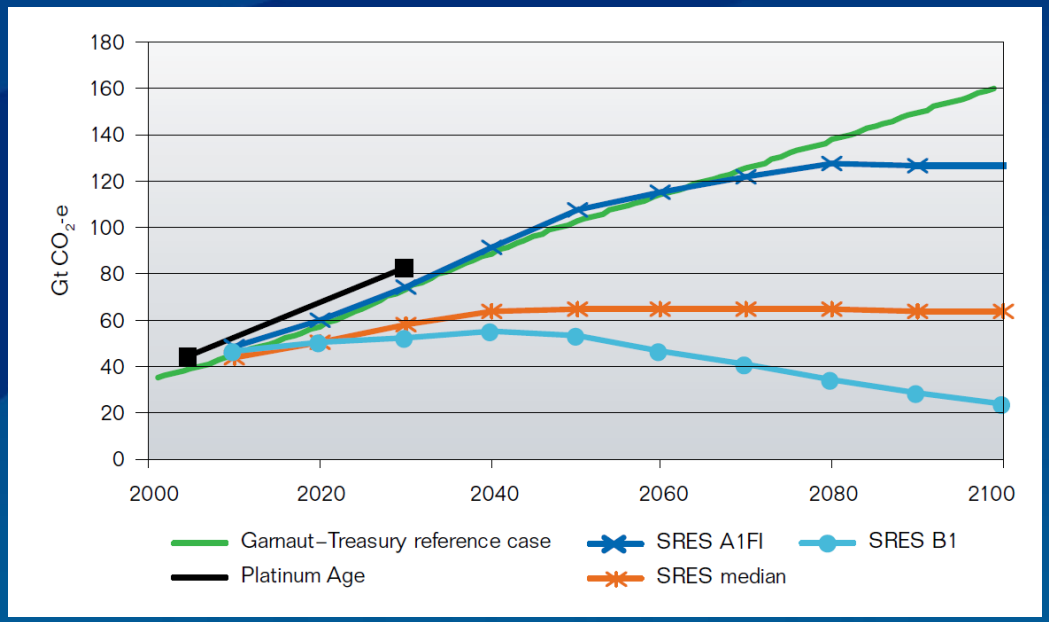
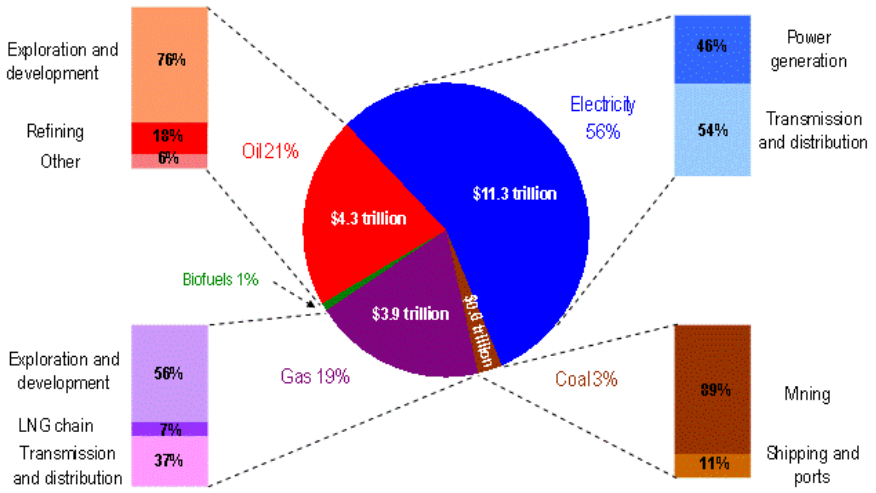


Rising energy demand



Rising carbon emissions

Cumulative Investment in Energy Infrastructure in the Reference Scenario, 2005-2030



Total investment = $20.2 trillion (in $2005)

World Energy Outlook 2006

INTERNATIONAL ENERGY AGENCY

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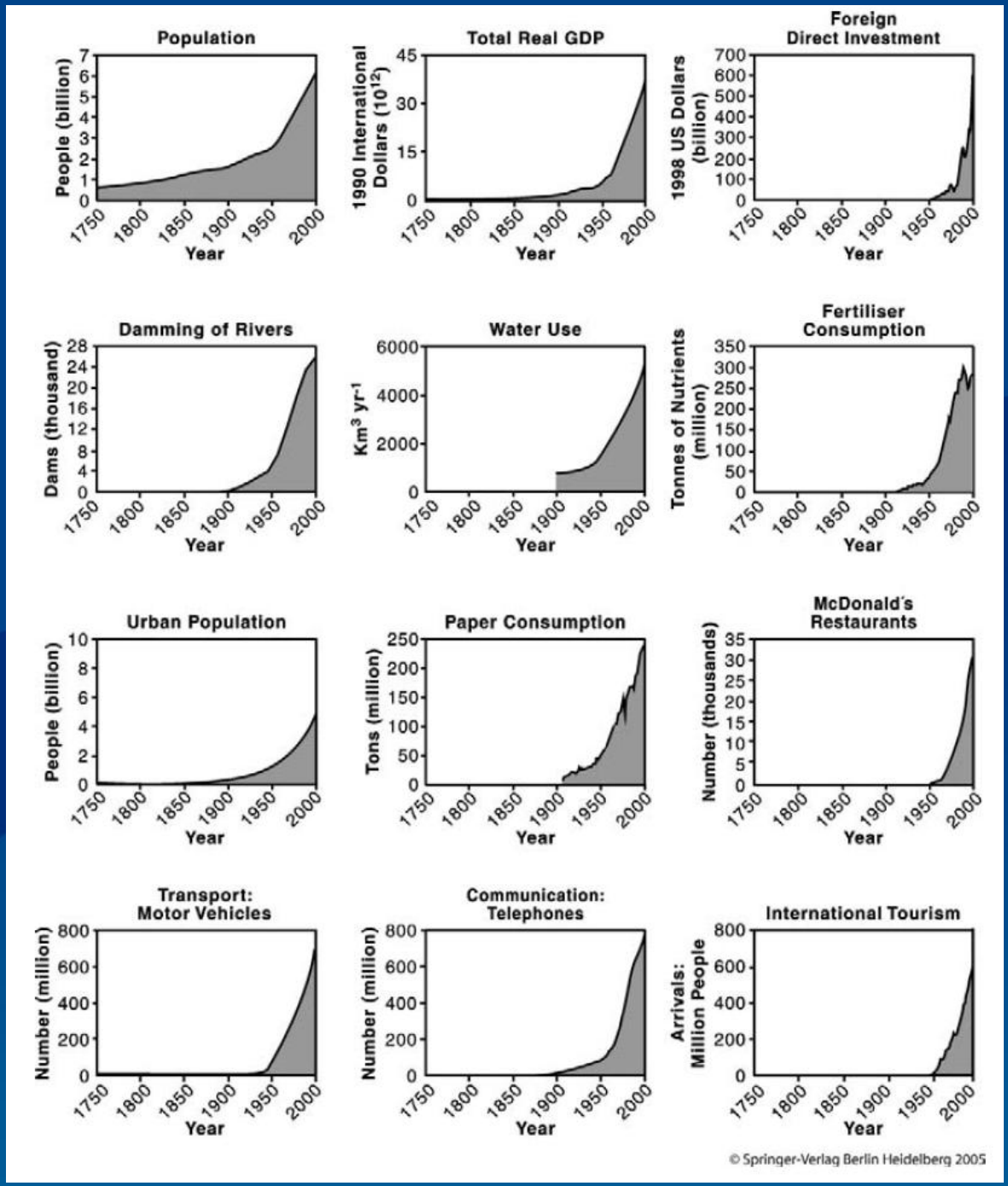
SUB CRUCE LUMEN

Table 10.1 New entrant capital costs (nominal 2008–09 capital cost estimates)

Technology	Capital cost ($/kW capacity)
Brown coal	1938
Black coal	1734
Combined-cycle gas turbine[a]	1071
Gas turbine	734

a A combined-cycle gas turbine generates electricity through the combustion of gas in a gas turbine, and captures waste heat from the combustion to generate additional electricity with an auxiliary steam turbine.

Source: ACIL Tasman, Fuel resource, new entry and generation costs in the NEM: Report 2 – data and documentation, accessed 6 June 2008, <http://www.nemmco.com.au/psplanning/410-0090.pdf >.



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Rising everything!

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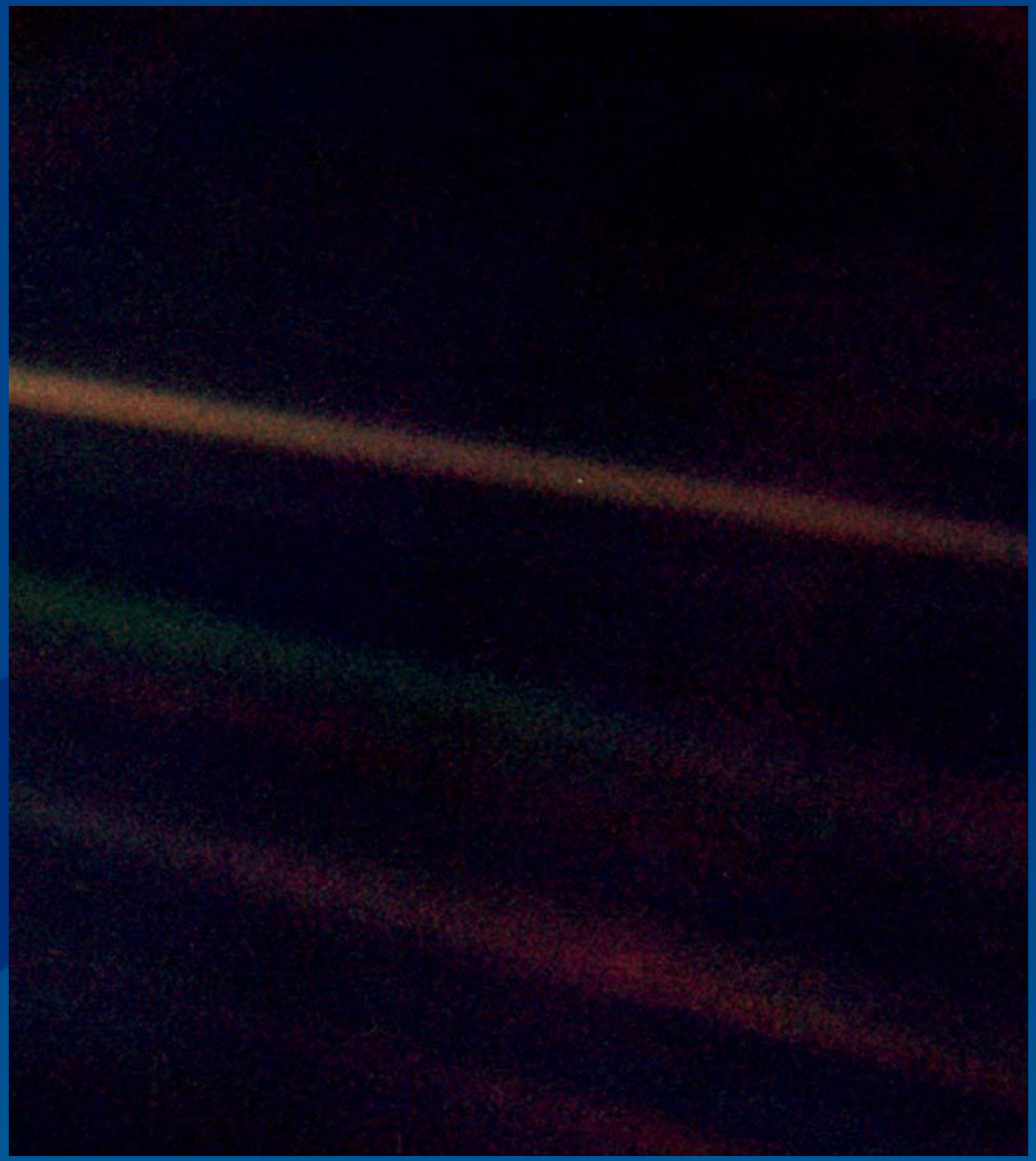

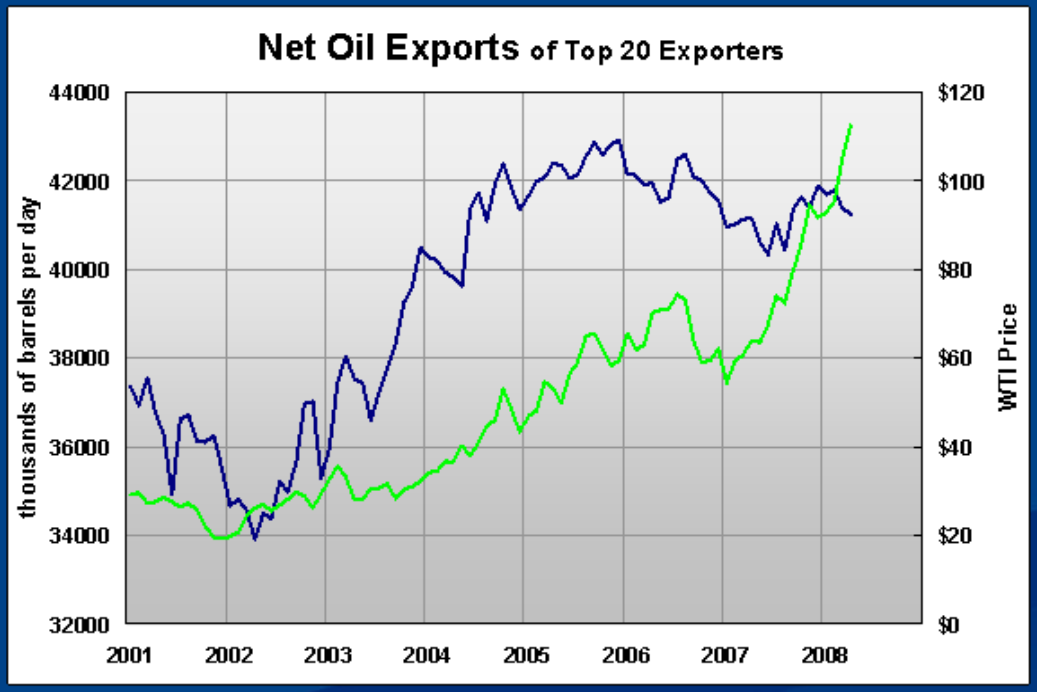

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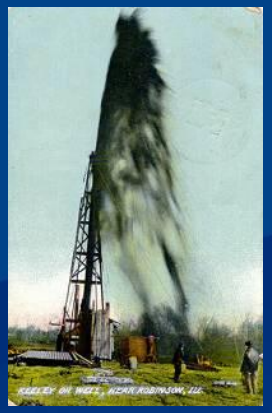

Limited fossil fuel supply

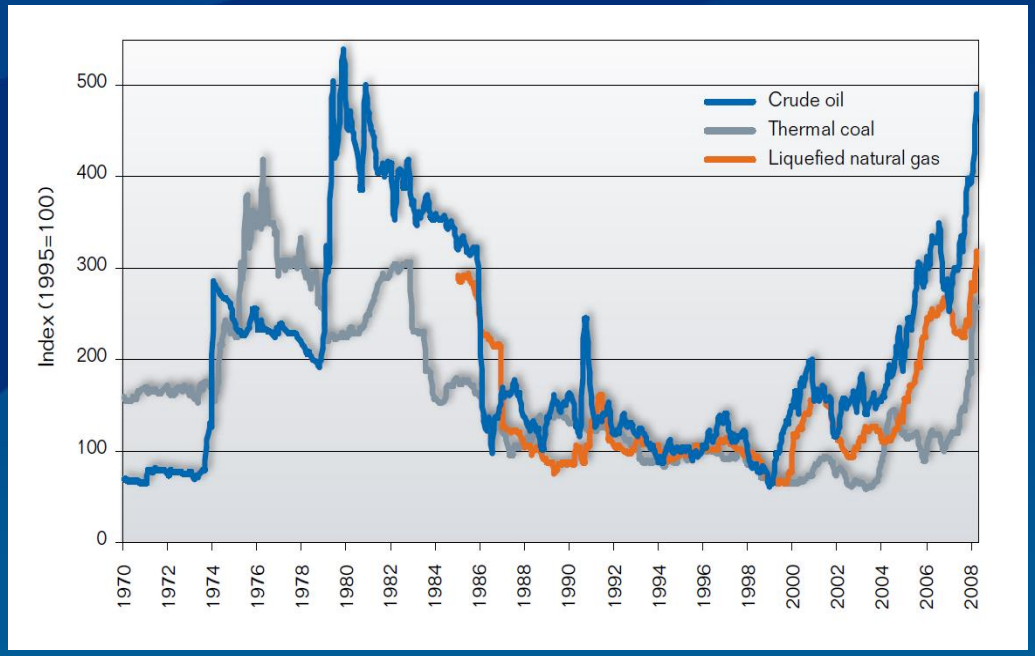

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Figure 4.1 The 20 largest greenhouse gas emitters: total emissions and cumulative share (%) of global emissions, c. 2004

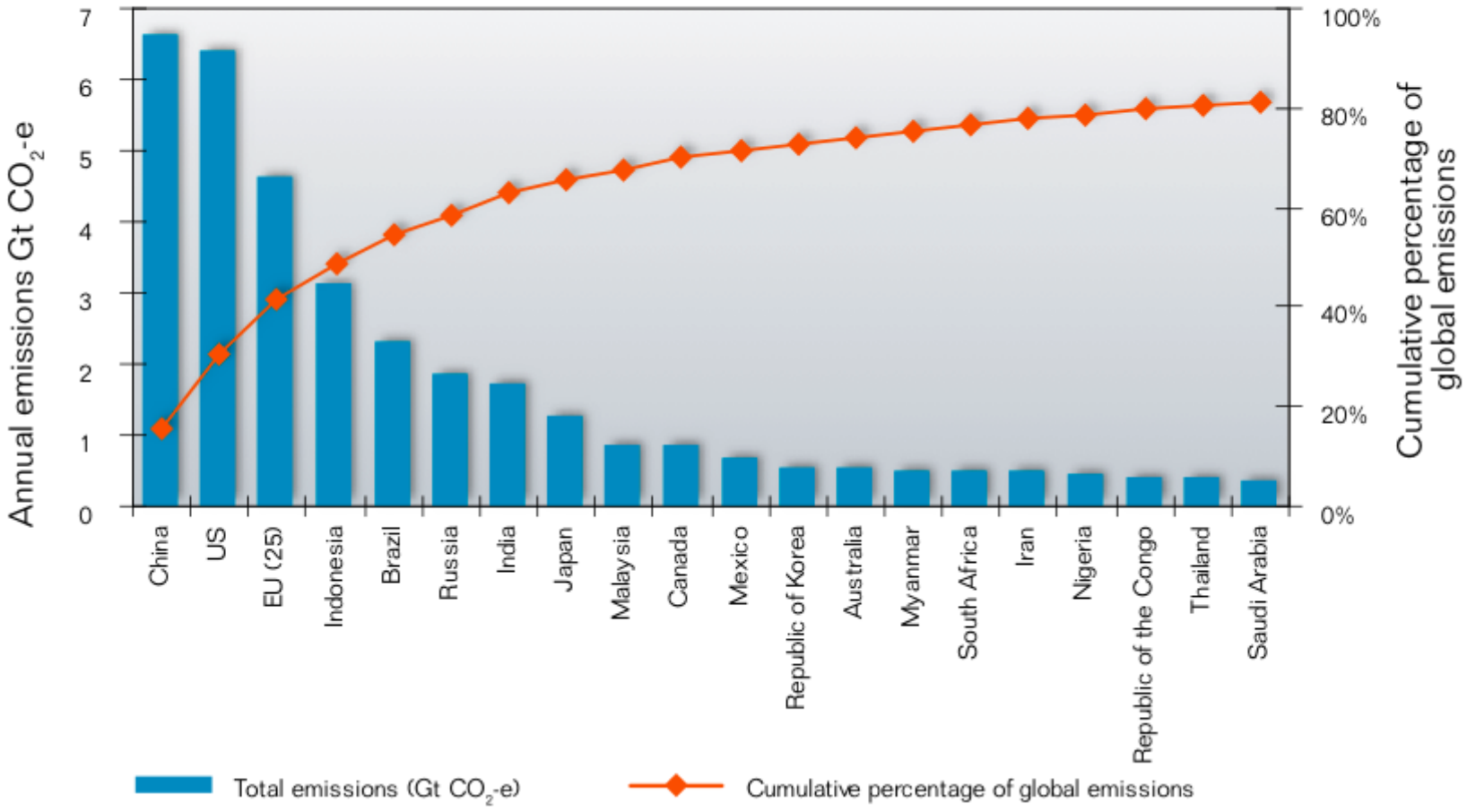

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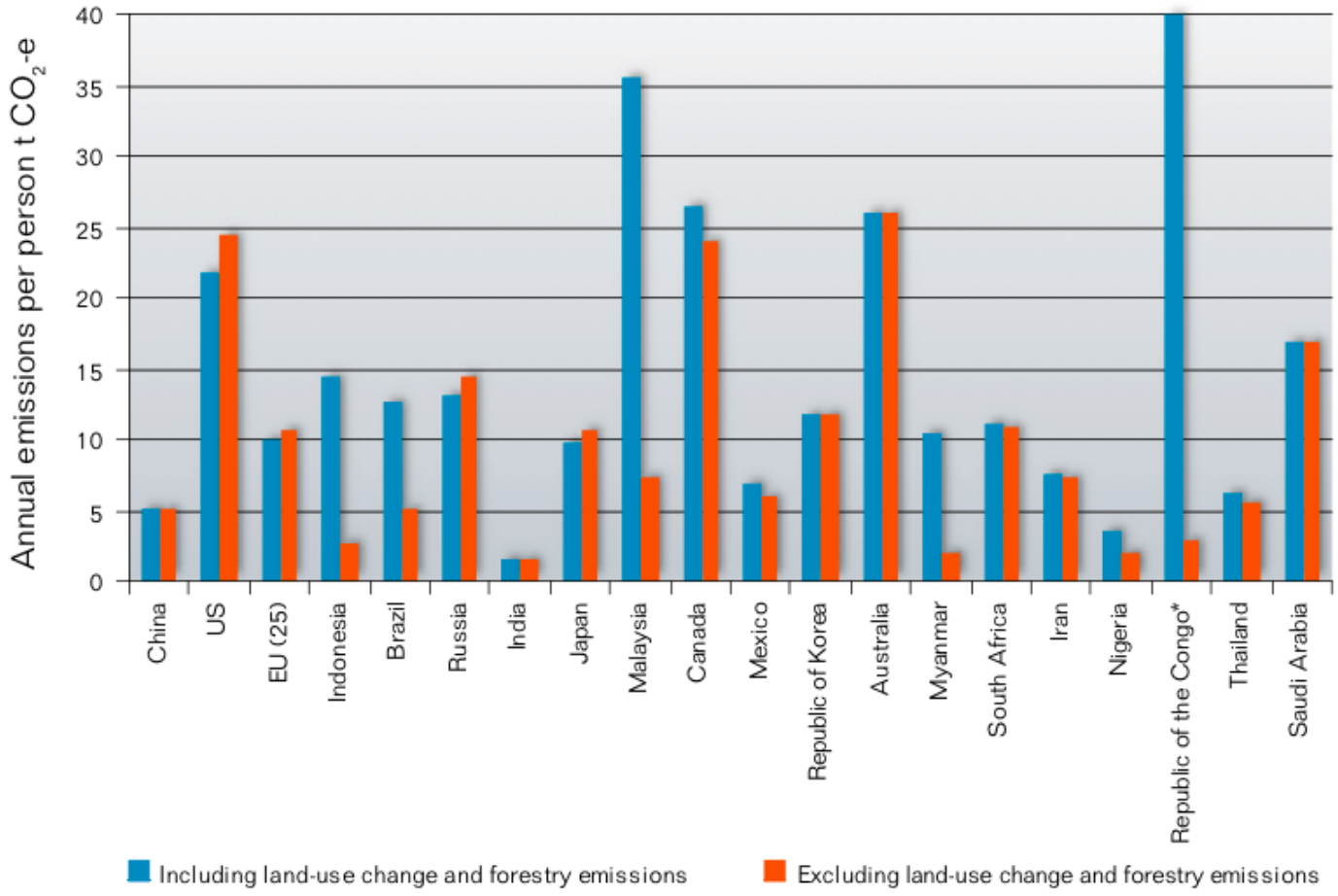
Figure 4.2 The 20 largest greenhouse gas emitters: per capita emissions excluding and including emissions from land-use change and forestry, c. 2004



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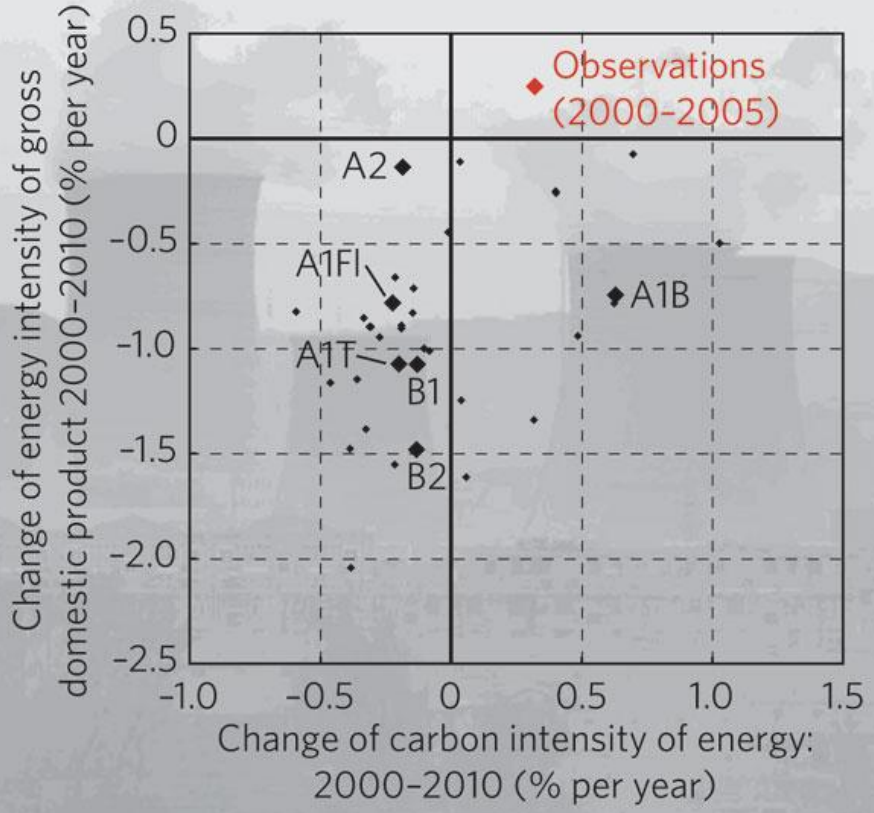
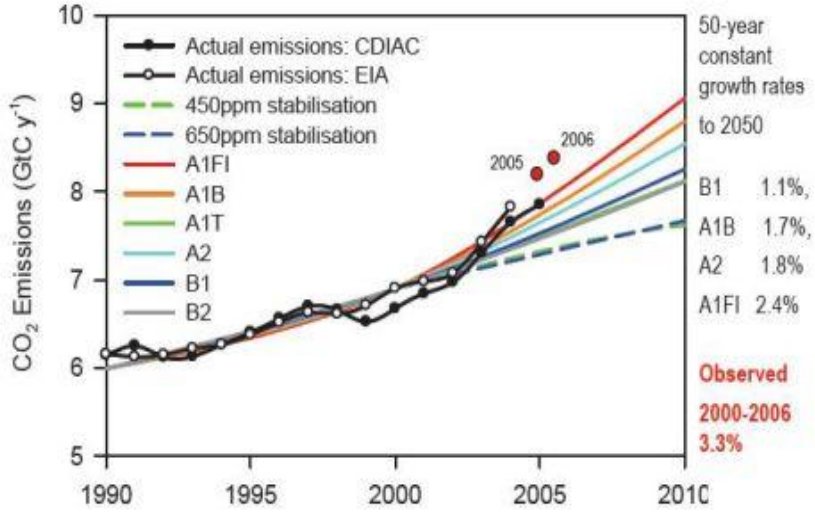
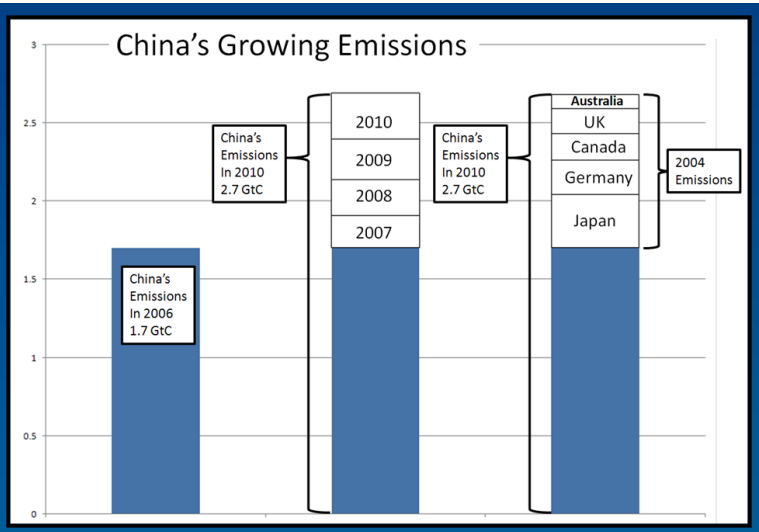
ASSUMED DECARBONIZATION IN THE 35 IPCC SCENARIOS FOR 2000–2010



Trajectory of Global Fossil Fuel Emissions



China's Growing Emissions



Fate of Anthropogenic CO_2 Emissions (2000-2007)

1.5 Pg C y^{-1}

+

7.5 Pg C y^{-1}

4.2 Pg y^{-1}
Atmosphere
46%

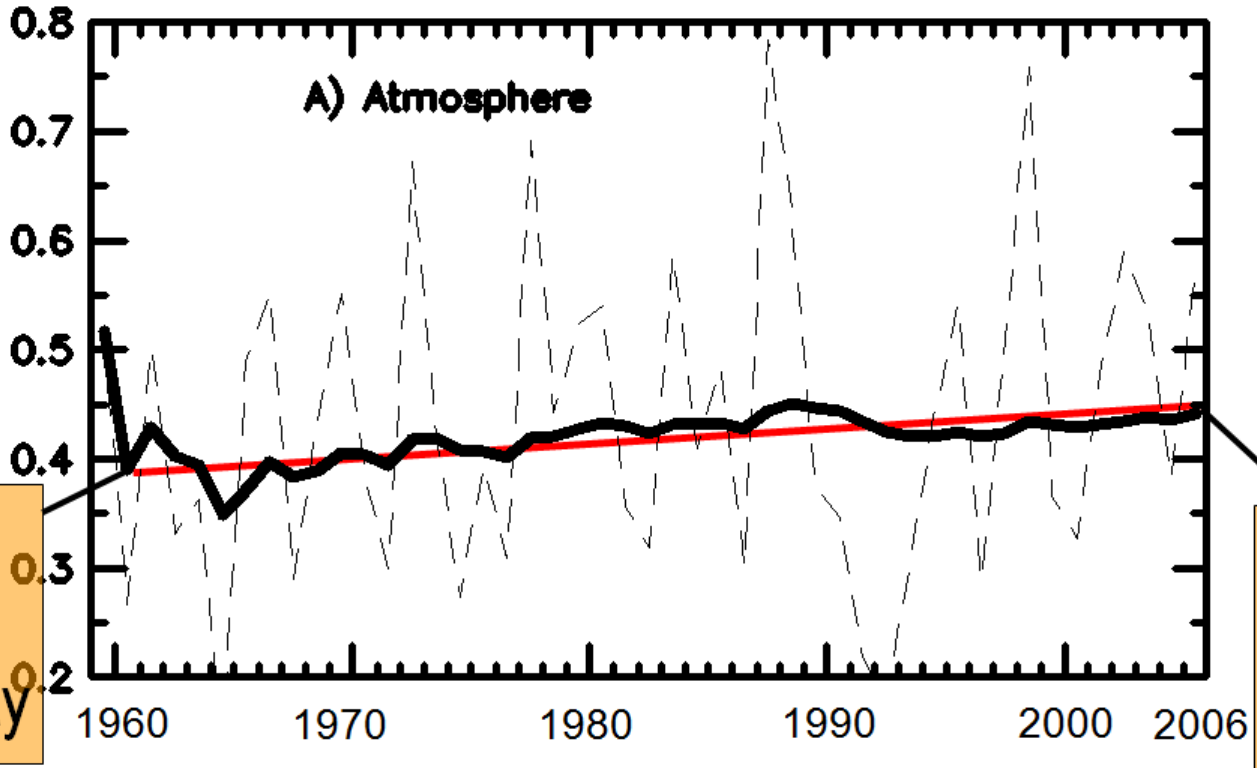
2.6 Pg y^{-1}
Land
29%

2.3 Pg y^{-1}
Oceans
26%

Canadell et al. 2007, PNAS (updated)

Decline in the Efficiency of CO_2 Natural Sinks

Fraction of all anthropogenic emissions that stay in the atmosphere



Emissions
1 tCO_2
400Kg stay

Emissions
1 tCO_2
450Kg stay

Canadell et al. 2007, PNAS

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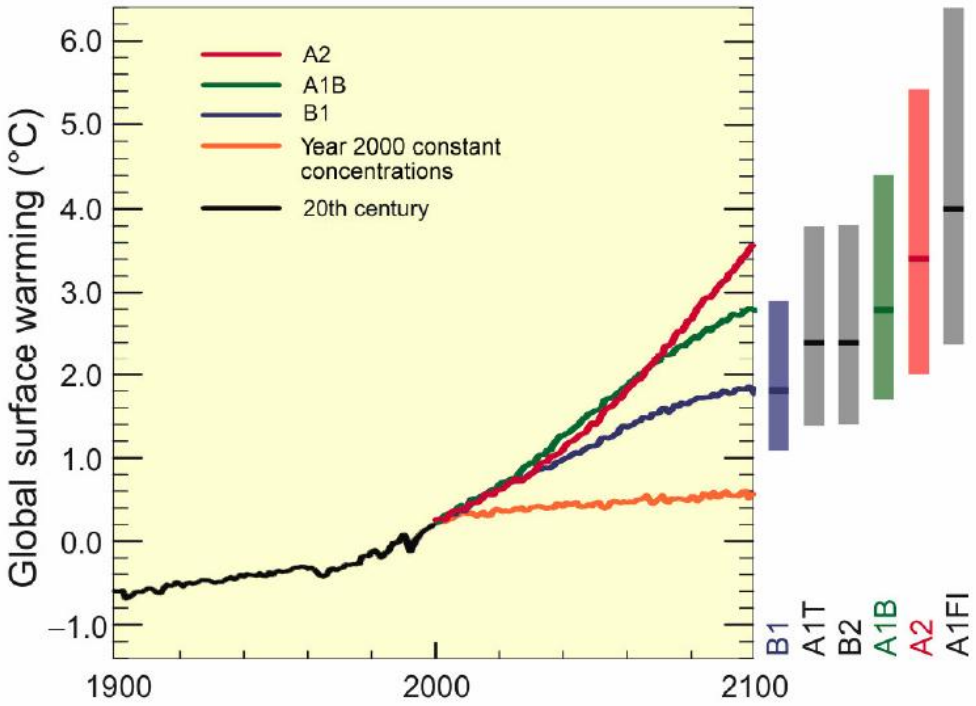
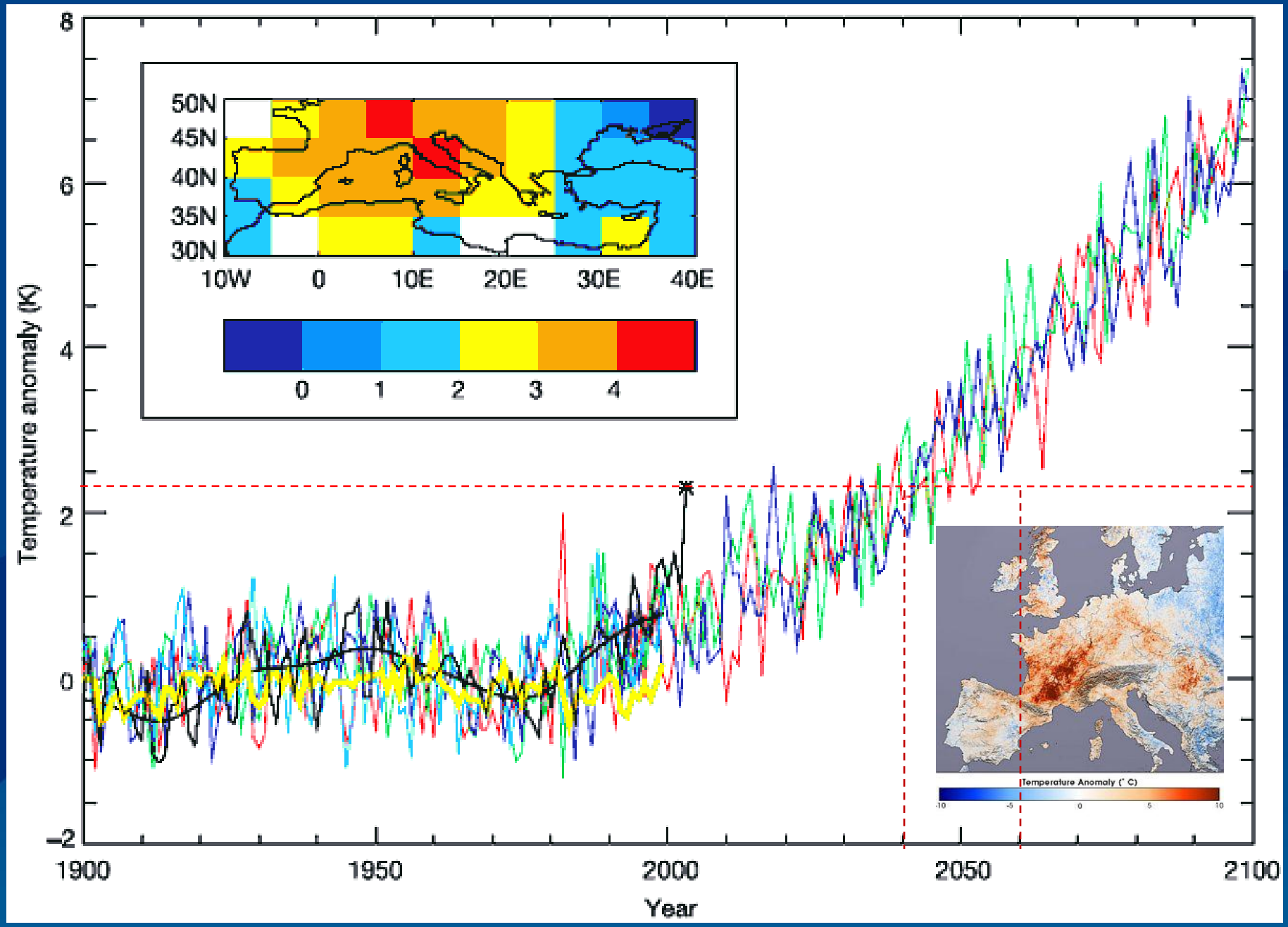
Projections of surface temperatures



Likely effects of emission reduction

Business as usual No action taken	**5.5–7.1C** rise in global temperature by 2100
Late and slow decline Action starts in 2030	**4–5.2C** rise in global temperature by 2100
Early but slow decline Action starts in 2010	**2.9–3.8C** rise in global temperature by 2100
Early and rapid decline Action starts in 2010	**2.1–2.8C** rise in global temperature by 2100

SOURCE: MET OFFICE


Temperature anomaly (K)
8
6
4
2
0
−2
1900
1950
2000
2050
2100
Year
50N
45N
40N
35N
30N
10W
0
10E
20E
30E
40E
0
1
2
3
4
Temperature Anomaly (° C)
-10
-5
0
5
10

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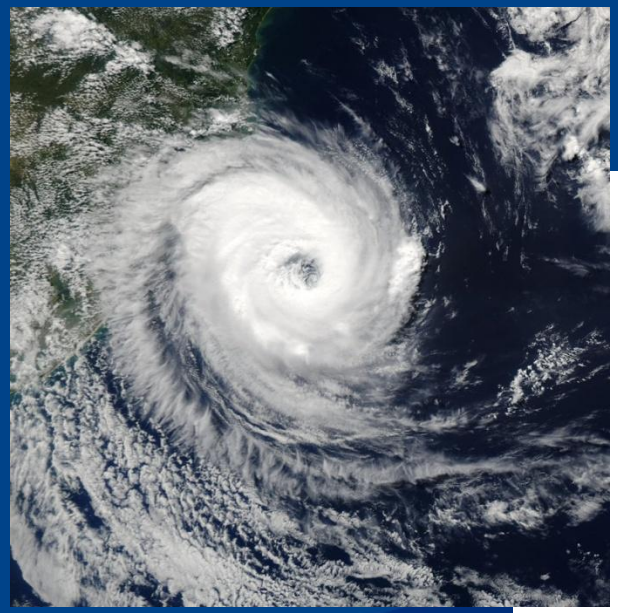

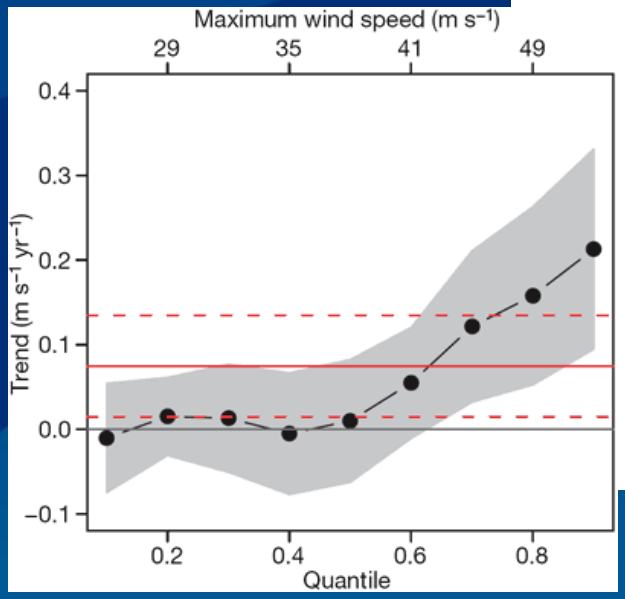

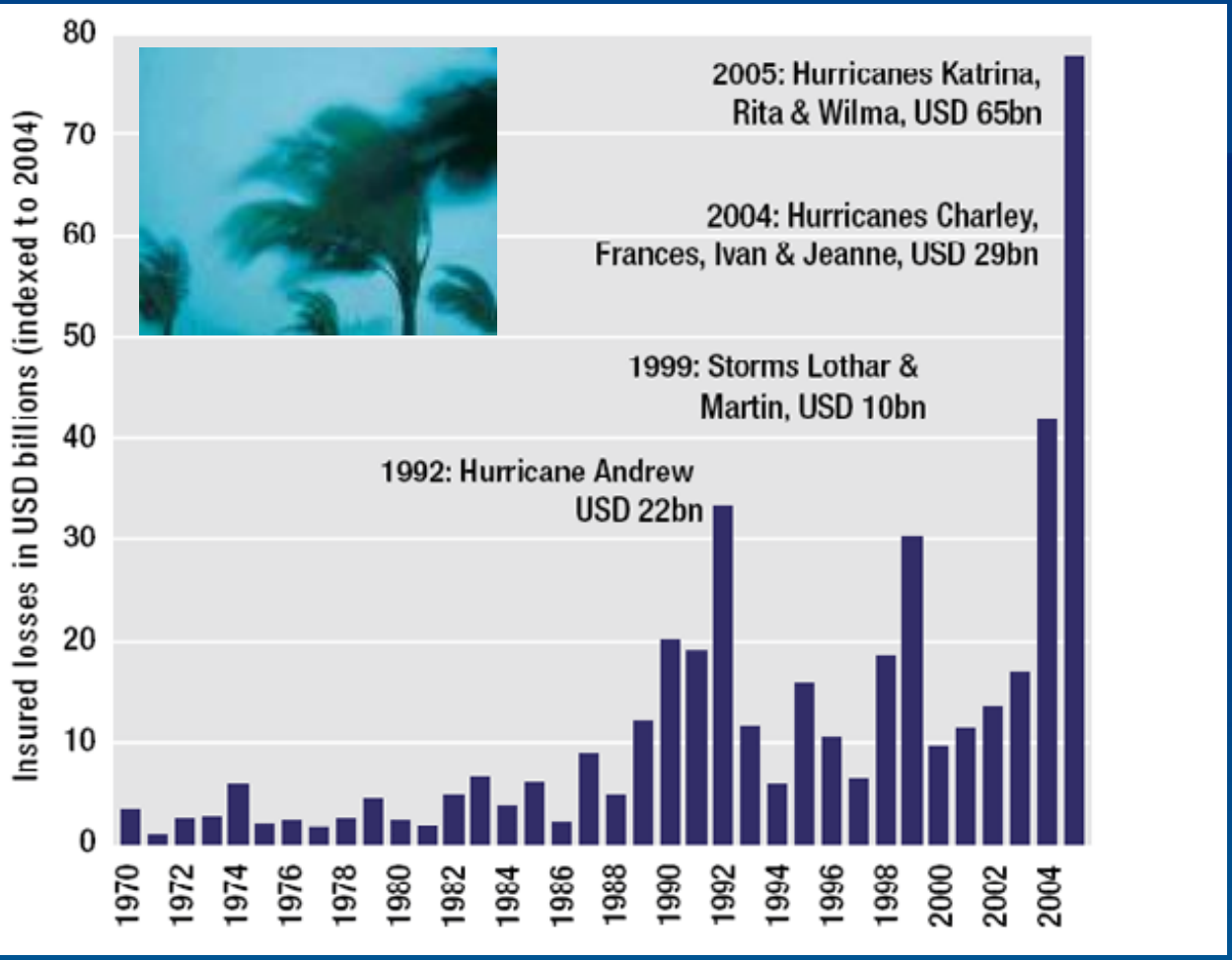

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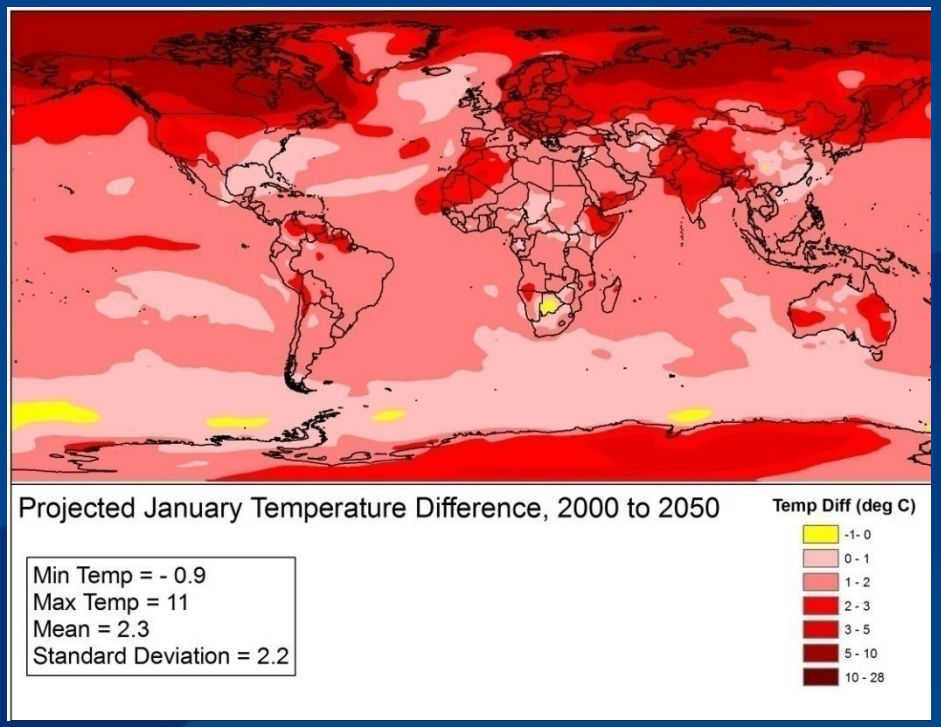
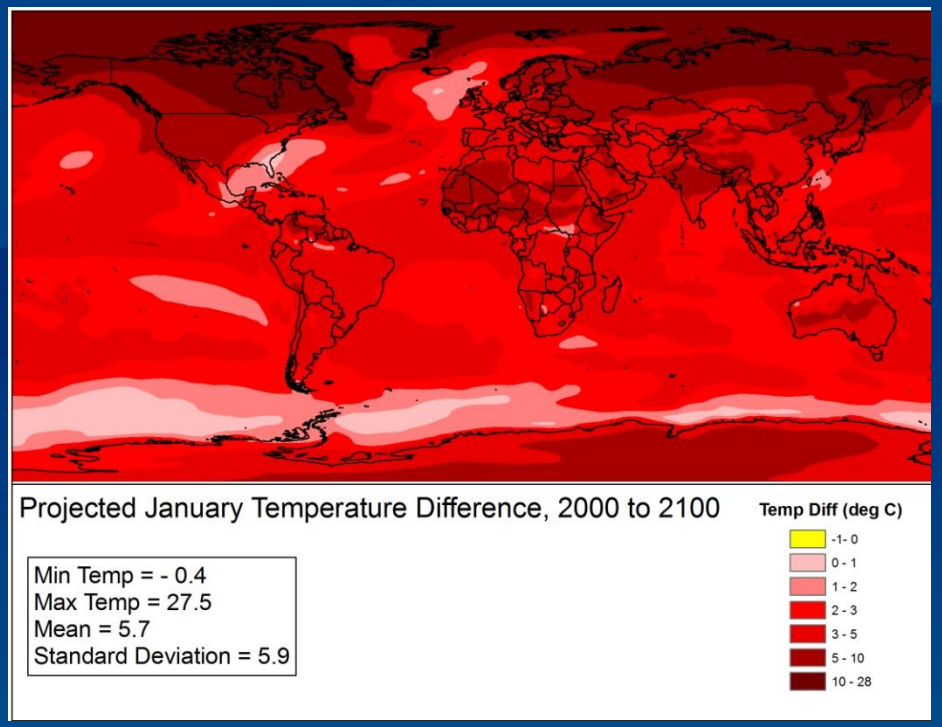
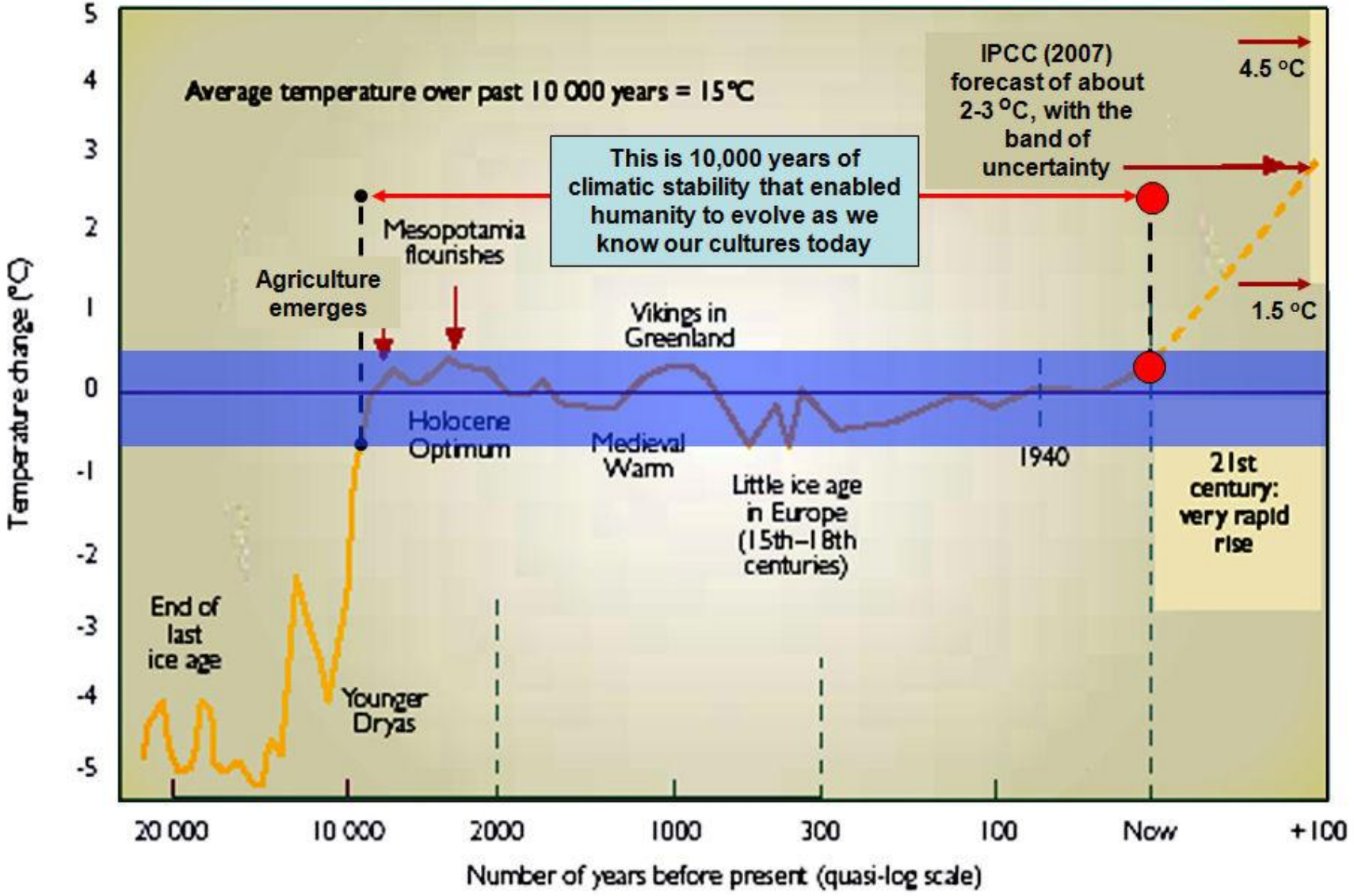
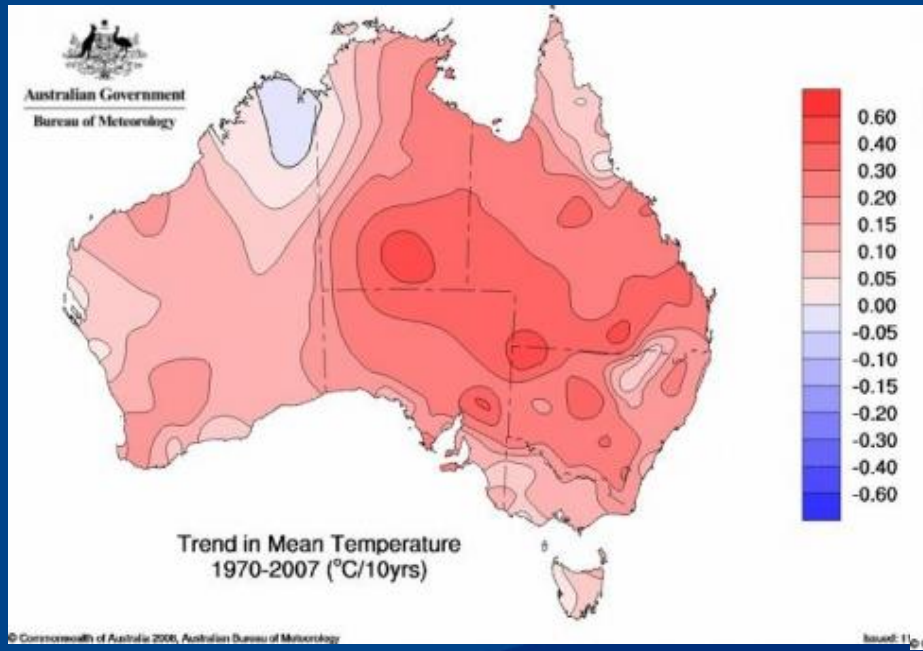
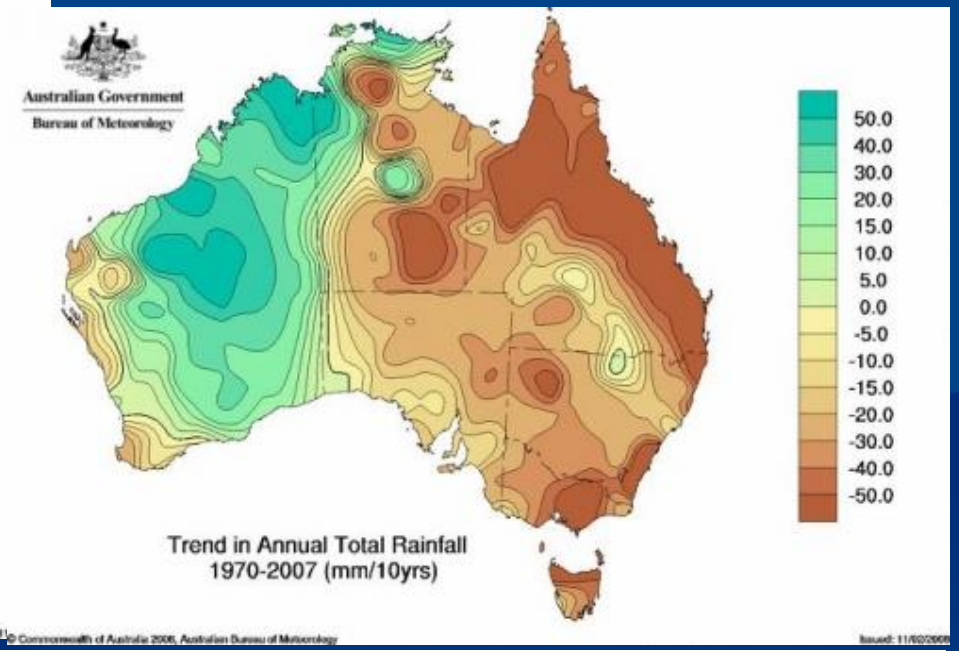


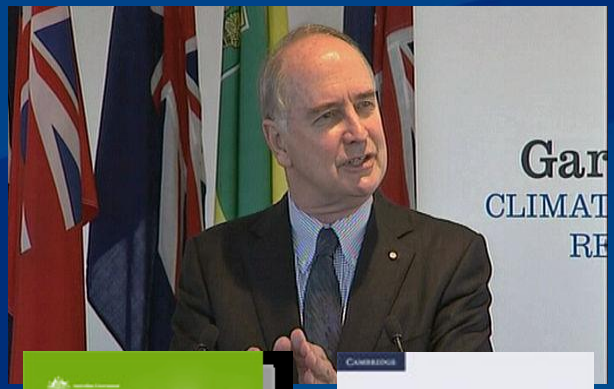


The Last 20,000 Years seems to have been Ideal for the Development of Human Societies. Is this a Historic "Sweet Spot" that Enabled Humans to Flourish?

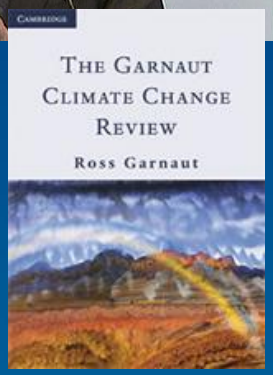


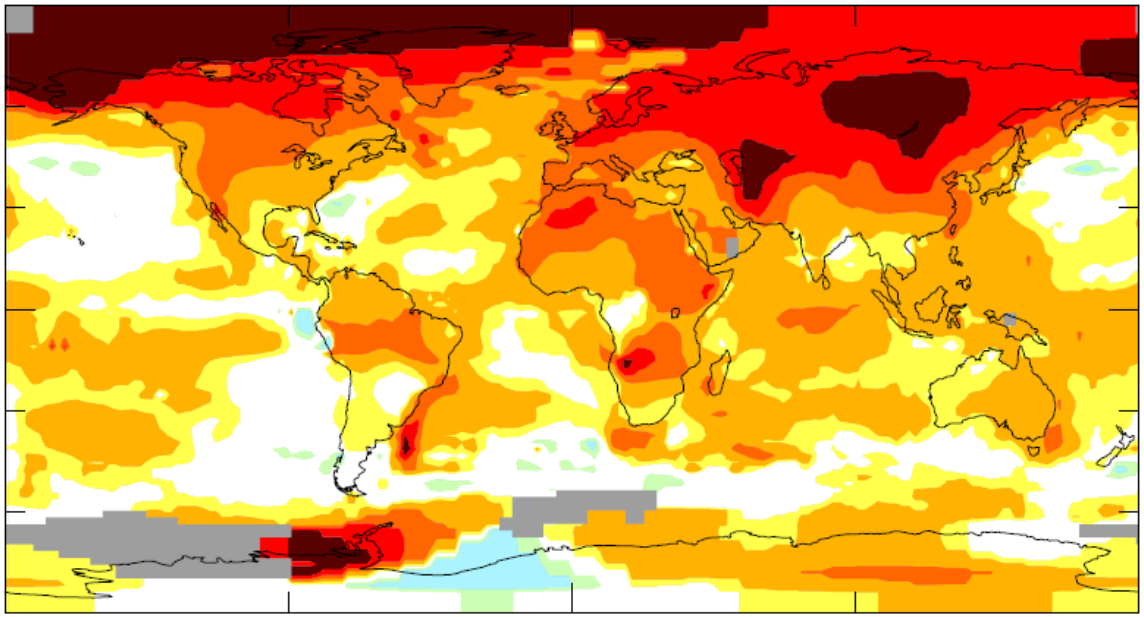

Australian Government
Bureau of Meteorology
0.60
0.40
0.30
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.30
-0.40
-0.60
Trend in Mean Temperature
1970-2007 (°C/10yrs)
© Commonwealth of Australia 2008, Australian Bureau of Meteorology


Australian Government
Bureau of Meteorology
50.0
40.0
30.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-30.0
-40.0
-50.0
Trend in Annual Total Rainfall
1970-2007 (mm/10yrs)
© Commonwealth of Australia 2008, Australian Bureau of Meteorology




CARBON POLLUTION
REDUCTION SCHEME
Green Paper
JULY 2008
SUMMARY


THE GARNAUT
CLIMATE CHANGE
REVIEW
Ross Garnaut



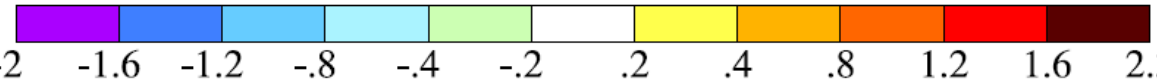

-2
-1.6
-1.2
-.8
-.4
-.2
.2
.4
.8
1.2
1.6
2.3

Table 1: Possible climate impacts in Australia for a range of temperature increases

Global average temperature increase by 2100 shown for business as usual and stabilisation targets discussed in this report – regional temperatures in Australia may vary from these values

Approximate rise in global temp by 2100 (A1FI / 550 ppm / 450 ppm)	Temp rise above 1990-2000	Biodiversity and Ecosystems (Preston and Jones 2006, The Climate Institute 2007a)	Primary Industries (Preston and Jones 2006)	Human Health (Preston and Jones 2006, The Climate Institute 2007a)	Settlements and Infrastructure (CSIRO, Maunsell Australia Pty Ltd, Phillips Fox (2007), Maunsell 2007)	Impacts in the Asia-Pacific Region (IPCC 2007, Preston and Jones 2006, NEF 2007, Dupont and Pearman 2006)	Abrupt and Large Scale Impacts (Preston and Jones 2006, Stern 2006)
	<1ºC	▪ Shrinkage of snow-covered area in the Australian Alps by 10-40%	▪ Livestock heat stress leads to decline in milk production	▪ Annual heatwave deaths increase from 134 (today) to 165-189 in Brisbane	▪ Decrease in thermal efficiency of electricity transmission infrastructure	▪ A decrease of between 2-5% in India's yield of wheat and maize ▪ Global rice yields could be reduced by 10%	▪ 14% decrease in North Atlantic Ocean Thermohaline Circulation, causing regional climate shifts
	1-2ºC	▪ Between 60-80% of the Great Barrier Reef is bleached every year ▪ Murray-Darling river flows fall by 10-25% ▪ Significant species extinction in internationally significant environments in north Queensland and Western Australia	▪ High annual costs of approximately $12million/yr to manage the southward spread of the Queensland fruit fly	▪ Southward spread of malaria receptive zones ▪ 1,200-1,400 more heat related deaths a year in major population centres	▪ Peak energy demand increases in Brisbane , Adelaide and other cities ▪ Increased bushfire damage ▪ Storm winds become more intense	▪ Sea level rise could lead to the flooding of residences of tens of millions of people in the low lying areas of South, Southeast, Northeast Asia and the South Pacific	▪ Significant reduction in global ocean Thermohaline Circulation ▪ Potential for the Greenland Ice Sheet to begin melting irreversibly ▪ Rising risk of collapse of the Atlantic Thermohaline Circulation ▪ Rising risk of collapse of West Antarctic Ice Sheet
	2-3ºC	▪ Almost all of the Great Barrier Reef is bleached every year ▪ 80% of Kakadu's freshwater wetlands lost to sea level rise	▪ 40% reduction in livestock carrying capacity for native pasture systems	▪ Southward spread of dengue transmission zone as far as Brisbane	▪ Increases in sea level expected to exponentially affect storm surge height – causing damage to coastal infrastructure	▪ Changes to India's annual monsoon could lead to severe droughts and intense flooding in parts of India ▪ Tibetan Plateau glaciers shorter than 4 km in length could disappear, with shrinkage of snow and ice cover affecting water supply in the Indus, Ganges, Brahmaputra, Yellow, Yangzi and Mekong rivers	
	3-4ºC	▪ Shrinkage of snow-covered area in the Australian Alps by 20-80%	▪ 25-50% decrease in 'generic' timber yield in north Queensland and the Top End.	▪ Up to a 200% increase in temperature related mortality among people aged over 65 years in capital cities			
	4-5ºC	▪ 60-90% loss of core habitat for Victorian vertebrate species.			▪ Coastal settlements and infrastructure commence relocation due to anticipated extreme sea level rise		
	>5ºC	▪ Under the A1FI scenario, the IPCC predicts that global average temperatures could rise by up to 6ºC, and perhaps more if positive feedback effects amplify the warming effect of greenhouse gases. The impacts of this level of temperature increase are difficult to capture in current models as they are so far outside human experience.					

Temperatures shown on left represent approximate global average increases above 1990-2000 levels, based on Figure SPM 8, IPCC FAR WG III. Note that at the national scale, climate change impacts are highly dependent on the level and pattern of rainfall and extreme events, which are highly variable and less certain than temperature increases. Note that temperature increases for given stabilisation scenarios are often quoted as the 'equilibrium temperature', which may not be reached until decades or centuries after stabilisation is reached. The level of temperature increase by 2100 also depends on the time taken to reach stabilisation, and hence the emissions trajectory. The ranges shown indicate the temperature change under the 'likely range' from the IPCC Fourth Assessment Report of 2ºC to 4.5ºC. Note that this table has been prepared using information currently available in the published literature. It will be updated for the Draft Report using relevant primary research conducted for the Review.

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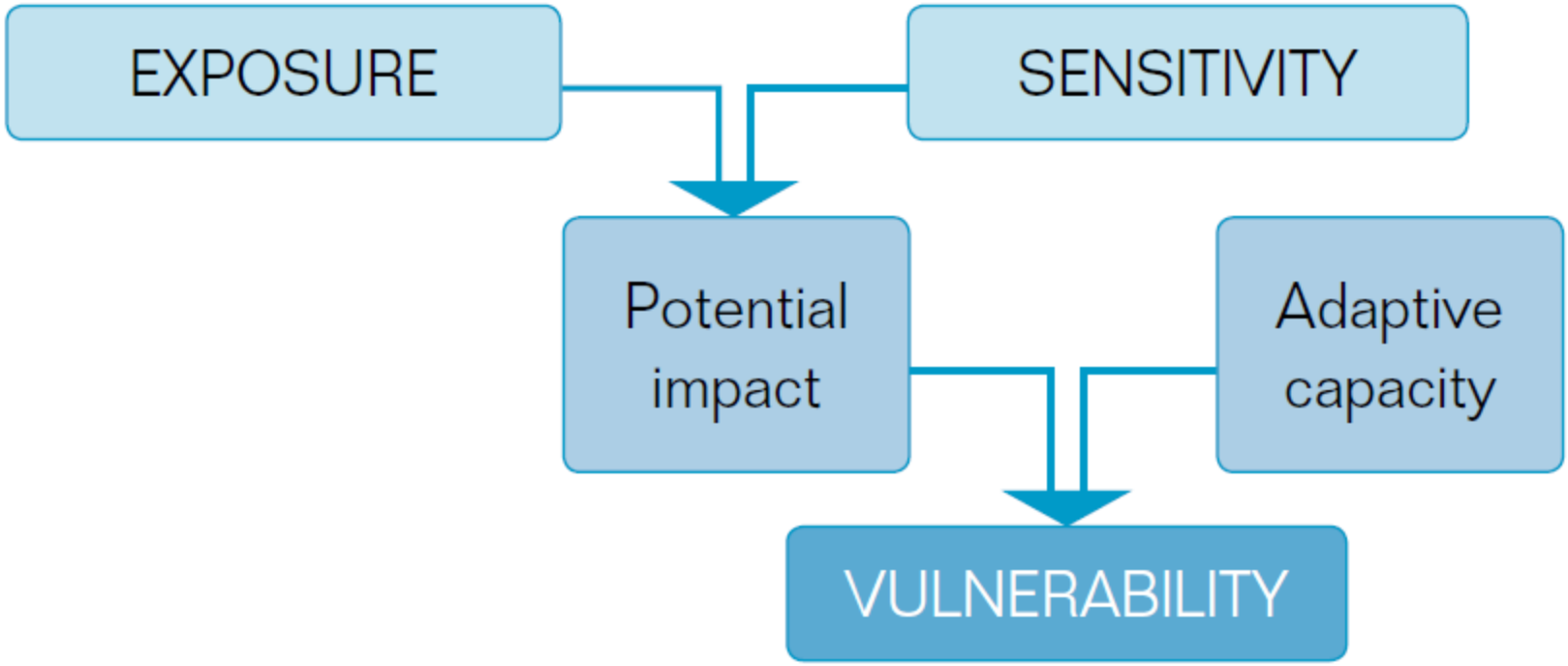
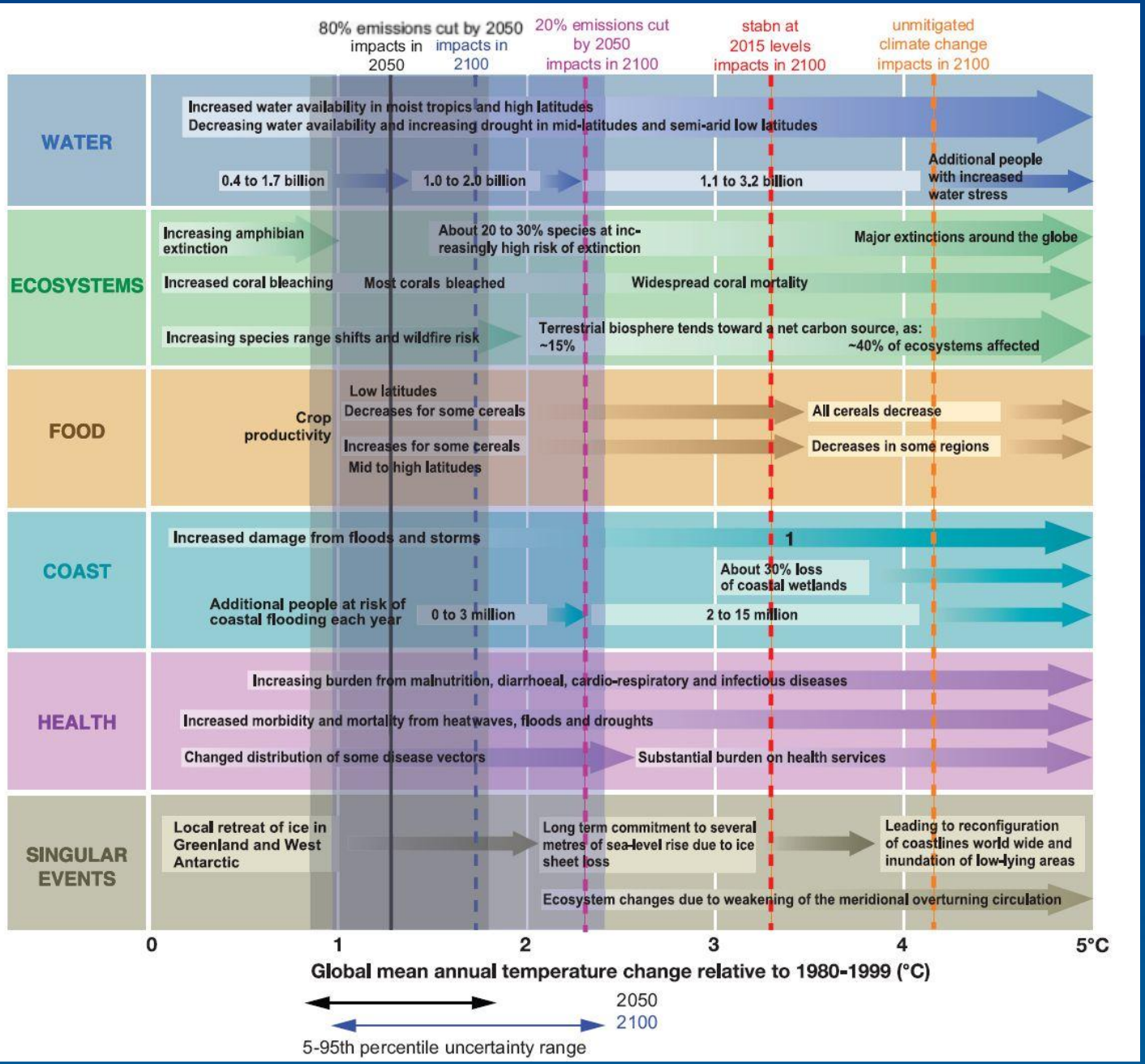
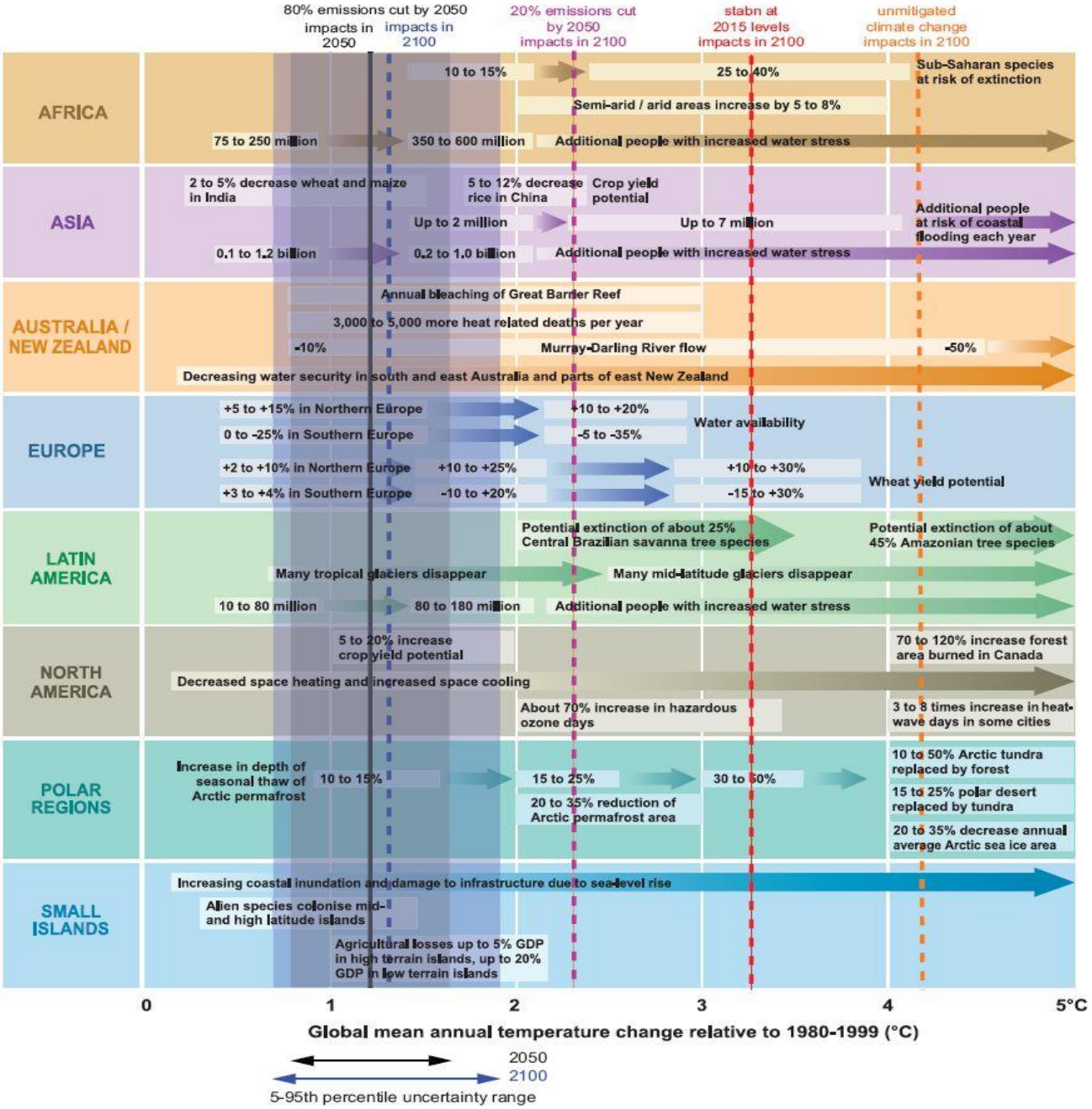
Vulnerability and its components




80% emissions cut by 2050 impacts in 2050
impacts in 2100
20% emissions cut by 2050 impacts in 2100
stabn at 2015 levels impacts in 2100
unmitigated climate change impacts in 2100
WATER
Increased water availability in moist tropics and high latitudes
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes
0.4 to 1.7 billion
1.0 to 2.0 billion
1.1 to 3.2 billion
Additional people with increased water stress
ECOSYSTEMS
Increasing amphibian extinction
About 20 to 30% species at increasingly high risk of extinction
Major extinctions around the globe
Increased coral bleaching
Most corals bleached
Widespread coral mortality
Increasing species range shifts and wildfire risk
Terrestrial biosphere tends toward a net carbon source, as:
~15%
~40% of ecosystems affected
FOOD
Crop productivity
Low latitudes
Decreases for some cereals
All cereals decrease
Increases for some cereals
Decreases in some regions
Mid to high latitudes
COAST
Increased damage from floods and storms
About 30% loss of coastal wetlands
Additional people at risk of coastal flooding each year
0 to 3 million
2 to 15 million
HEALTH
Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases
Increased morbidity and mortality from heatwaves, floods and droughts
Changed distribution of some disease vectors
Substantial burden on health services
SINGULAR EVENTS
Local retreat of ice in Greenland and West Antarctic
Long term commitment to several metres of sea-level rise due to ice sheet loss
Leading to reconfiguration of coastlines world wide and inundation of low-lying areas
Ecosystem changes due to weakening of the meridional overturning circulation
0
1
2
3
4
5°C
Global mean annual temperature change relative to 1980-1999 (°C)
2050
2100
5-95th percentile uncertainty range



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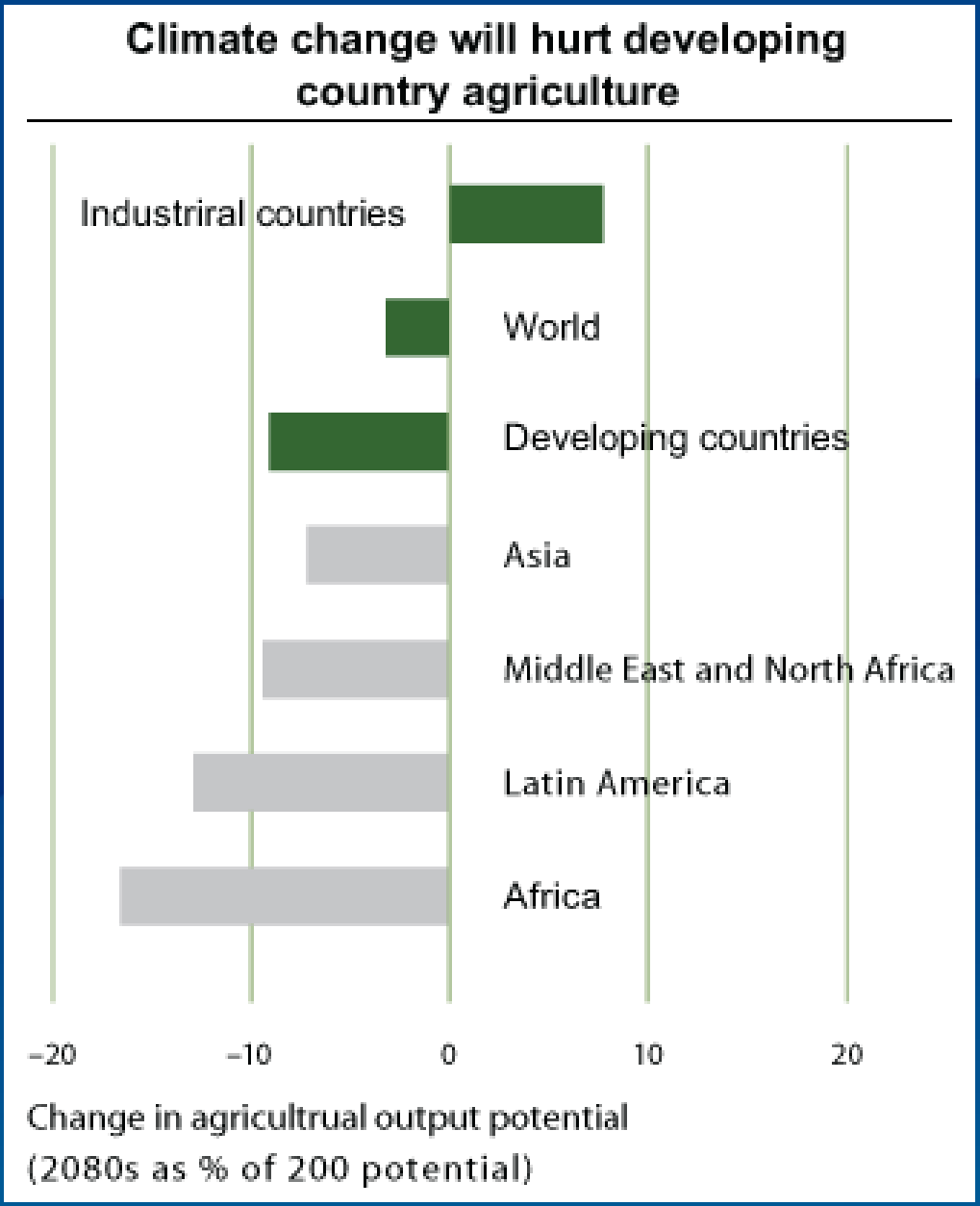
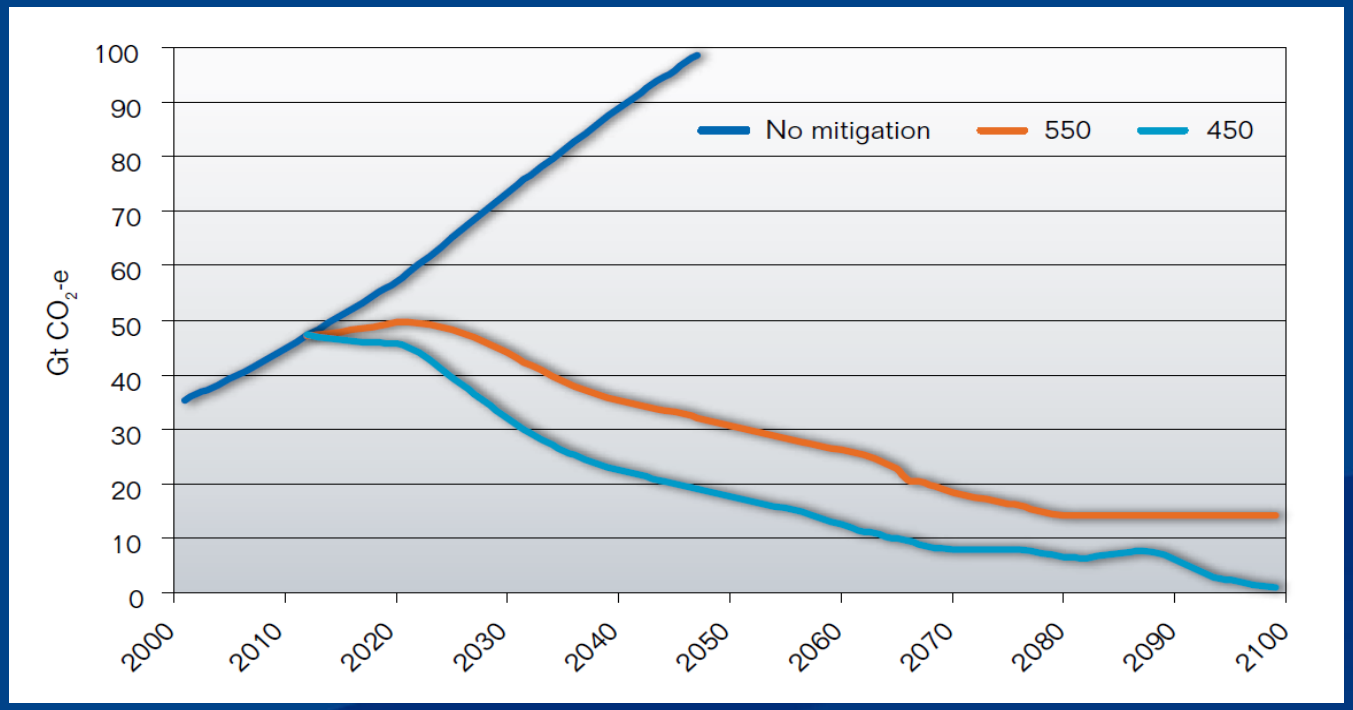
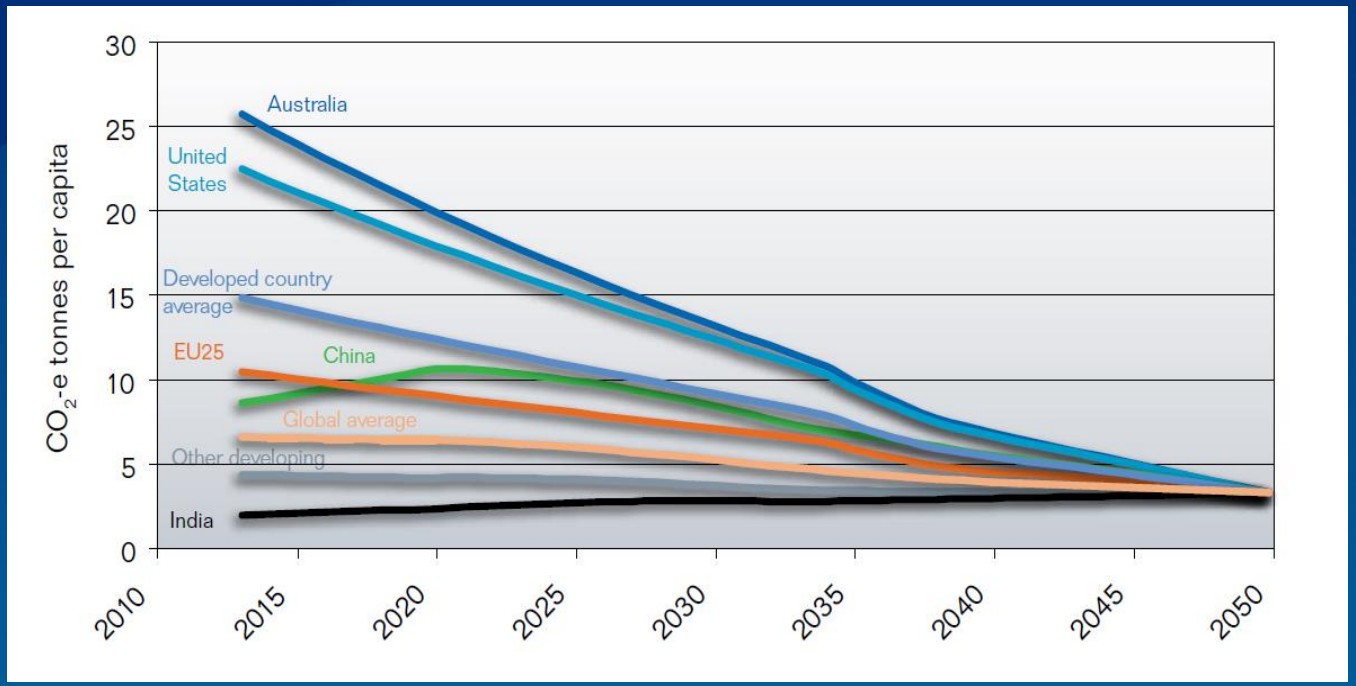
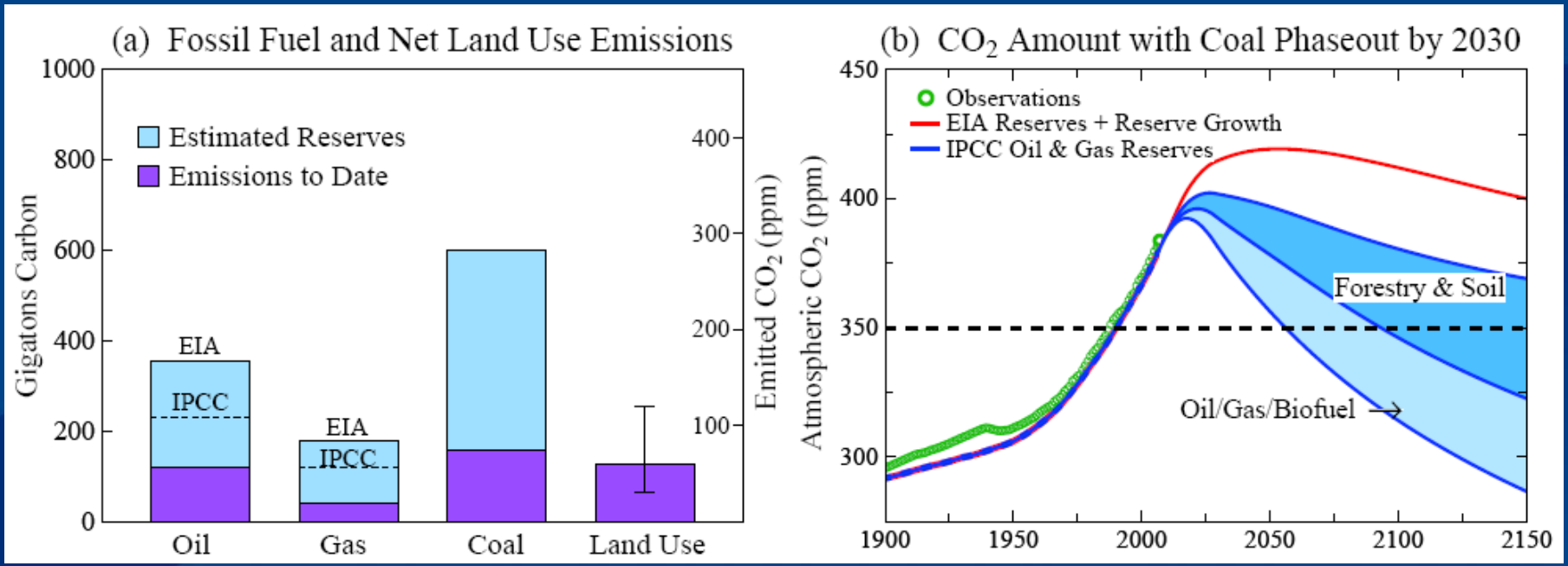
AUSTRALIA
SUB CRUCE LUMEN


Climate change will hurt developing country agriculture
Industriral countries
World
Developing countries
Asia
Middle East and North Africa
Latin America
Africa
–20
–10
0
10
20
Change in agricultrual output potential
(2080s as % of 200 potential)


100
90
80
70
60
50
40
30
20
10
0
Gt CO_2-e
No mitigation
550
450
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100


30
25
20
15
10
5
0
CO_2-e tonnes per capita
Australia
United States
Developed country average
EU25
China
Global average
Other developing
India
2010
2015
2020
2025
2030
2035
2040
2045
2050


(a) Fossil Fuel and Net Land Use Emissions
Gigatons Carbon
Emitted CO_2 (ppm)
Estimated Reserves
Emissions to Date
EIA
IPCC
EIA
IPCC
Oil
Gas
Coal
Land Use
(b) CO_2 Amount with Coal Phaseout by 2030
Atmospheric CO_2 (ppm)
Observations
EIA Reserves + Reserve Growth
IPCC Oil & Gas Reserves
Forestry & Soil
Oil/Gas/Biofuel

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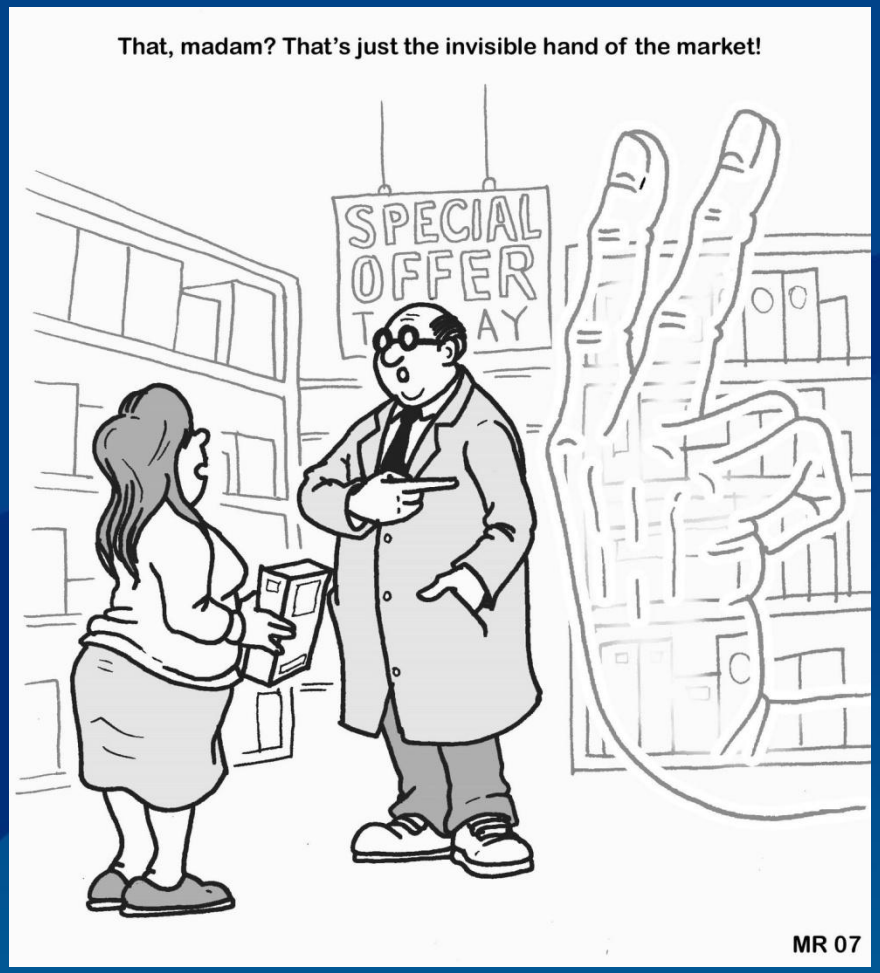
Cap-and-Trade or Tax?



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EMISSIONS CAP-and-TRADE

- Cap reductions ensure falling emissions – *in theory*
- Reduce inefficiencies or overpricing
- Creates both incentives and disincentives for abatement
- Chance to profit from 'doing the right thing'
- Enrich middle men / brokers
- Requires army of bureaucrats / new system
- Encourages rent seeking – pleading by special interest groups
- Limited price certainty – requires projected 'gateways'

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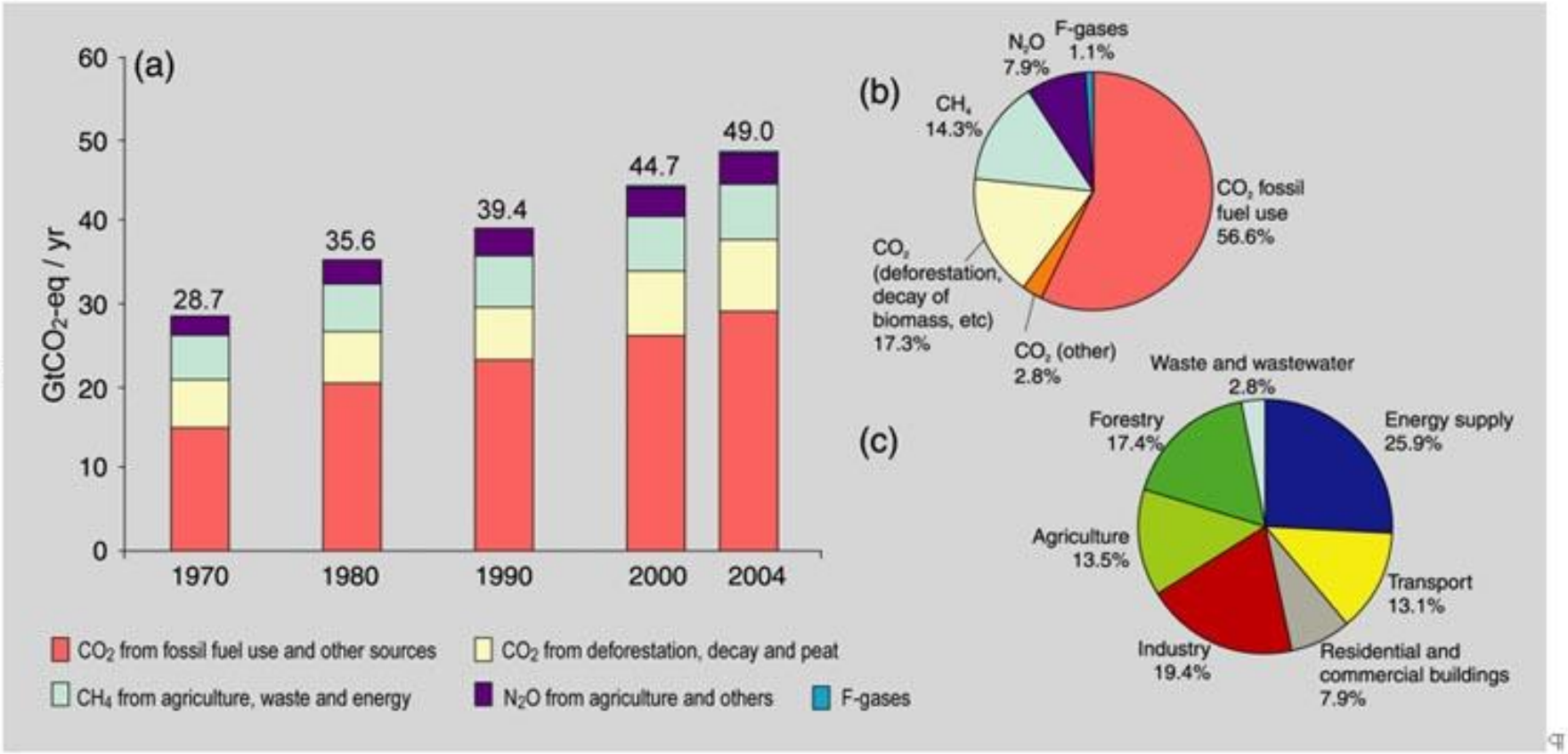
CARBON TAX

- Politicians or bureaucrats set costs – inefficiencies and pressure
- No guarantee that emissions will fall
- Clear forward price projection = investment certainty
  - – removes incentives for hedge funds, derivatives etc.
  - – better allows for long-term business planning
- Can use current tax system
- Better hands EITE industries via carbon tariffs

Global anthropogenic GHG emissions



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Achieving deep cuts in greenhouse gas emissions by 2050 - A potential scenario

Government of South Australia
Department of the Premier and Cabinet

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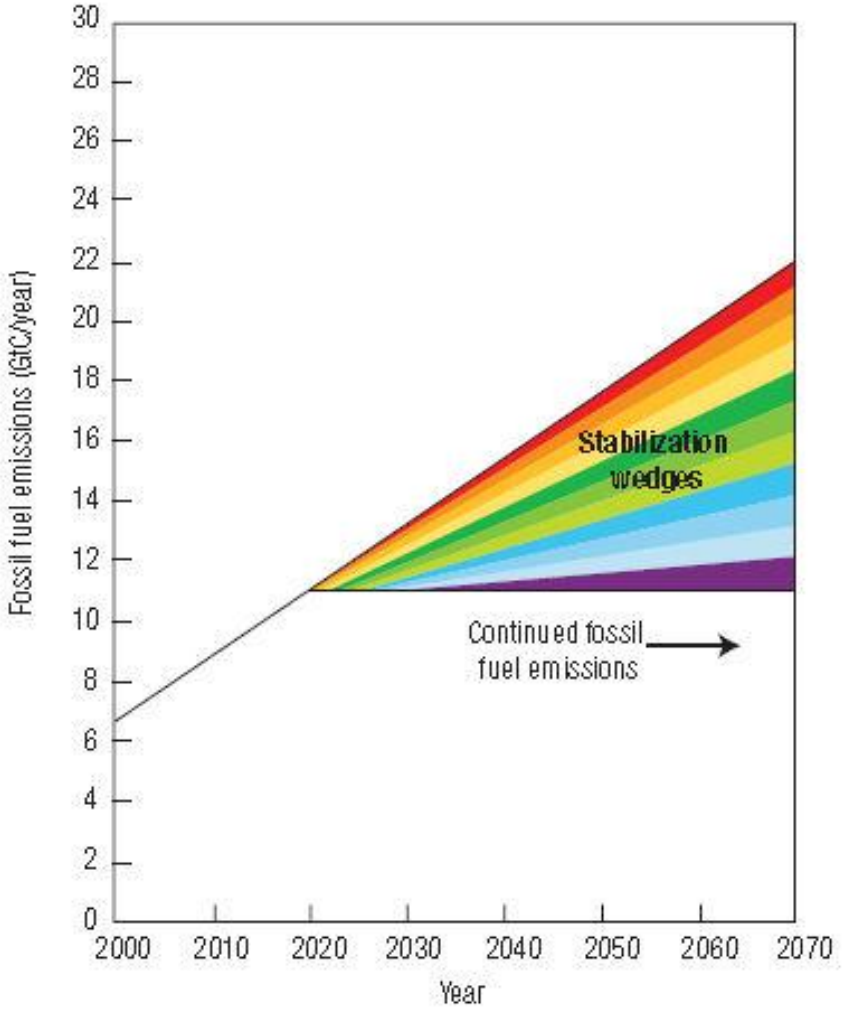
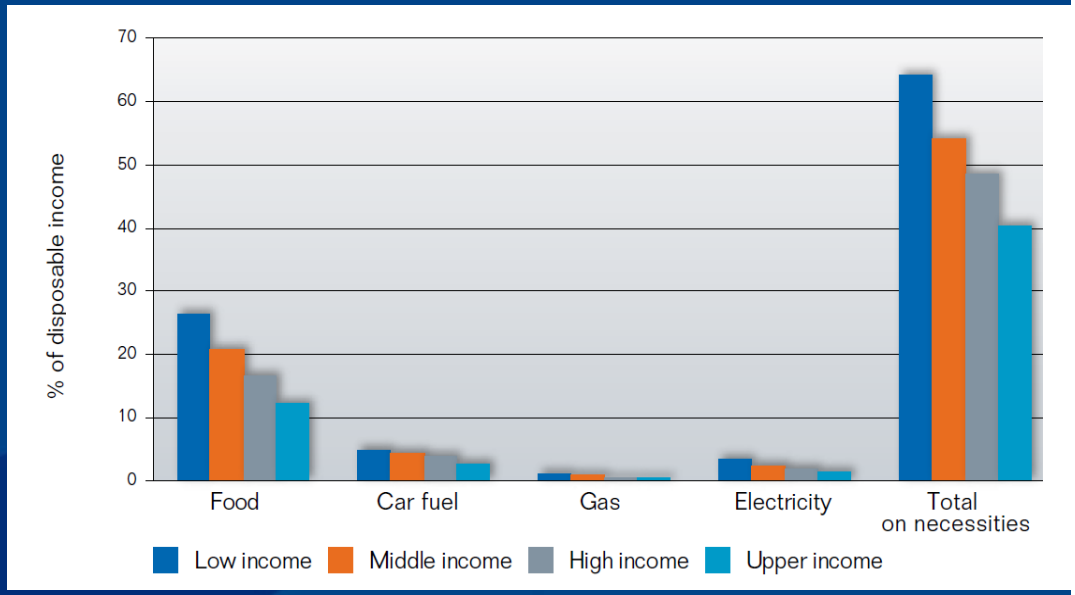
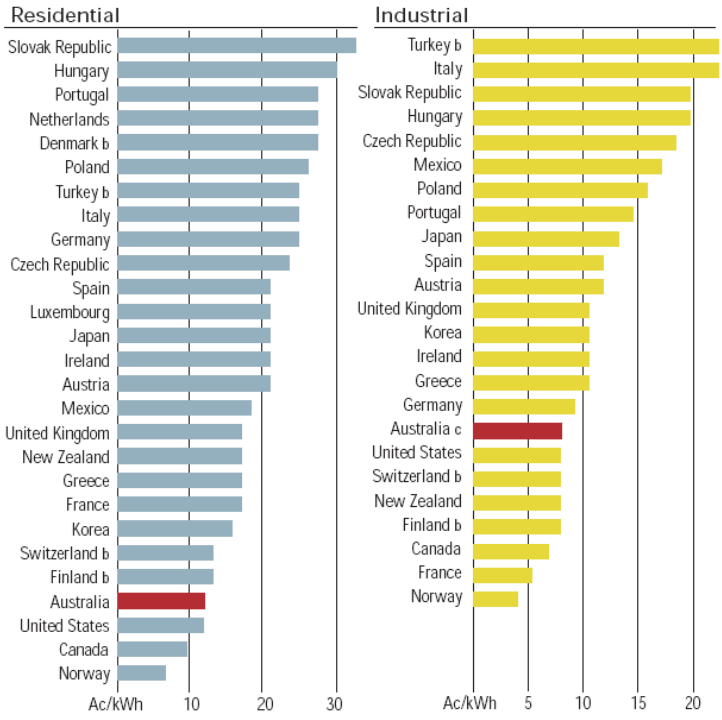


- Coal: 800 gigawatt-sized plants with all the carbon captured and permanently sequestered
- Nuclear: 700 new gigawatt-sized plants (plus replacement plants)
- Concentrated solar thermal electric: 1,600 gigawatts peak power
- Solar photovoltaics: 3,000 gigawatts peak power
- Efficient buildings: savings totalling 5 million gigawatt-hours
- Efficient industry: savings totalling 5 million gigawatt-hours, including co-generation and heat recovery
- Wind power: 1 million large wind turbines (2 megawatts peak power)
- Vehicle efficiency: all cars 60 miles per US gallon
- Wind for vehicles: 2,000 gigawatts wind, with most cars plug-in hybrid electric vehicles or pure electric vehicles
- Cellulosic biofuels: using up to one-sixth of the world's cropland
- Forestry: end all tropical deforestation

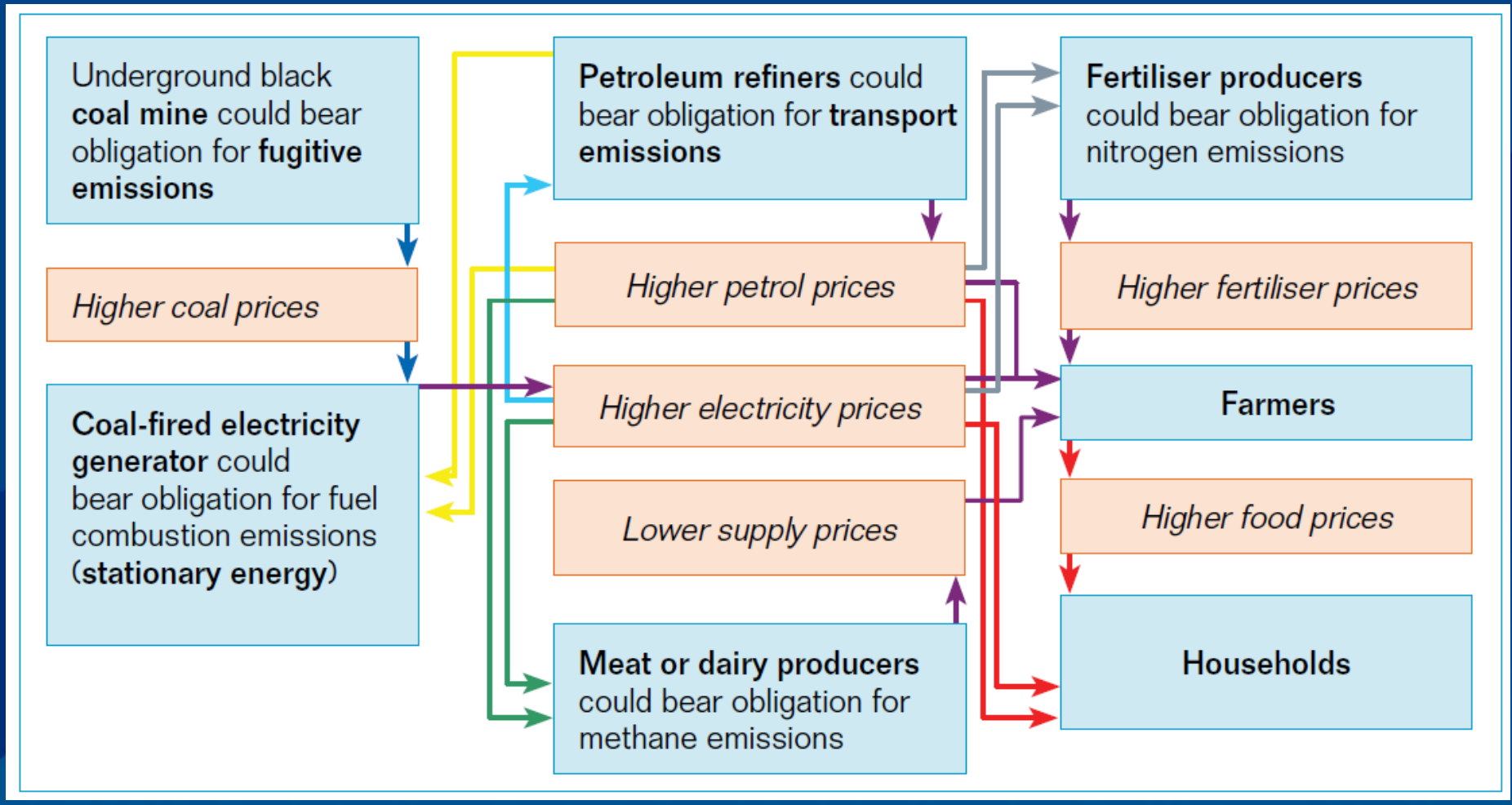


OECD electricity prices, 2005 a

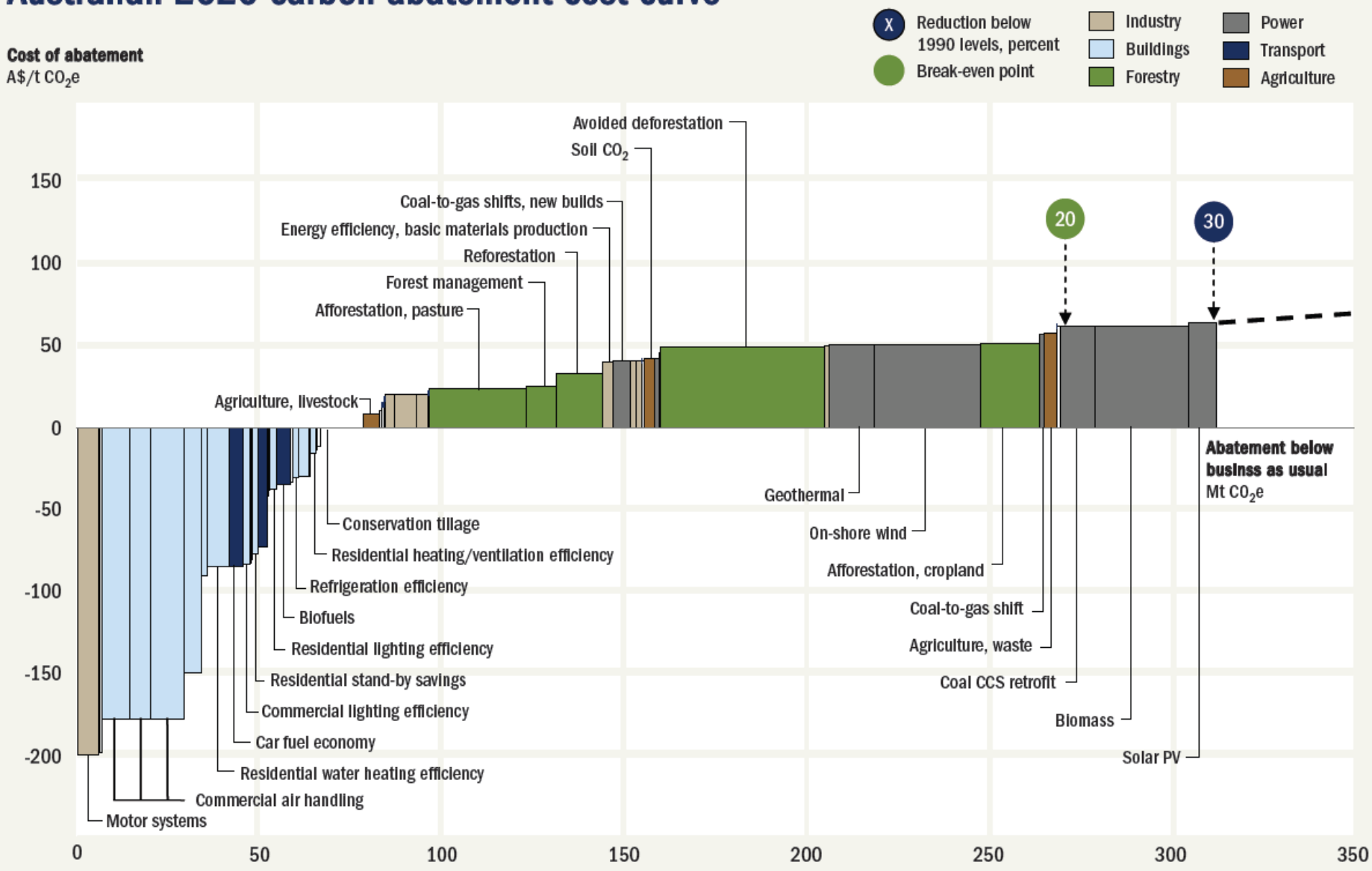


a Average end-user prices. b Representative prices. c Includes commercial users.

Source: IEA


Underground black **coal mine** could bear obligation for **fugitive emissions**
Higher coal prices
Coal-fired electricity generator could bear obligation for fuel combustion emissions (**stationary energy**)
Petroleum refiners could bear obligation for **transport emissions**
Higher petrol prices
Higher electricity prices
Lower supply prices
Meat or dairy producers could bear obligation for methane emissions
Fertiliser producers could bear obligation for nitrogen emissions
Higher fertiliser prices
Farmers
Higher food prices
Households

Australian 2020 carbon abatement cost curve



Note: Abatement opportunities are not additive to those of previous years

Source: McKinsey Australia Climate Change Initiative

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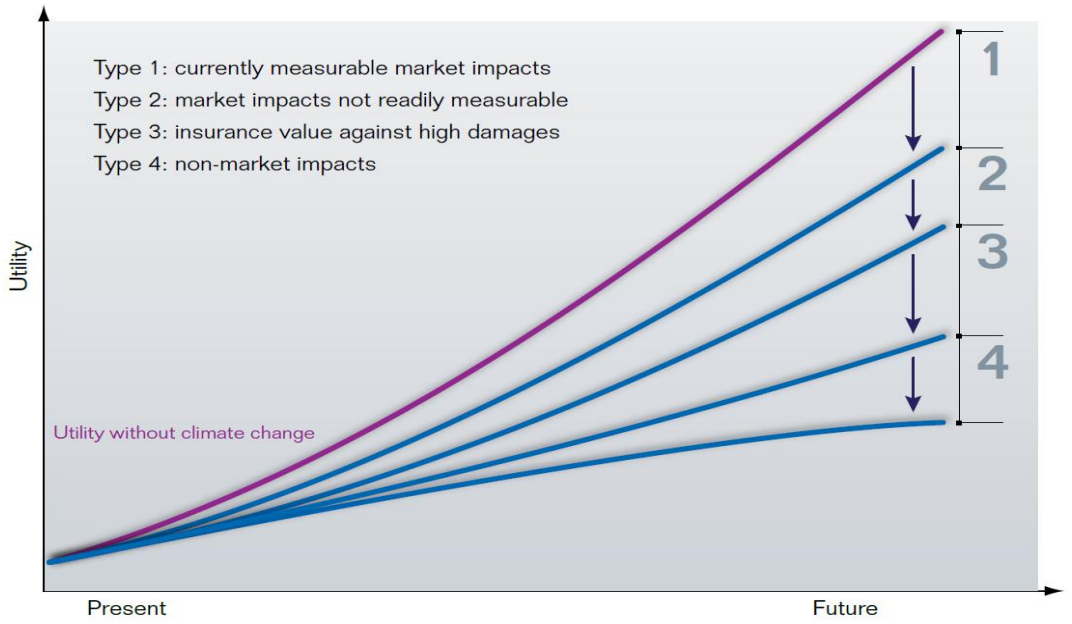
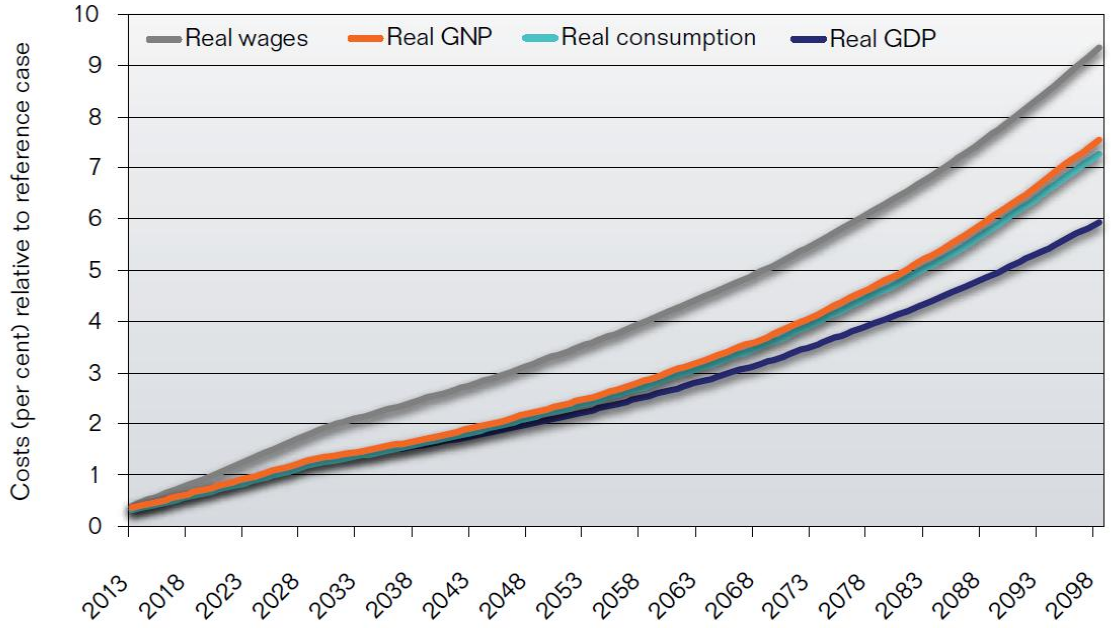
Figure 1.3 The four types of climate change impacts





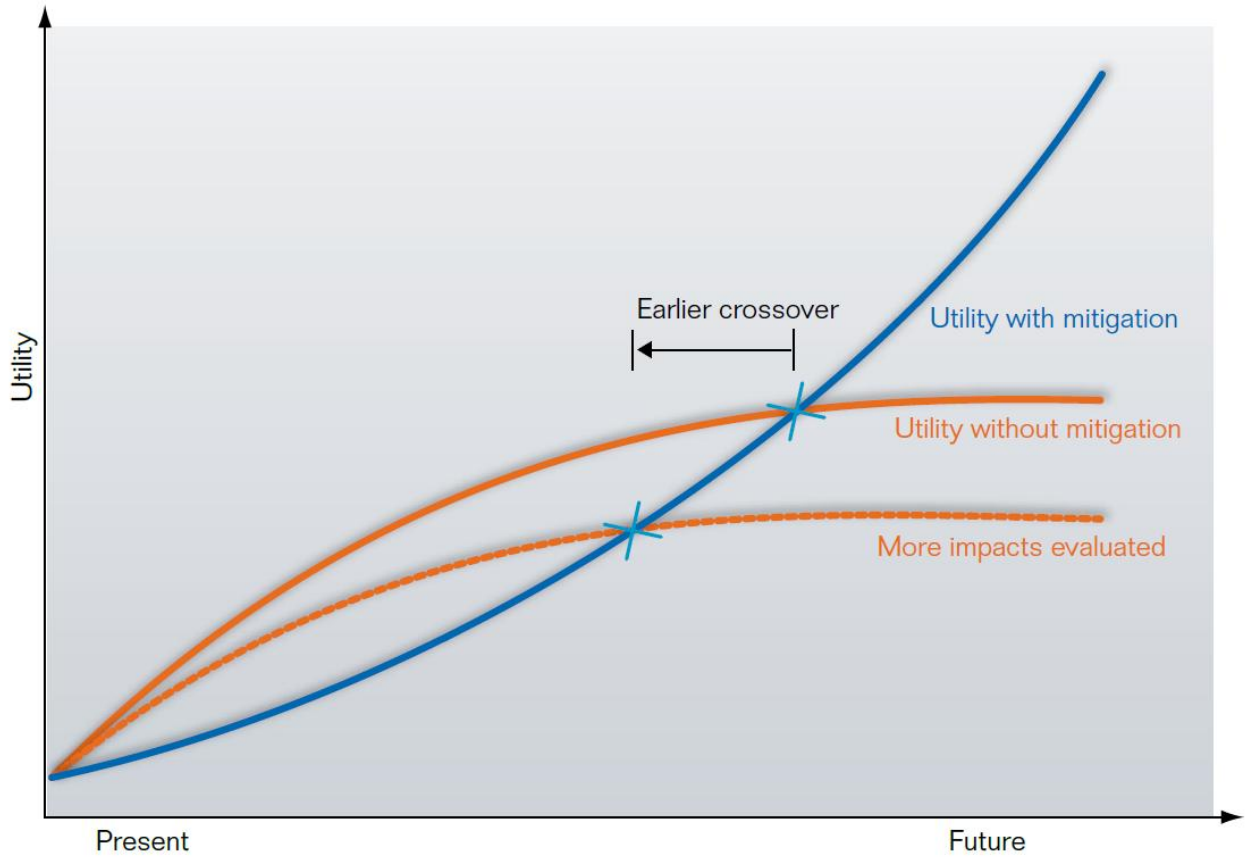


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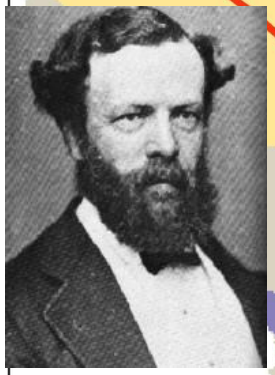
Table 6.4 Decline in value of irrigated agricultural production in the Murray-Darling Basin out to 2100 from a world with no human-induced climate change

	No-mitigation case	Global mitigation with CO_2-e stabilisation at 550 ppm by 2100	Global mitigation with CO_2-e stabilisation at 450 ppm by 2100	Hot, dry extreme case (the 'bad-end story')
Year	Decline in economic value of production (%)			
2030	12	3	3	44
2050	49	6	6	72
2100	92	20	6	97

Industry subsector	Vulnerability to biophysical impacts of climate change
Sheep (dryland)	High
Sheep (irrigated)	Very high
Grain (dryland)	High
Grain (irrigated)	Very high
Beef cattle (dryland)	High
Dairy cattle (irrigated)	Very high
Pigs (intensive)	Low
Poultry (intensive)	Low
Other (horticulture & viticulture)	Moderate (high for wine quality)
Forestry	Moderate
Fisheries	High for some species, but largely unknown

South Australia Annual Rainfall



Goyder's Line

Hawker

Clare

Adelaide

Legend

Goyder's Line

SA_Annual_Rainfall.img

<VALUE>

0

0.01 - 160

170 - 210

220 - 280

290 - 350

360 - 440

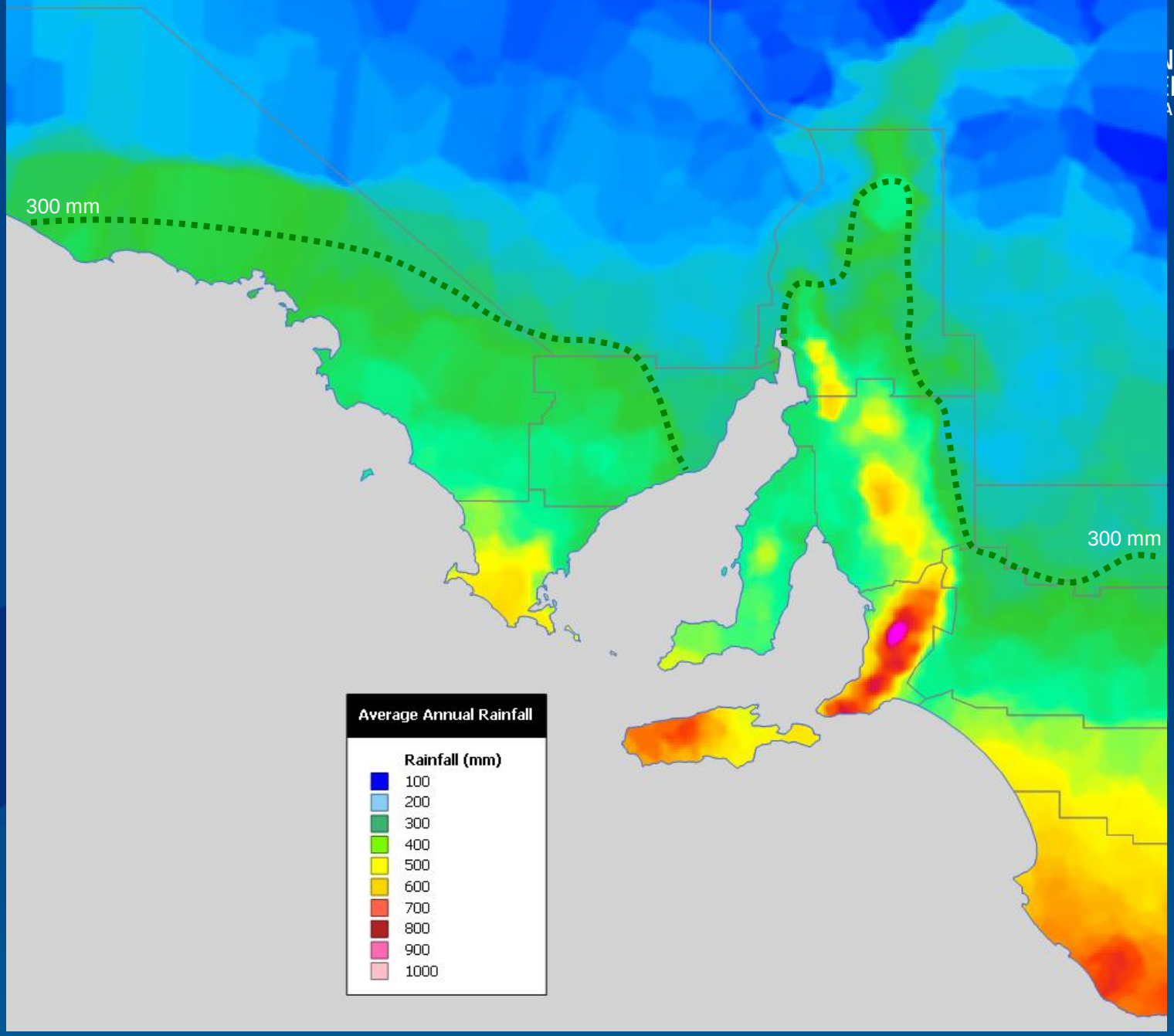
450 - 530

540 - 630

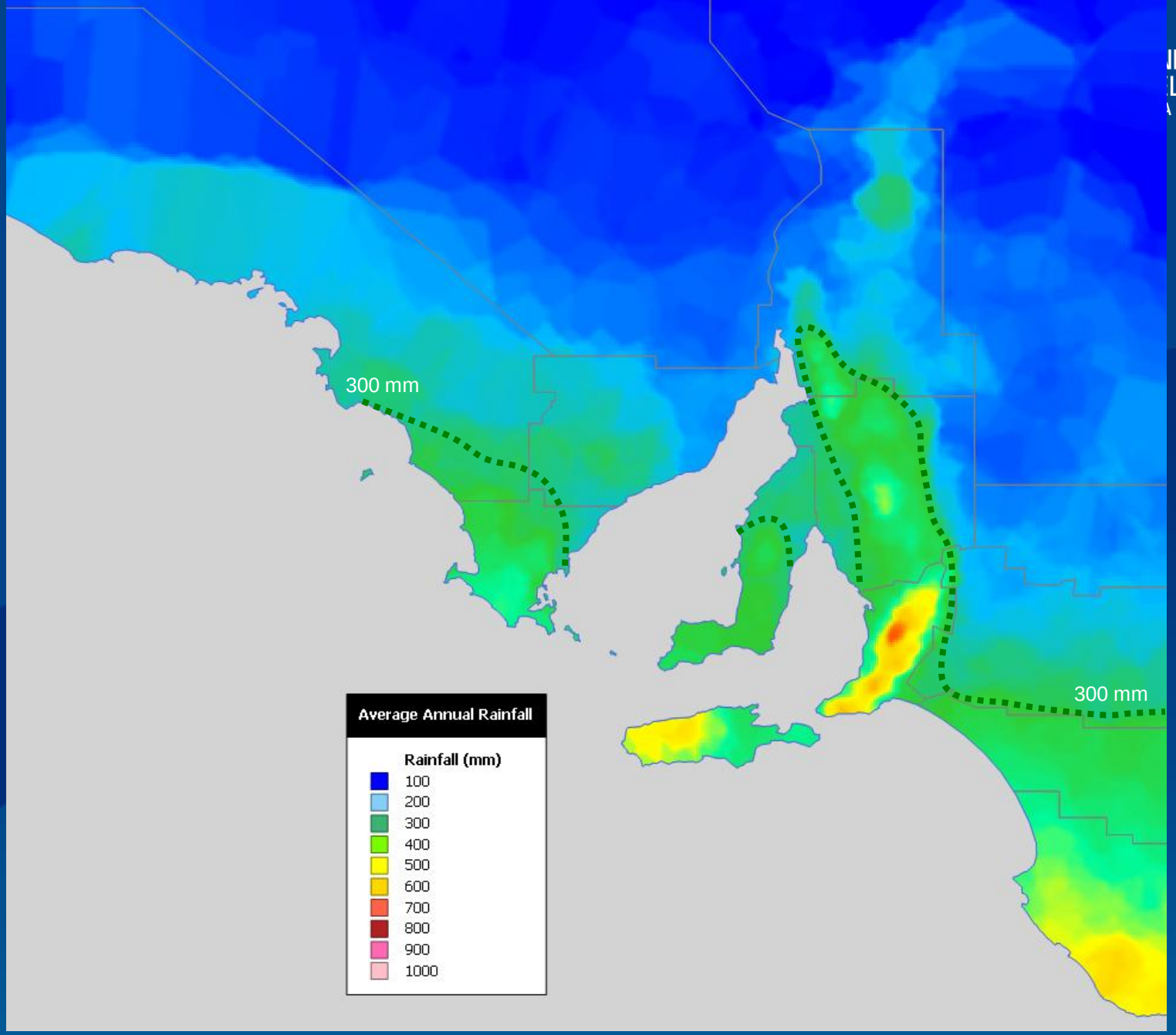
640 - 750

760 - 1,200

Professor Barry W. Brook (barry.brook@adelaide.edu.au), Sir Hubert Wilkins Chair of Climate Change, Research Institute for Climate Change and Sustainability



Average Annual Rainfall : South Australia



30% reduction in annual rainfall : South Australia

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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

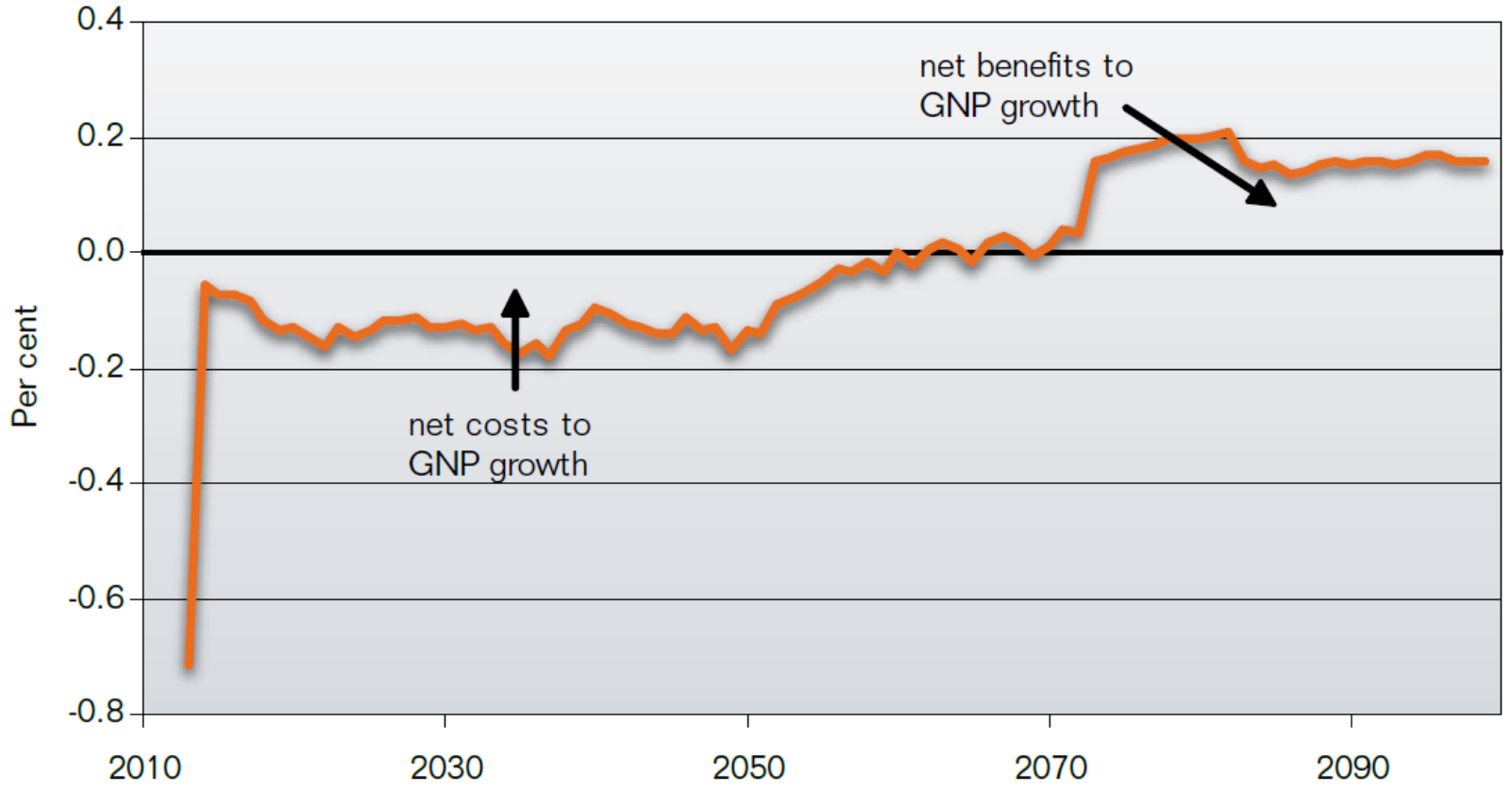

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Table 23.1 Total after-tax per capita income (2005 dollars)

	2006	2020	2050
Reference	$36 548	$42 676	$60 622
Reference—relative to 2006	–	+17%	+66%
550 standard technology scenario	–	$42 207	$57 304
550 standard technology scenario—relative to 2006	–	+15%	+57%
450 standard technology scenario	–	$42 044	$56 675
450 standard technology scenario—relative to 2006	–	+15%	+55%

Source: MMRF reference case and policy simulations without climate change impacts.

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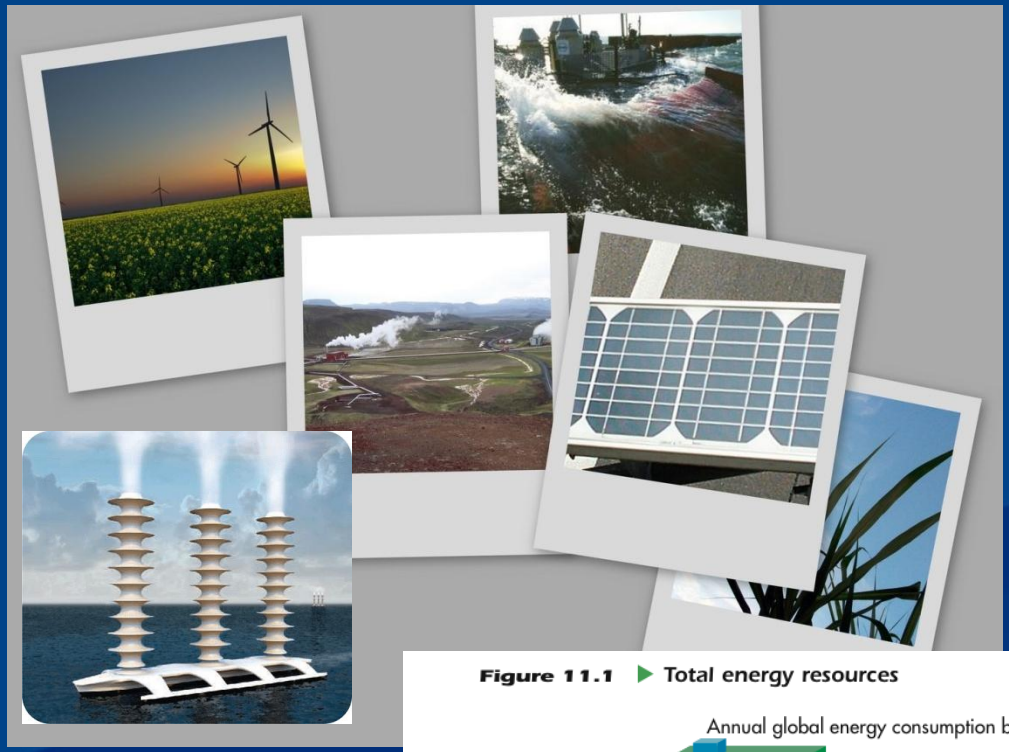
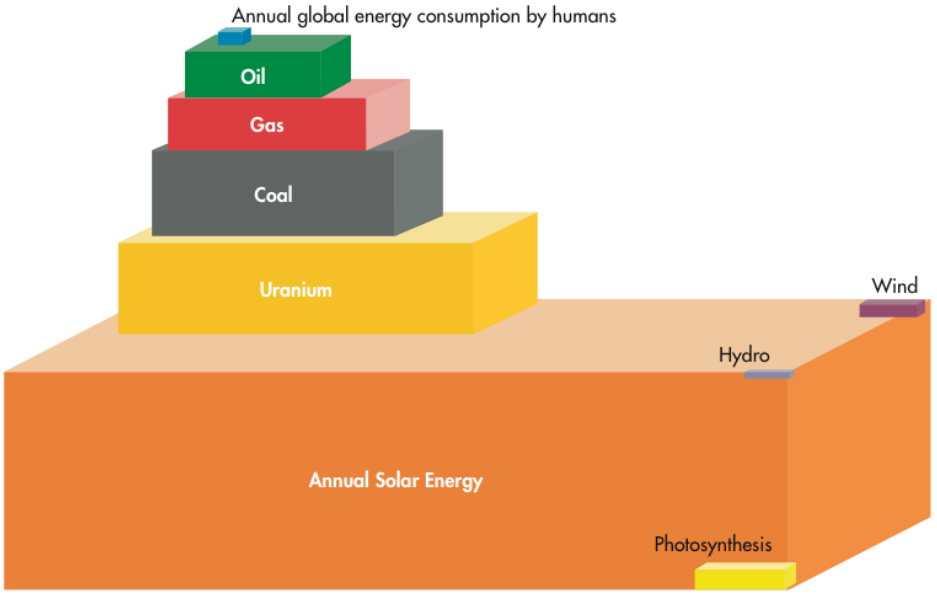


Figure 11.1 ▶ Total energy resources



Source: National Petroleum Council, 2007 after Craig, Cunningham and Saigo.

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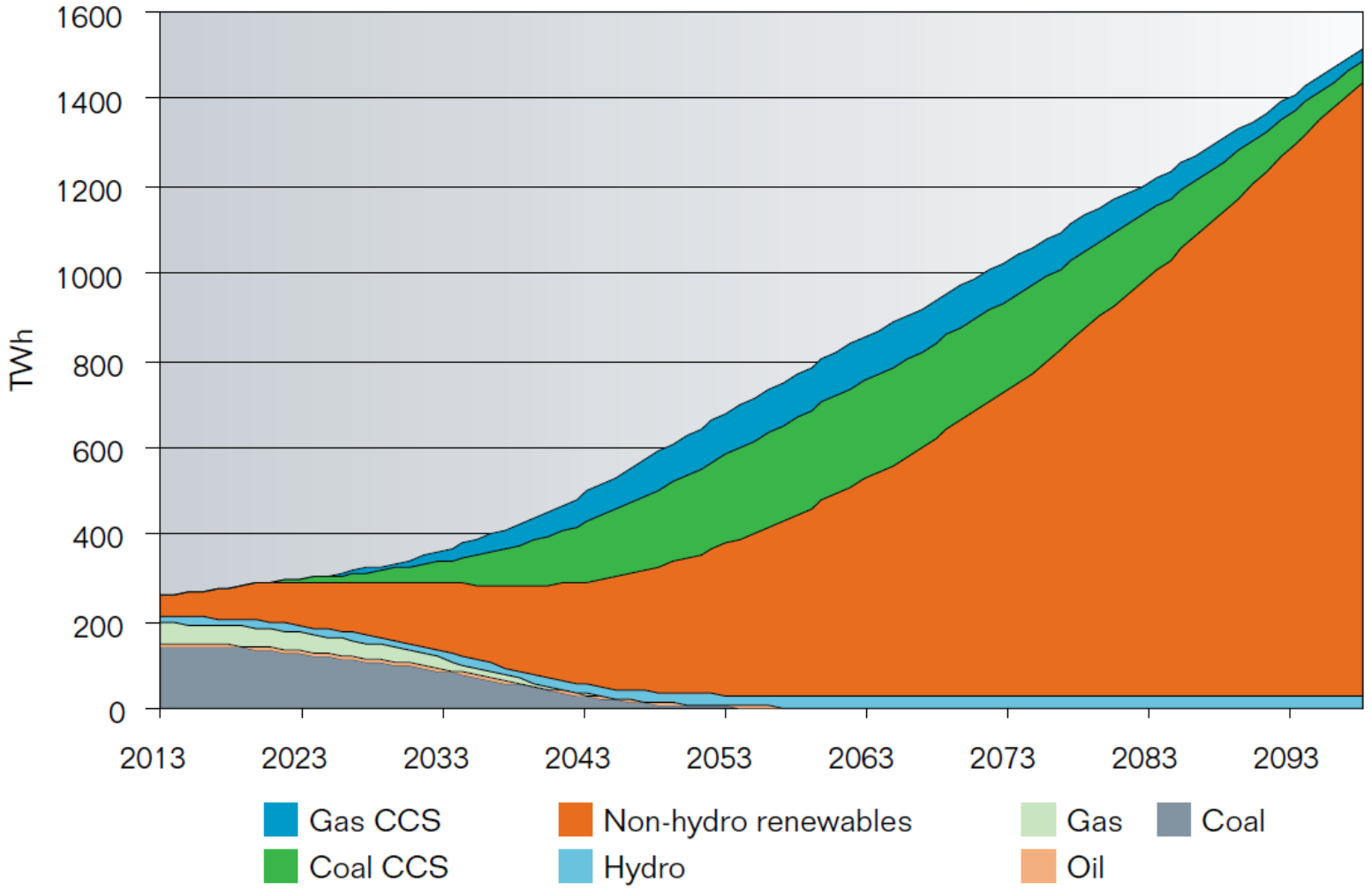
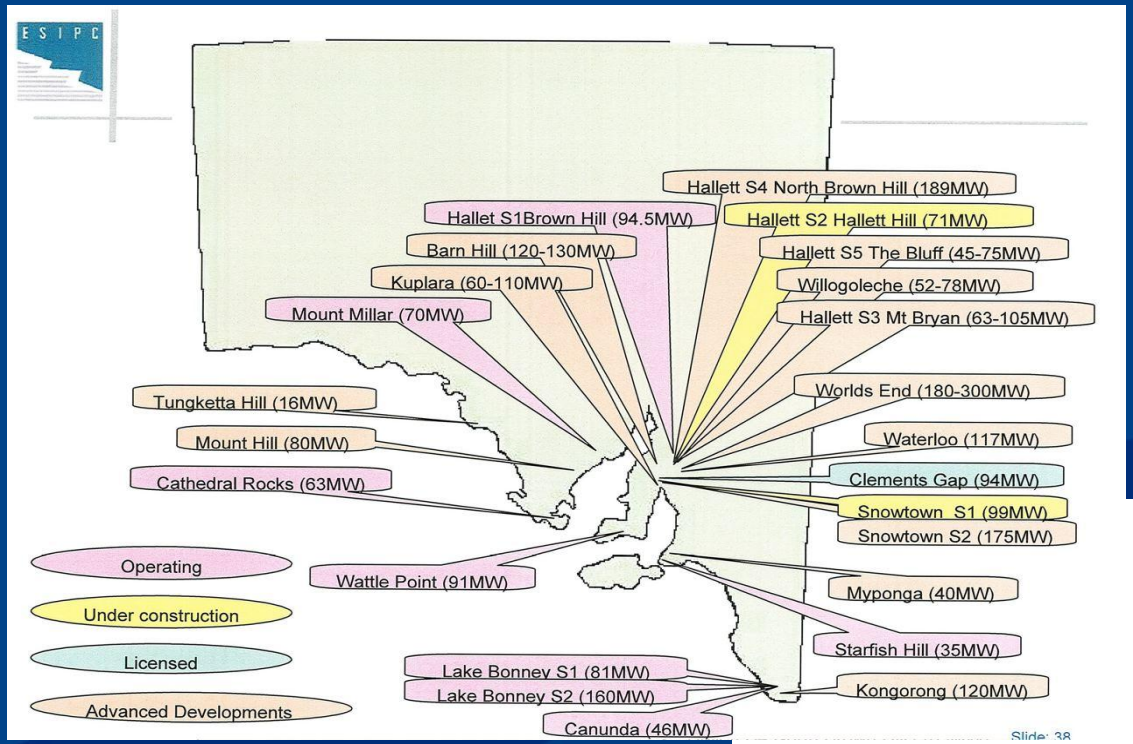
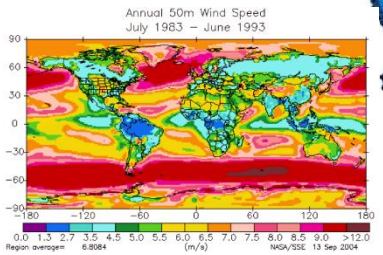
Figure 20.10 Australia's electricity generation technology shares, 450 scenario





Model of success in uptake

Abundant coastal resources



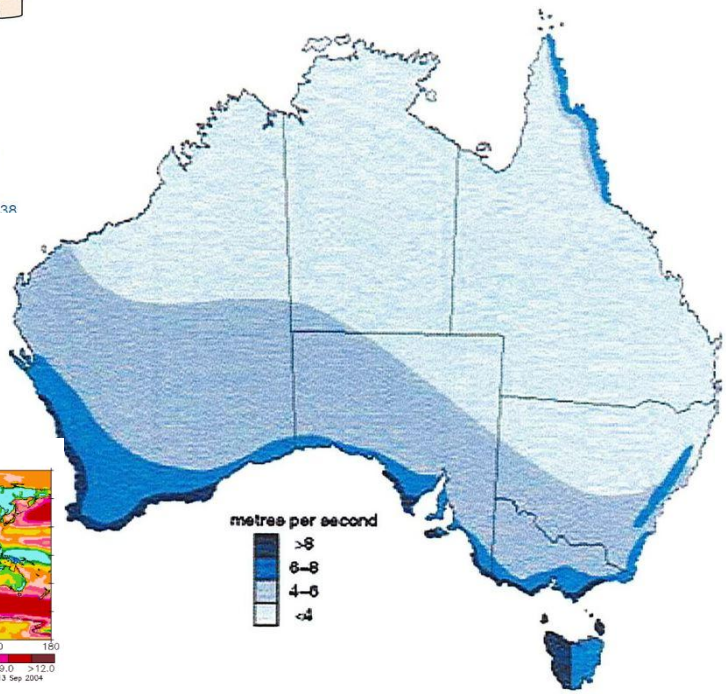


Figure 2: Australia's wind resources (source: CSIRO)

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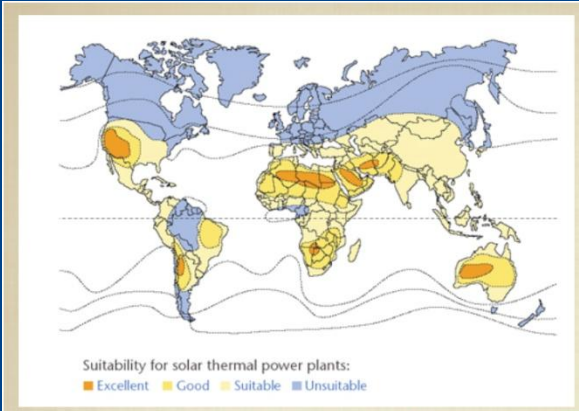
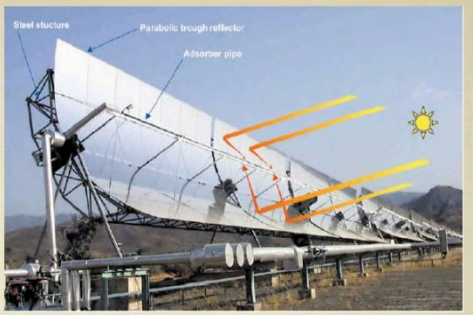




PARABOLIC TROUGHS
CALIFORNIA

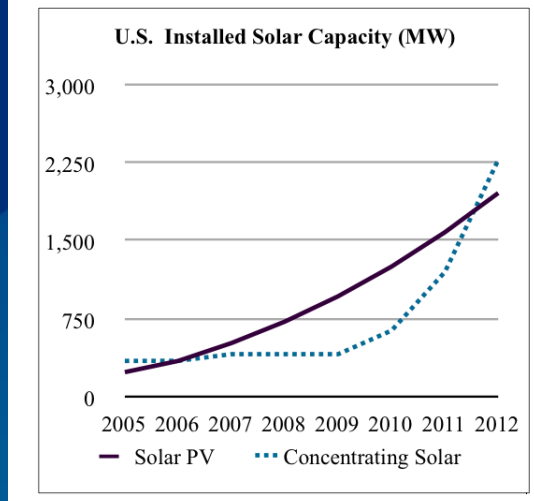
SOLAR TOWERS
SPAIN

SOLAR DISHES
CALIFORNIA

LINEAR
REFLECTORS

Optimal at large scale

Abundant inland resources



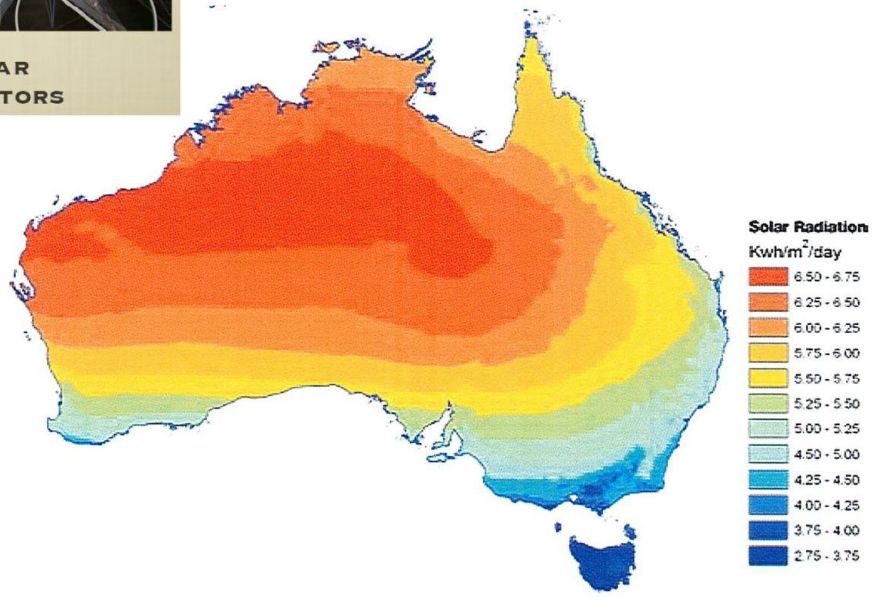


Figure 4: Improved global solar radiation map for Australia, mean annual solar radiation levels, kWh/m2/day (constructed from data supplied in ANUCLIM - data and map supplied by CRES, ANU)

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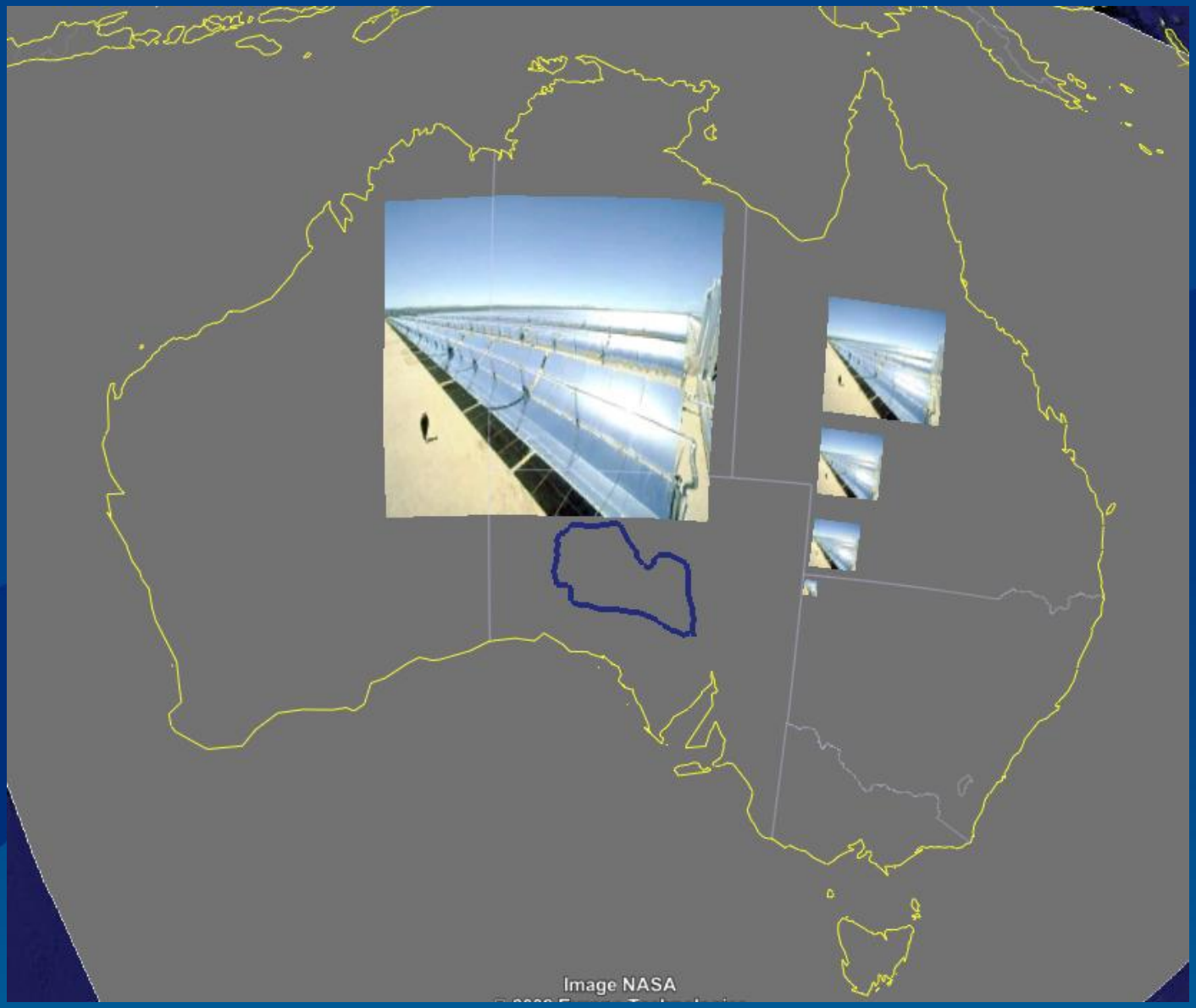
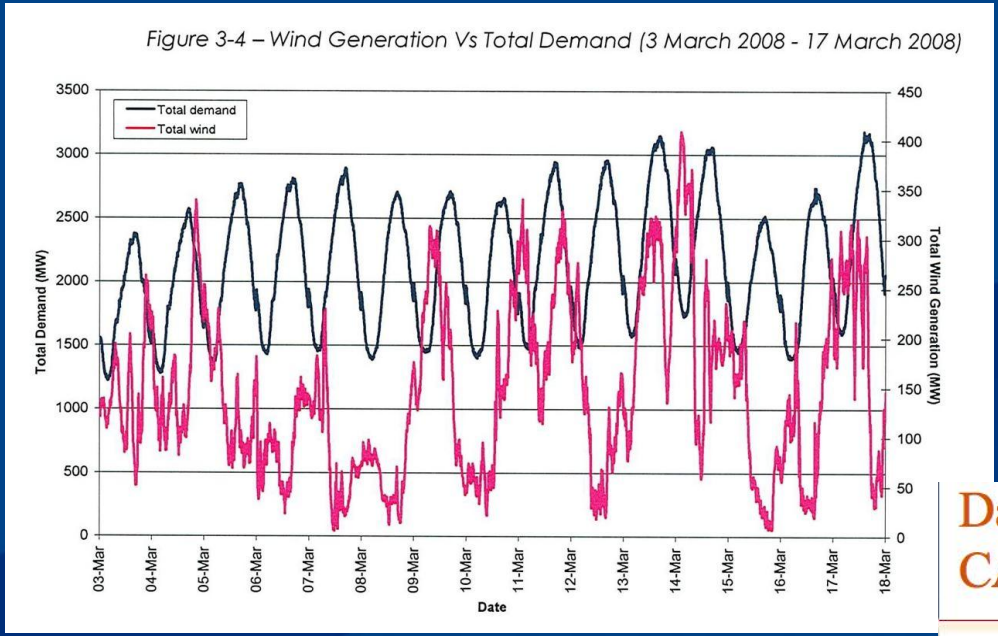
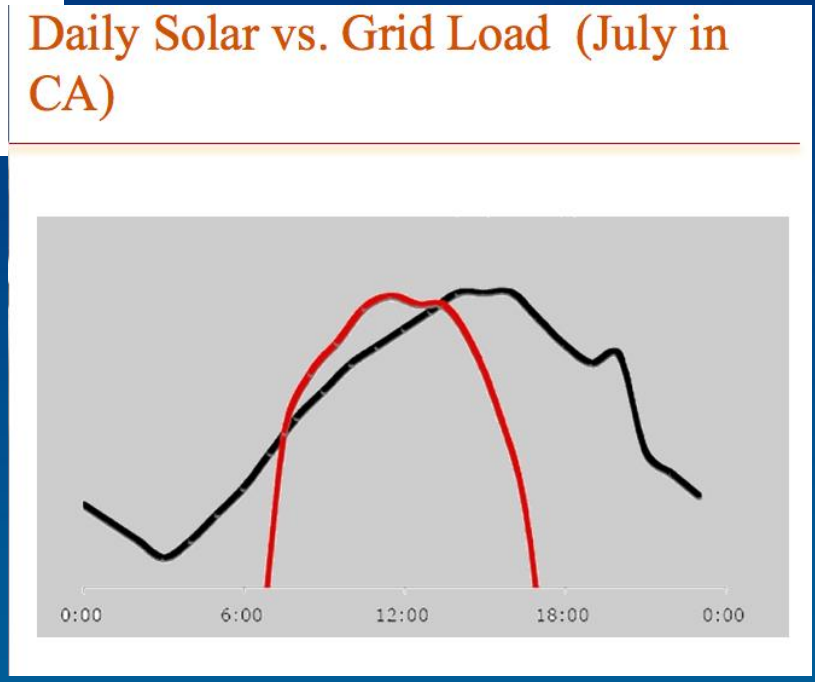


Need for diversified renewable supply…





Baseload renewable power

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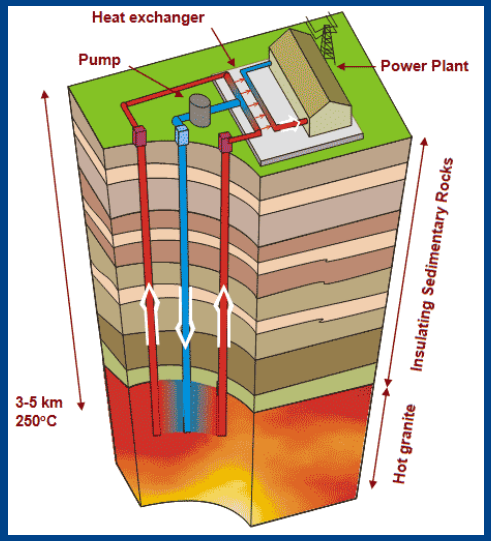
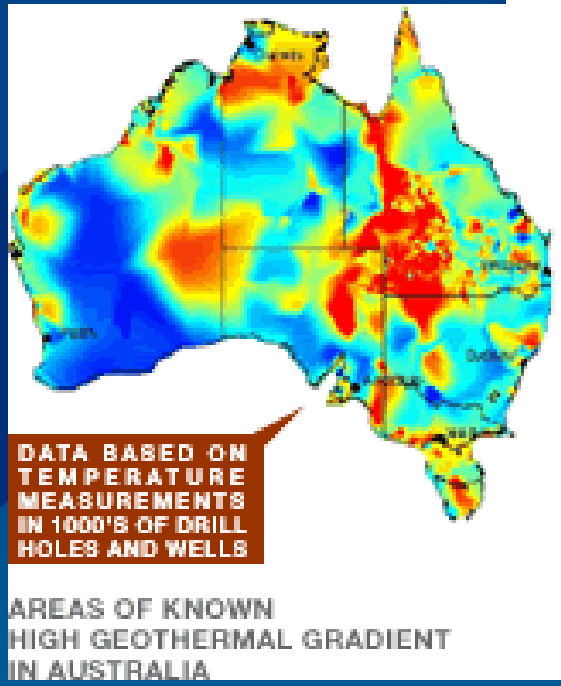
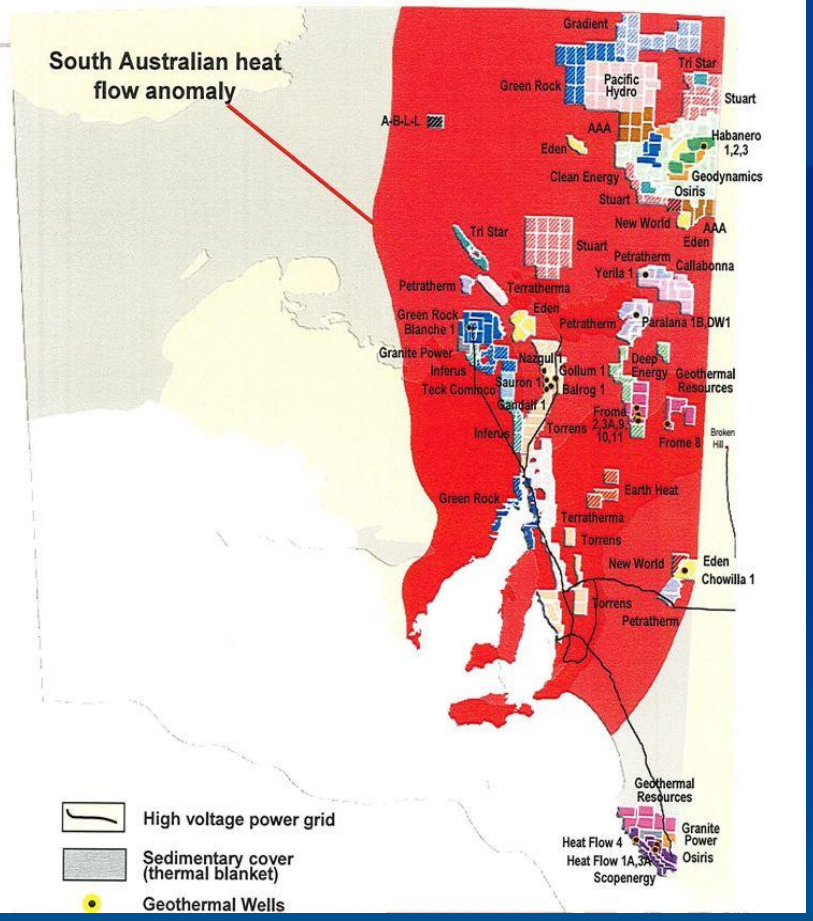




Geothermal

- ✓ Tri-Star Energy
- ✓ Clean Energy Australasia
- ✓ Osiris Energy
- ✓ Origin Energy
- ✓ Callabonna
- ✓ Deep Energy
- ✓ Inferus
- ✓ A-B-L-R Joint Venture
- ✓ AAA Energy
- ✓ Earth Heat
- ✓ New World Energy
- ✓ Stuart Petroleum
- ✓ Geodynamics
- ✓ Petratherm
- ✓ Geothermal Resources
- ✓ Green Rock
- ✓ Torrens Energy
- ✓ Eden Energy
- ✓ Scopenergy/Uranoz-Panax
- ✓ Pacific Hydro
- ✓ Teck Cominco
- ✓ Granite Power
- ✓ Gradient Energy

Sourced from South Australian Department of Primary Industries and Resources



Abundant inland resources, 80% investment in SA

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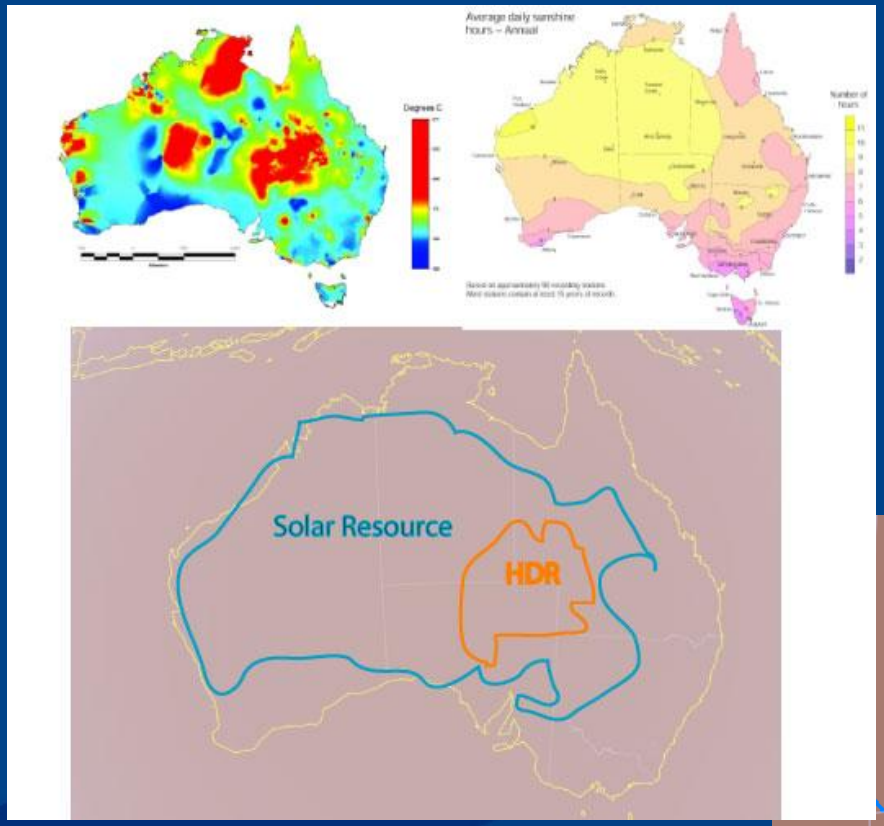

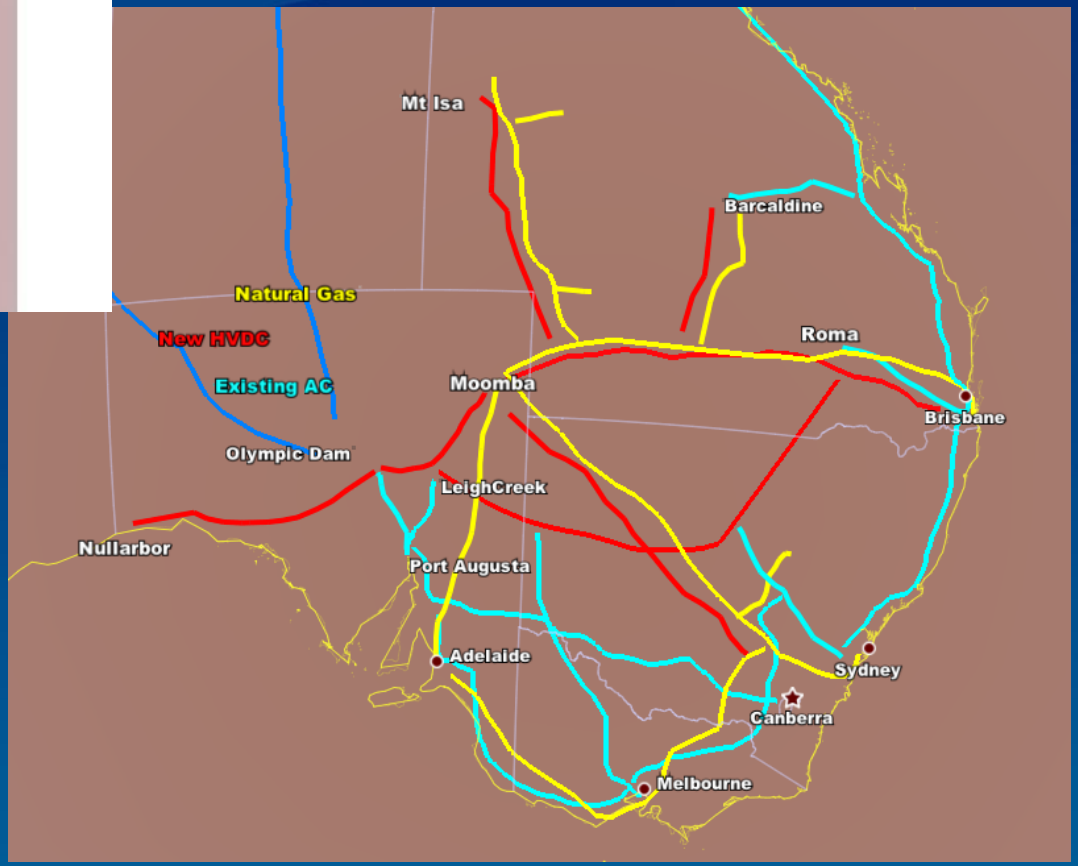

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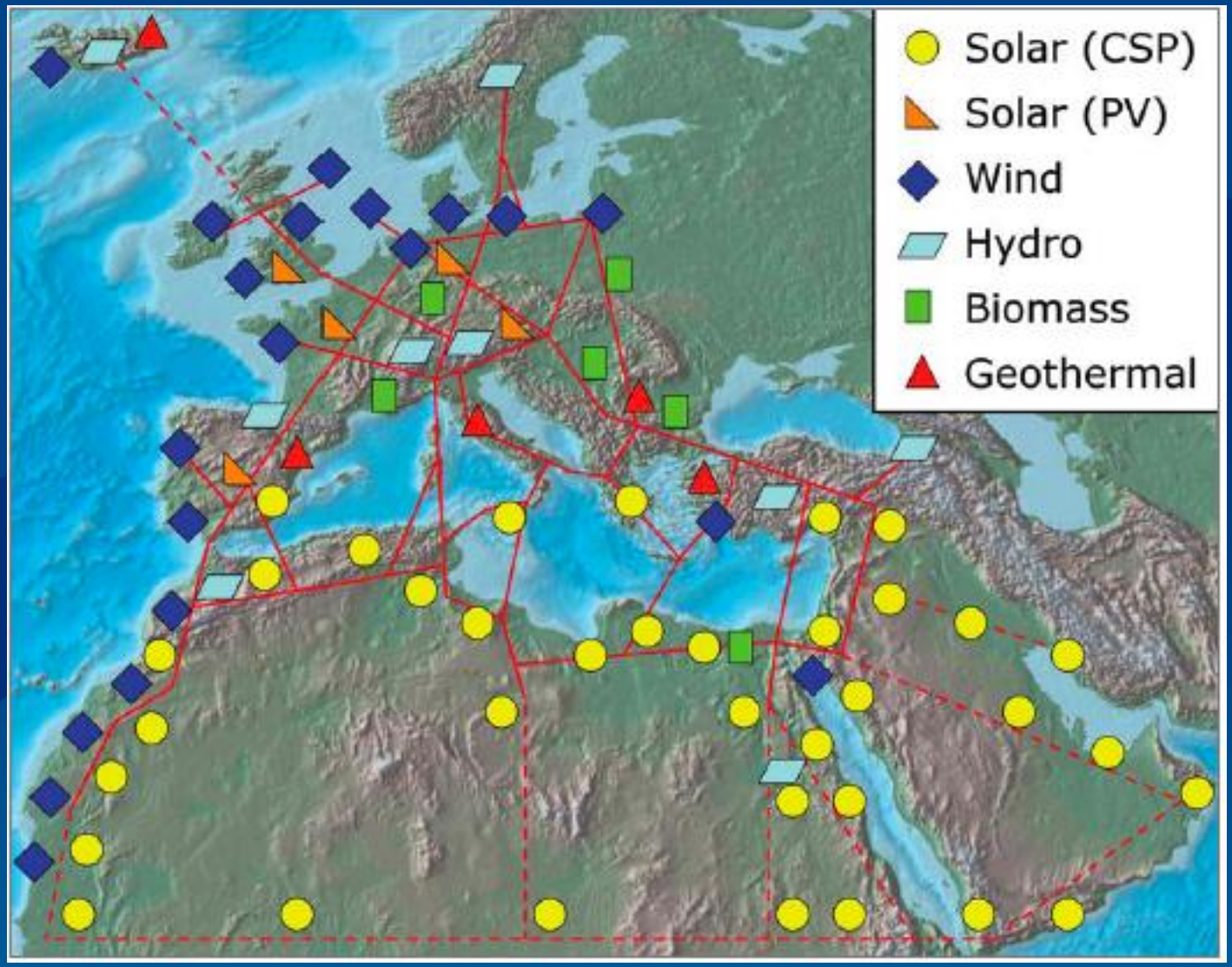
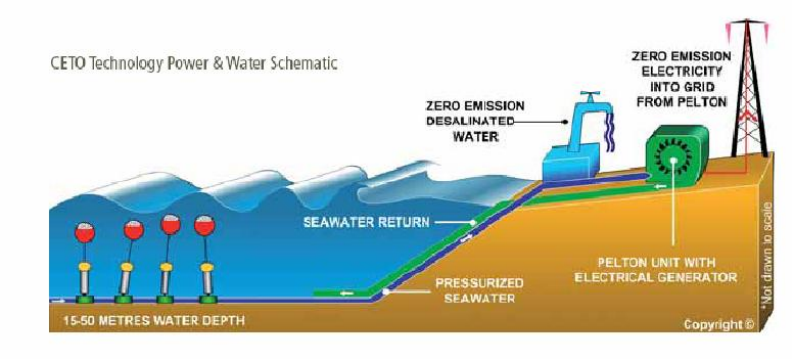
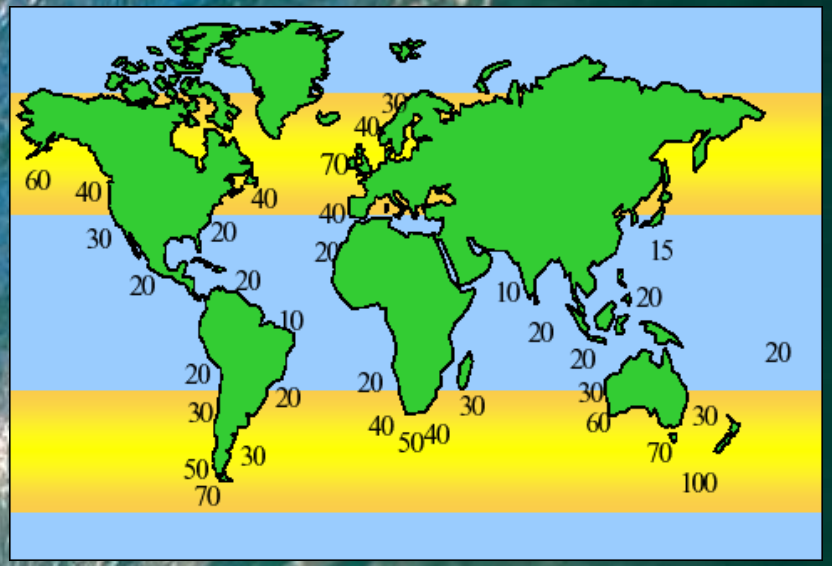
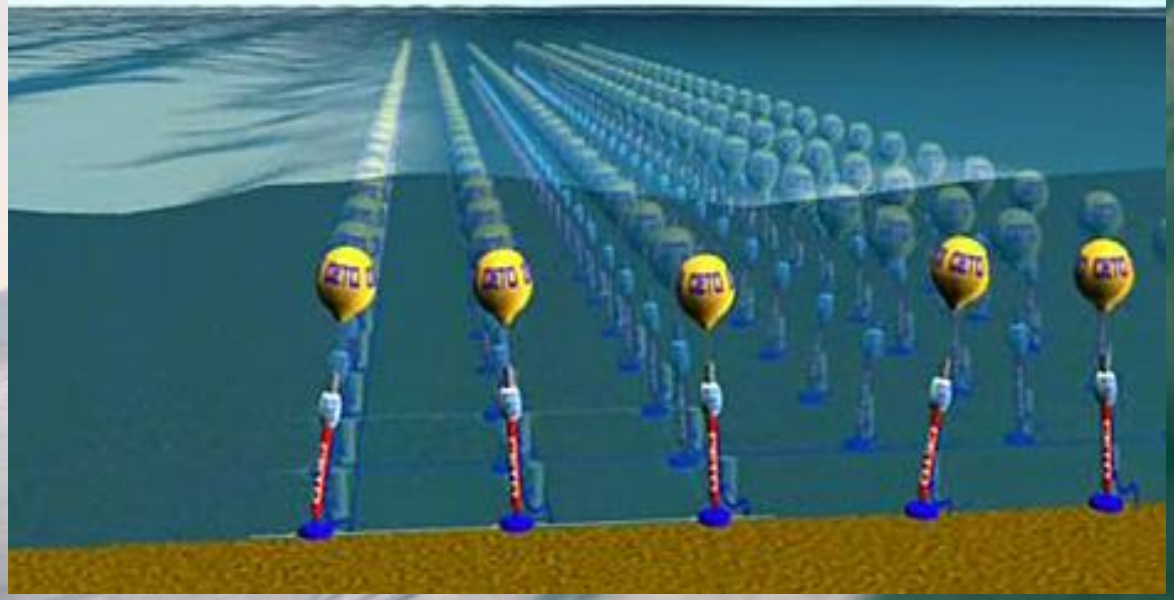






Wave power - synergy with wind & desal



– Renewable liquid fuel

– Microalgal biodiesel = huge yield

– Does not displace agriculture

– Aust supply = 60 x 60 km area

– Multiple products

HOW GREEN ARE BIOFUELS?

Biofuels are getting a bad rap as stories of rising food prices and shortages fill the news. But the environmental, energy and land use impacts of the crops used to make the fuels vary dramatically. Current fuel sources – corn, soybeans and canola – are more harmful than alternatives that are under development.

FUEL SOURCES

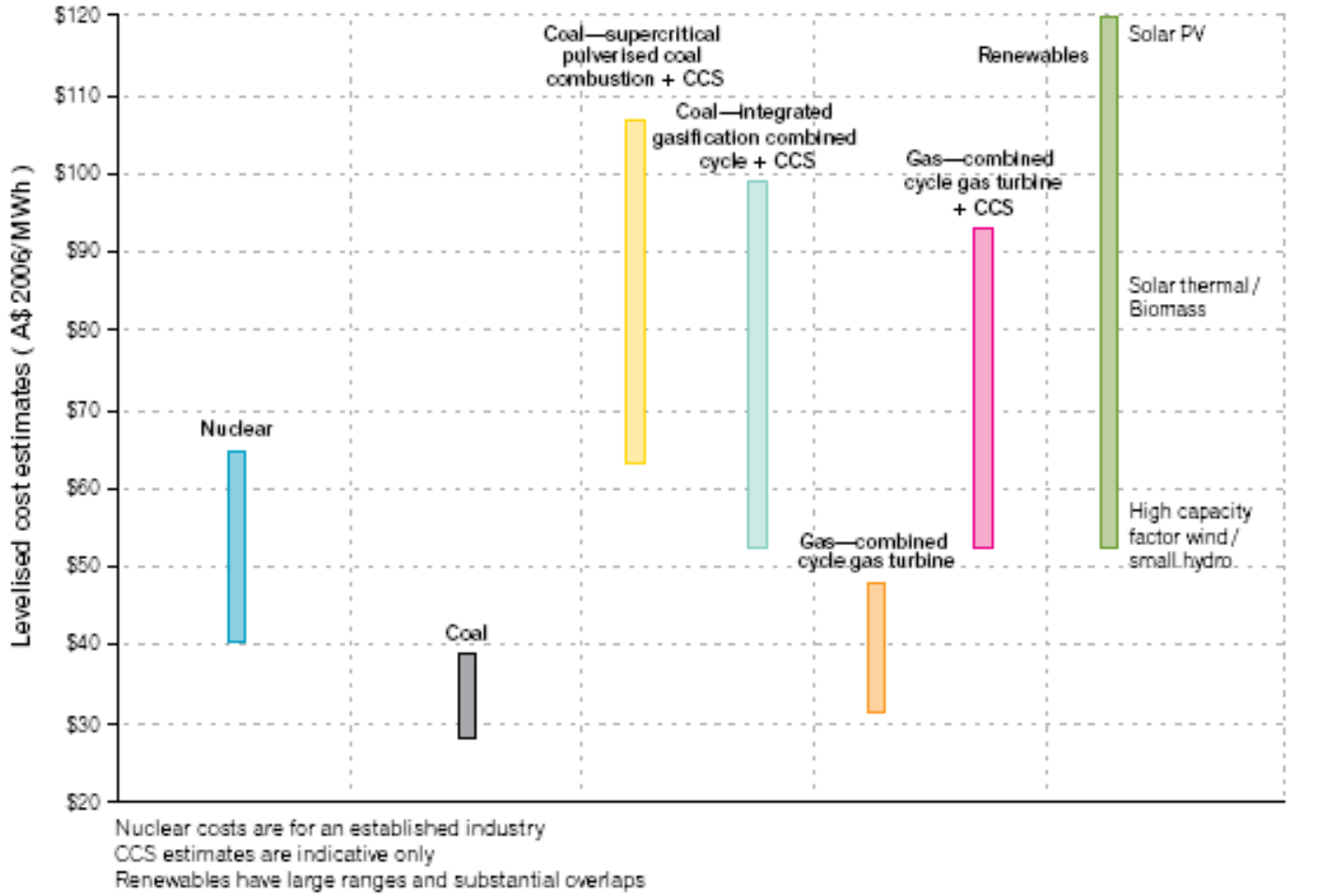
CROP	USED TO PRODUCE	GREENHOUSE GAS EMISSIONS* Kilograms of carbon dioxide created per mega joule of energy produced	USE OF RESOURCES DURING GROWING, HARVESTING AND REFINING OF FUEL				PERCENT OF EXISTING U.S. CROP LAND NEEDED TO PRODUCE ENOUGH FUEL TO MEET HALF OF U.S. DEMAND	PROS AND CONS
			WATER	FERTILIZER	PESTICIDE	ENERGY		
Corn	Ethanol	81-85	high	high	high	high	157%-262%	Technology ready and relatively cheap, reduces food supply
Sugar cane	Ethanol	4-12	high	high	med	med	46-57	Technology ready, limited as to where will grow
Switch grass	Ethanol	-24	med-low	low	low	low	60-108	Won't compete with food crops, technology not ready
Wood residue	Ethanol, biodiesel	N/A	med	low	low	low	150-250	Uses timber waste and other debris, technology not fully ready
Soybeans	Biodiesel	49	high	low-med	med	med-low	180-240	Technology ready, reduces food supply
Rapeseed, canola	Biodiesel	37	high	med	med	med-low	30	Technology ready, reduces food supply
Algae	Biodiesel	-183	med	low	low	high	1-2	Potential for huge production levels, technology not ready

* Emissions produced during the growing, harvesting, refining and burning of fuel. Gasoline is 94, diesel is 83.

Source: Martha Groom, University of Washington; Elizabeth Gray, The Nature Conservancy; Patricia Townsend, University of Washington; as published in Conservation Biology

SEATTLE P-I

Figure 4.7 Levelised cost ranges for various technologies



Nuclear costs are for an established industry
CCS estimates are indicative only
Renewables have large ranges and substantial overlaps

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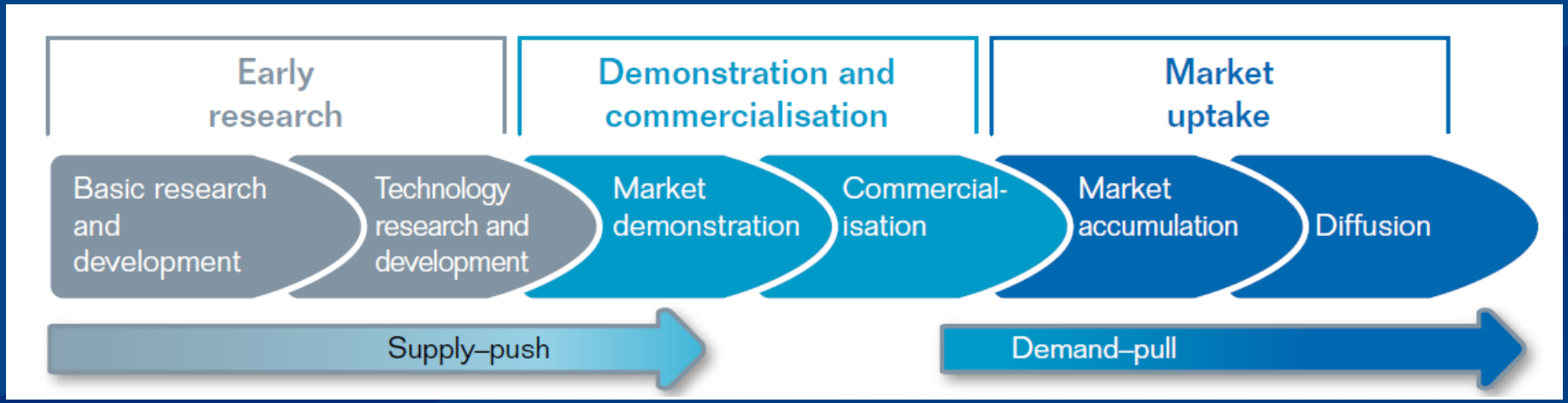
Biodiesel Wave Wind

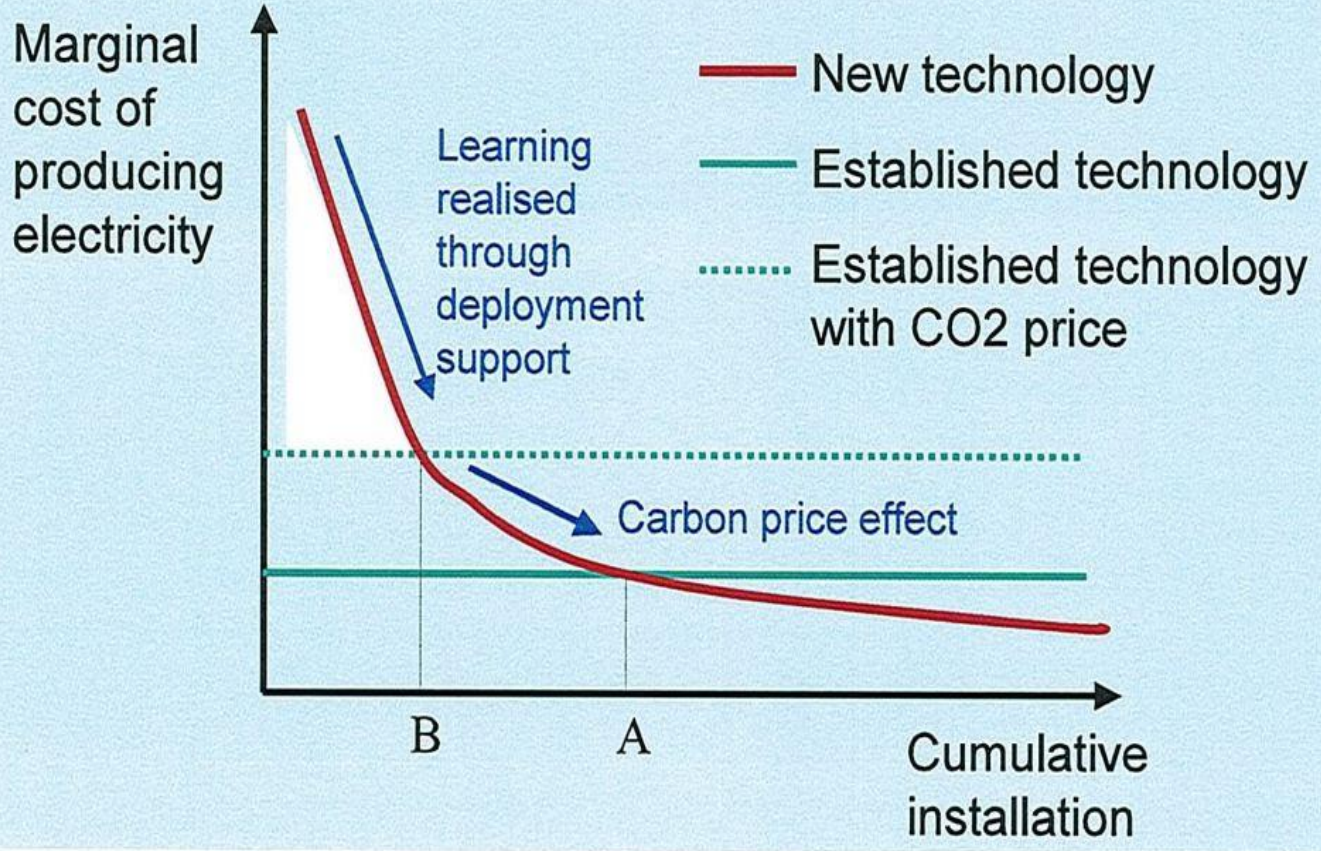


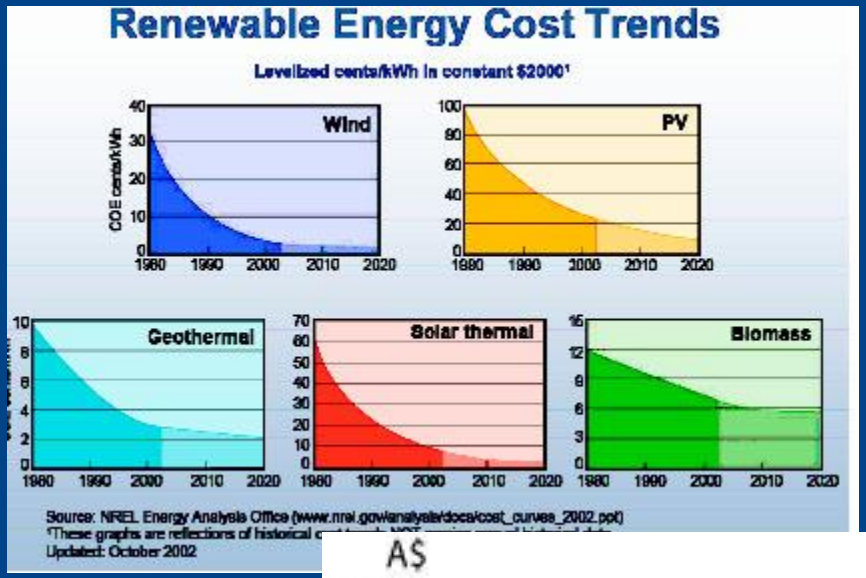
Coal CCS Solar CP

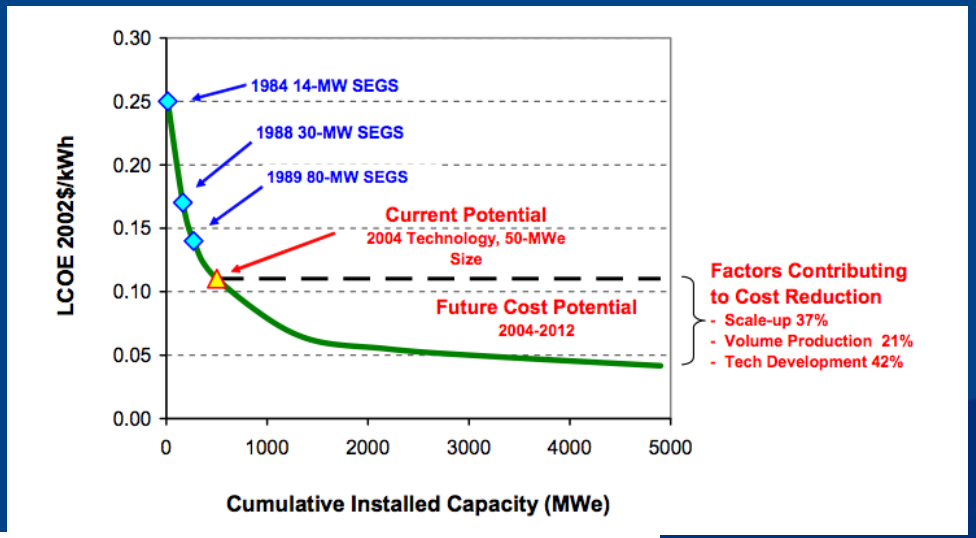
Geothermal

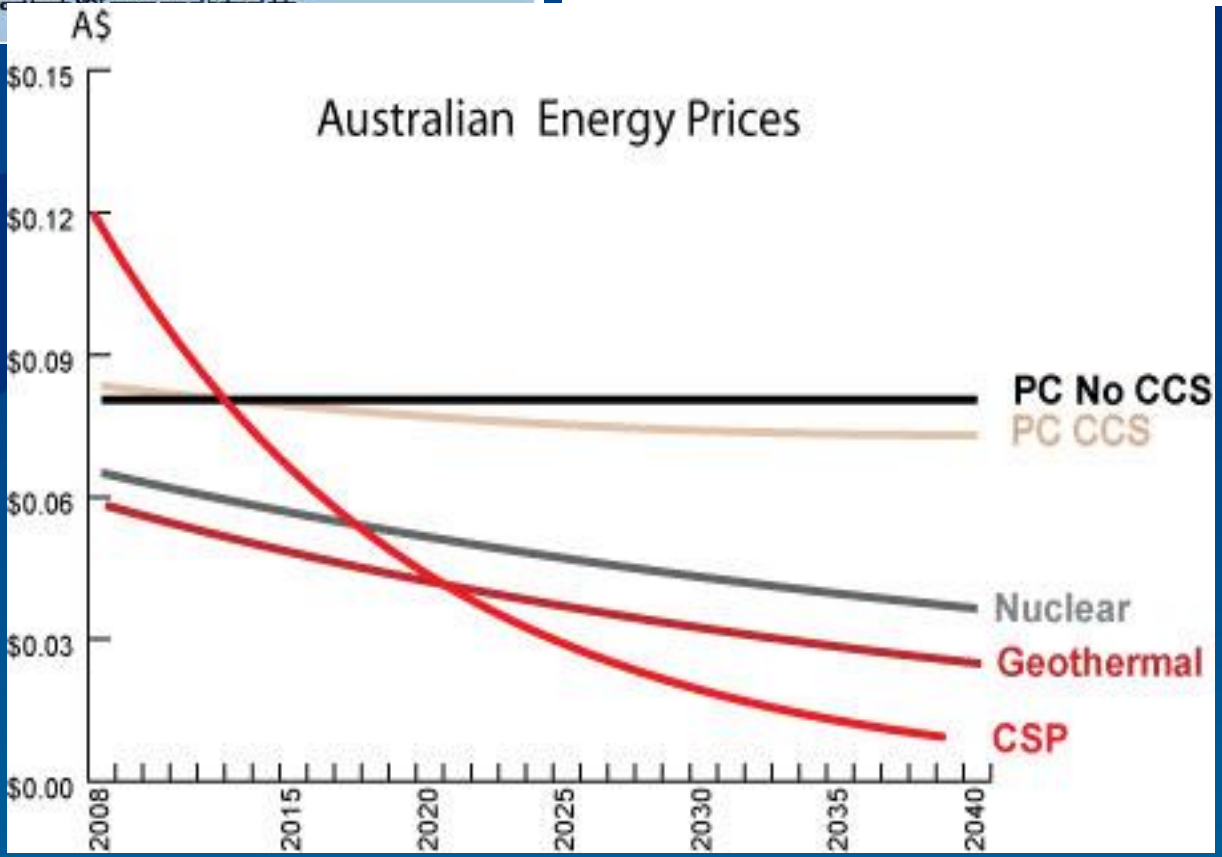
Garnaut: $3B to R&D and demonstration

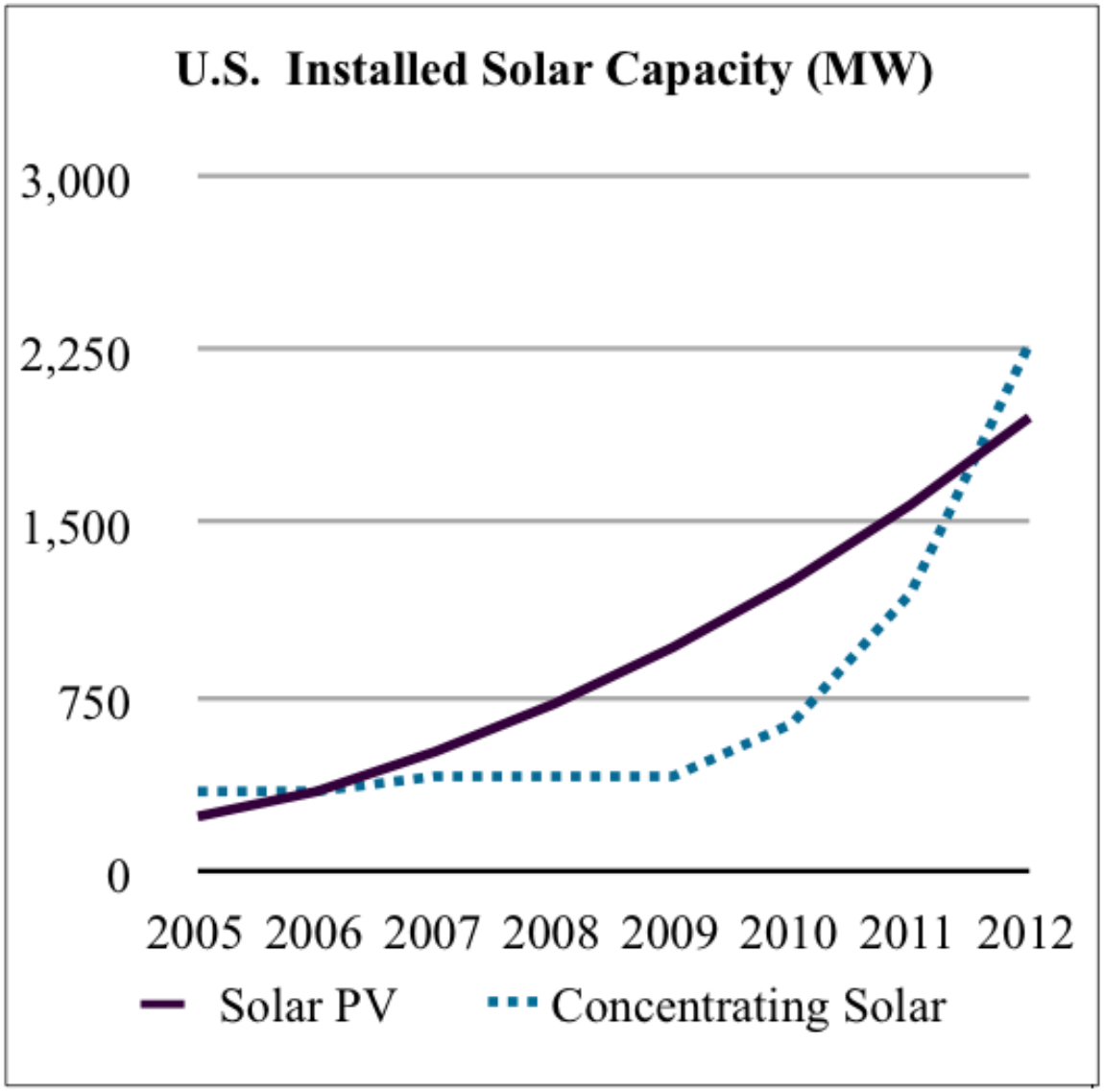
Figure 16.6 Interaction between carbon pricing and deployment support[32]




Renewable Energy Cost Trends
Levelized cents/kWh in constant $2000¹
Wind
PV
Geothermal
Solar thermal
Biomass
COE cents/kWh
1980 1990 2000 2010 2020
Source: NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_2002.ppt)
¹These graphs are reflections of historical
Updated: October 2002


LCOE 2002$/kWh
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1984 14-MW SEGS
1988 30-MW SEGS
1989 80-MW SEGS
Current Potential
2004 Technology, 50-MWe Size
Future Cost Potential
2004-2012
Factors Contributing to Cost Reduction
- Scale-up 37%
- Volume Production 21%
- Tech Development 42%
0 1000 2000 3000 4000 5000
Cumulative Installed Capacity (MWe)


A$
Australian Energy Prices
$0.15
$0.12
$0.09
$0.06
$0.03
$0.00
PC No CCS
PC CCS
Nuclear
Geothermal
CSP
2008
2015
2020
2025
2030
2035
2040


U.S. Installed Solar Capacity (MW)
3,000
2,250
1,500
750
0
2005 2006 2007 2008 2009 2010 2011 2012
Solar PV
Concentrating Solar

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Tech	Cost (MWh)	Lead time (yr)	Cost rdn (% pa)
Solar Thermal	80 - 100	2 - 5	5
Wave	80 - 100	3 - 10	4
Wind	55 - 70	Now	1
Geothermal	45 - 70	10 - 20	2
Biomass	40 - 130/b	3 - 5	2
Coal + CCS	55 - 110	10 - 20	?
Gas + CCS	50 - 95	10 - 20	?
Coal + $40/t cp	60 - 90	2	Rising

solar thermal, wind & wave are easily expandable

Geothermal

Solar

Wind

Wave

Biodiesel

Transect

Once the whirring wheels of innovation start spinning…

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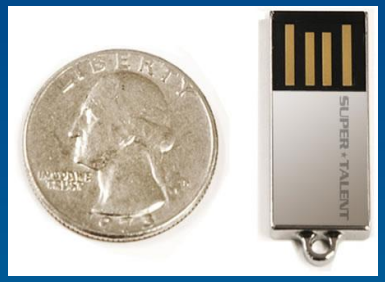
SUB CRUCE LUMEN

1950s

1980s

MARTIN COOPER
Conceived the first portable cellular phone and led the 10-year process of bringing it to market

Today



KICK THE HABIT!

WORLD ENVIRONMENT DAY

The Advertiser

HELPING TO SAVE PLANET EARTH - JUNE 5, 2008

10 STEPS TO HELP YOU KICK THE CO_2 HABIT

By University of Adelaide climate change Professor BARRY BROOK

SOLVING climate change is a huge international challenge. Only a concerted global effort, involving the governments of all nations, will be enough to avert dangerous consequences. But that said, the individual actions of everyday people are still crucial.

Large and complex issues, like climate change, are usually best tackled by breaking down the problem into manageable bits.

For carbon emissions, this means reducing the carbon dioxide (CO_2) contribution of each and every one of the 6.5 billion people on the planet.

But what can you, as an individual person or family, do that will most make a difference to the big picture?

Here are my top-10 action items, which are both simple to achieve and have a real effect. They are ranked by how much impact they make to "kicking the CO_2 habit".

1 MAKE CLIMATE-CONSCIOUS POLITICAL DECISIONS

Some commentators said the 2007 federal election was the first to be influenced by the stance taken by competing political parties on the issue of climate change.

Regardless of how true this may be, it is obvious the action needed to combat climate change would require a healthy dose of political will and courage.

This willpower comes from voters, who consistently demand real action and can see through "greenwashing" (pretend solutions and half measures).

Climate change should be a totally non-partisan issue since it affects all people and all countries. If climate change is not perceived by both sides of politics as a "core issue", it will inevitably be marginalised by ostensibly more pressing concerns.

So assess policies clearly, and make your vote count towards real climate solutions - each and every election.

2 EAT LESS RED MEAT

Traditional red meat comes from ruminant livestock such as cattle and sheep. These animals produce large amounts of methane, which is a greenhouse gas that packs 72 times the punch of CO_2 over a 20-year period.

Other types of meat, such as chicken, pork or kangaroo, produce far less emissions.

At average levels of a family's consumption, emissions from beef would easily outweigh the construction and running costs of a large 4WD vehicle, in less than five years. There is no need to cut out red meat entirely, but fewer steaks and snags mean far less CO_2.

3 PURCHASE "GREEN ELECTRICITY"

The future of energy is clearly in the form of renewable sources such as solar, wind, wave power and hot rocks. Even without climate change, there are limits to available oil, natural gas and coal.

"Green power" is electricity that comes from renewable technologies, but is delivered to you in the same way as dirty power from fossil-fuel burning; that is, down your power lines.

You can buy enough to replace your entire energy usage, or some fraction (I recommend going for 100 per cent; the cost is a few more cents per kilowatt hour of electricity).

Most energy suppliers now offer this service. As more people take up this scheme, it will drive investment and reduce the cost of development.

4 MAKE YOUR HOME ENERGY EFFICIENT

We all unthinkingly leave lights on when we are not in a room, switch off the TV by the remote control instead of at the wall, fire up the heater when we could put on an extra layer of clothing, or turn on the air conditioner when we only need to open a window and turn on a fan.

It's force of habit – a bad habit we can break, with just a little thought.

Behaviour change lies at the heart of most individual actions on reducing our individual carbon footprint.

By being sensible about your household energy use, and making sure your house is well insulated, you can make a huge dent in your CO_2 emissions.

Oh, and it will save you plenty of money that you no longer spend on wasted energy.

5 BUY ENERGY AND WATER-EFFICIENT APPLIANCES

Aside from behavioural change, we can invest in more sensible technologies that help us in our day-to-day lives.

When buying new electronic appliances, air conditioners or washing machines, look at their energy and water usage.

The more energy efficient they are, the more they'll save you in the long run, and the lower their CO_2 impact will be.

In most cases the "payback period" – the difference between the initial cost of a high- versus low-efficiency appliance and the long-term savings in electricity and water bills – is only a matter of a few months to a few years.

After that, you are laughing all the way to the bank.

6 WALK, CYCLE OR TAKE PUBLIC TRANSPORT.

Cars are not only a slow way to get to work when you're faced with a city gridlock, they are also a huge user of oil (which is running out globally) and cost the taxpayer hefty amounts in road building and maintenance.

Getting people from A to B using trains, buses, bikes and on foot is much more greenhouse friendly and often cheaper.

The main problem right now with public transport is that not enough people use it.

There is not enough investment by government to improve the quality of service and capacity to support large volumes of commuters.

It might seem like a Catch-22, but some cities have solved the dilemma and now move most of their people about on public transport. So, start patronising your public transport network and push governments at all levels for some decent bicycle and walking trails instead of building more roads and worrying about fuel costs.

The transition to a new transport system has to start with each and every one of us.

7 RECYCLE, RE-USE AND AVOID USELESS PURCHASES.

We throw too much away and still recycle too little of what we must discard.

Large amounts of energy and water go into producing endless amounts of "stuff", much of which we don't really need or use. So be sure to use your local recycling service for plastics, metals and paper.

Try to get appliances and tools fixed rather than replaced - the carbon footprint of fixing things is far lower than making them from scratch. Avoid the temptation to buy useless trinkets, just because it feels good to accumulate things.

There are limits to everything including, most importantly, the ability of the planet to supply people with raw materials. Think sustainability.

8 TELECOMMUTE AND TELECONFERENCE

Do you really need to fight your way through traffic each day, just to sit at your office desk and work on your computer?

Do you need to fly to a business meeting in another capital city in order to talk to your colleagues?

Or can you think inventively and make best use of the benefits of the Internet to do some of this remotely?

Telecommuting can be an effective way of doing paperwork in your home office, and more and more employers are seeing the benefits of this and embracing the concept.

Teleconferences mean fewer wasted aeroplane trips which create a huge CO_2 burden. It can't always be done, but even fewer trips, here and there, make a big difference. As with the other 10 points, it is about making smart and informed choices.

9 BUY LOCAL PRODUCE

Food miles are now firmly part of the new carbon lingo.

This is a way of expressing how far an item of food has travelled before it reaches your dinner table, and therefore how much CO_2 has been emitted during freighting.

A better concept is probably "embodied energy", which takes account of all the carbon, water and energy that goes into producing any food or manufactured item.

Either way, a good rule of thumb is that if you buy something that has been produced locally, it will usually have a lower CO_2 tag attached to it and help the economy.

Your local fresh food market is a good place to start for your food shopping.

Buying Australian-manufactured and grown products is another carbon-friendly option.

10 OFFSET WHAT YOU CAN'T SAVE

Avoiding the release of CO_2 and other greenhouse gases, in the ways described above, is by far the best and most direct way of reducing our climate change impact.

Yet some emissions are unavoidable. For those, offsetting is a worthwhile option.

This is done by purchasing "carbon credits" from accredited companies, which will then invest those dollars in renewable energy projects or planting trees.

Carbon offsets should definitely not be seen as the solution, or as a relatively pain-free way to expel your carbon guilt.

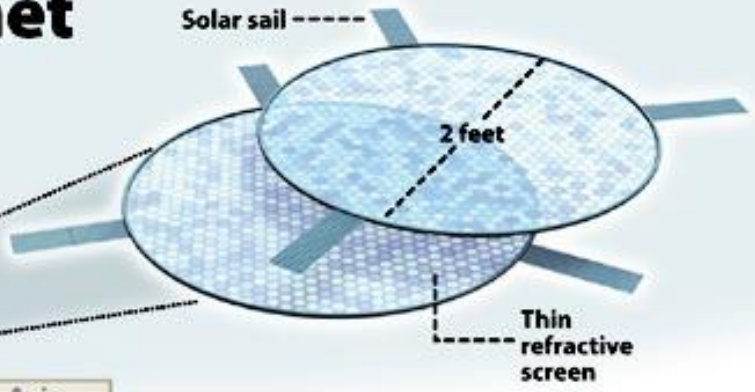
There is nowhere near enough offsetting potential in the world for this to be an option for most of the world's population.

But in conjunction with other methods of kicking the CO_2 habit, offsets can help make a difference and allow you to pay a small penance.

Ways to engineer a cooler planet

Scientists are publicly contemplating last-ditch efforts to slow climate change, ranging from forests of artificial trees that would reduce carbon dioxide in the atmosphere to trillions of small disks in space that would act as an umbrella to block the sun's heat.

One-ton payload of 800,000 fliers deployed over one year.



SOLAR UMBRELLA

Proposal: In 20 million launches, deploy 16 trillion refracting disks in orbit between Earth and the sun.

Problems: Cost could be $4 trillion; no effect on carbon dioxide.

The disks would block 1.8 percent of solar flux.

Submicrometer sulfate particles would last up to two years in the stratosphere.

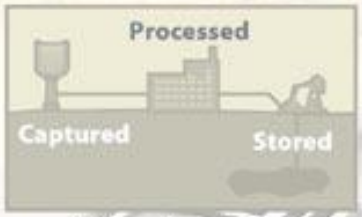
VOLCANO EFFECT

Proposal: Use balloons, jet engines, and artillery to put millions of tons of sulfates into the stratosphere to mimic the cooling effects of a volcanic eruption.

Problems: Expensive; tens of thousands of pounds needed per month to produce enough cooling; no effect on carbon dioxide; could cause drying of the Mediterranean and the Middle East.

Sulfur dioxide and ash from volcanoes reduce solar radiation and cool the troposphere.

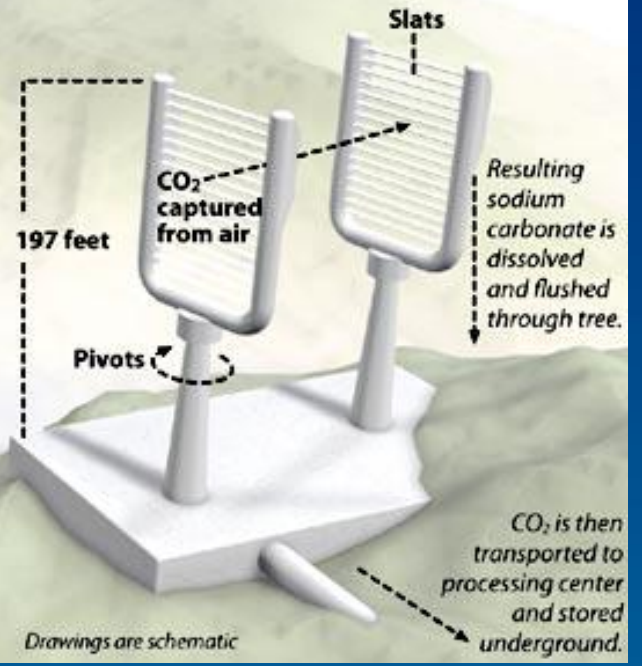
ARTIFICIAL TREE

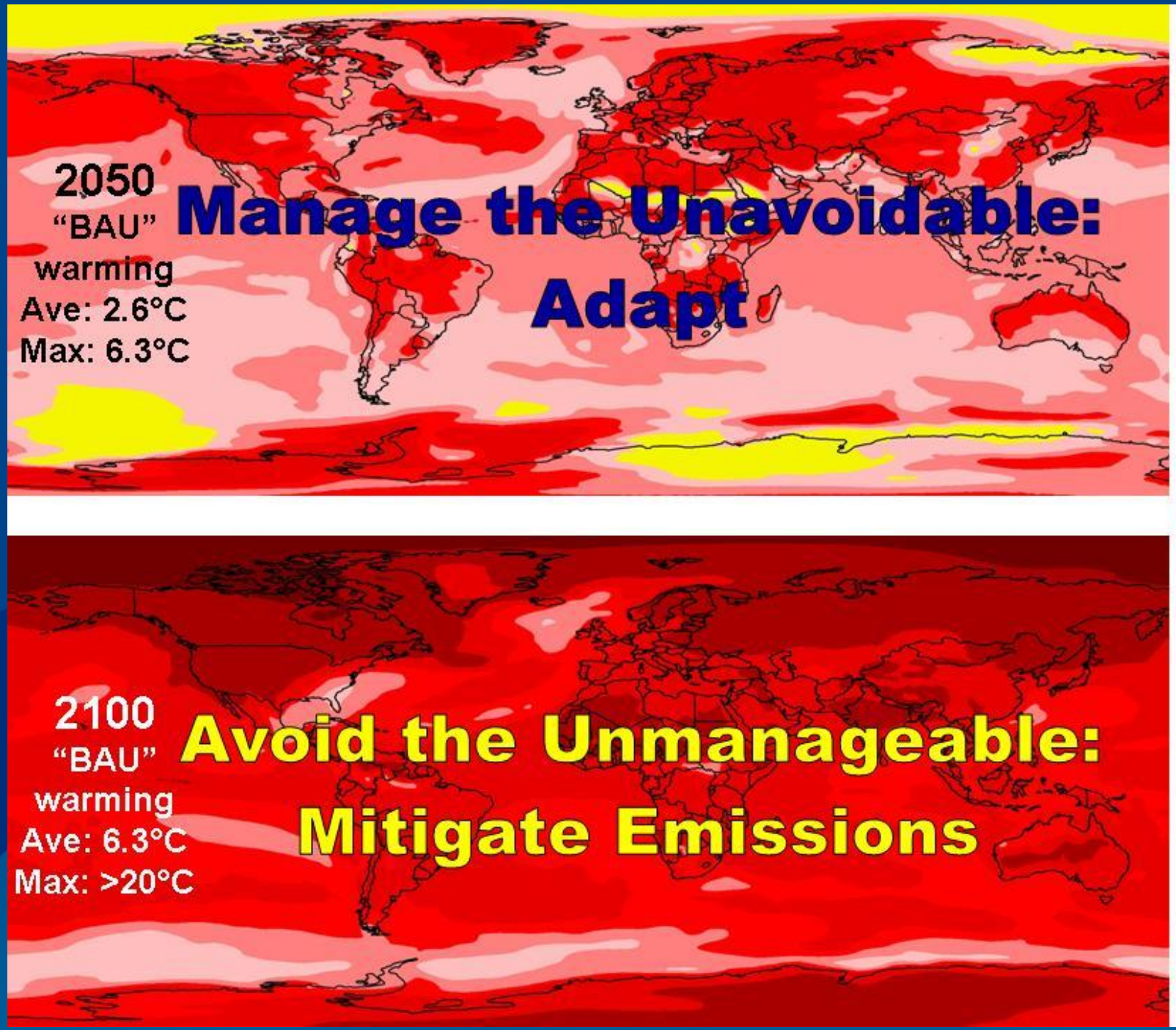


CO_2 is captured in the slats of the artificial tree with a sodium hydroxide liquid and sent to a processing facility to be converted into a gaseous form before it is stored.

Proposal: Use industrial-size artificial trees to filter 90,000 tons of carbon dioxide from the air each year. Each tree could filter 6.6 pounds of CO_2 per second.

Problems: Separation, transportation, and disposal costs are high; leakage a risk to humans, ecosystems.





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More information and discussion:

www.bravenewclimate.com

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Climate Q&A slide sources include:

http://www.grist.org/news
http://n3xus6.blogspot.com
http://tamino.wordpress.com
http://www.realclimate.org
http://www.skepticalscience.com
http://www.aussmc.org
http://www.bom.gov.au/climate
http://arctic.atmos.uiuc.edu/cryosphere
http://sealevel.colorado.edu
http://cce.890m.com
http://www.ipcc.ch
http://data.giss.nasa.gov/gistemp
http://nsidc.org/arcticseaicenews
http://environment.newscientist.com/channel/earth/dn11462
http://www.woodfortrees.org
http://blogs.news.com.au/heraldsun/andrewbolt
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http://sciencemag.com
http://pnas.org
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http://www.global-greenhouse-warming.com
http://www.remss.com/msu
http://climate.uah.edu
http://atmoz.org/blog
http://climateprogress.org
http://forecast.uchicago.edu
http://geosci.uchicago.edu/~rtp1/ClimateBook
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http://www.eoearth.org
http://www.cpc.noaa.gov
http://earthobservatory.nasa.gov
http://www.climateprediction.net
http://scitizen.com
http://www.desmogblog.com
http://www.climatedenial.org
http://www.psie.psu.edu
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http://www.abc.net.au/news/tag/climate-change
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http://wattsupwiththat.wordpress.com
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http://www.ukcip.org.uk
http://climatesci.org
http://blogs.nature.com/climatefeedback
http://stephenschneider.stanford.edu
http://scienceblogs.com
http://www.wmo.int
http://chriscolose.wordpress.com
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http://www.theoildrum.com
http://dotearth.blogs.nytimes.com
http://frankbi.wordpress.com
http://www.layscience.net
http://www.energybulletin.net
http://www.daf.gov.au
http://www.climatechange.gov.au
http://csiro.au
http://www.worldviewofglobalwarming.org
http:/www.ncdc.noaa.gov/oa/climate