## Climate change: A matter of sustainability

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Climate science
Societal issues
Planetary boundaries
Emission abatement policies

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On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction by John Tyndall: Philosophical Transactions of the Royal Society of London, Volume 151, (1861), pp. 1-36



# Greenhouse effect on planetary temperatures

	Surface pressure (relative to Earth	Main greenhouse gases	Surface temperature in absence of greenhouse effect (°C)	Observed surface temperature (°C)	Warming due to greenhouse effect (°C)
Venus	90	>90%CO <sub>2</sub>	-46	477	523
Earth	1	~0.04% CO <sub>2</sub> ~1% H <sub>2</sub> O	-18	15	33
Mars	0.007	>80% CO <sub>2</sub>	-57	-47	10

Based on IPCC 1990. Working Group 1

## Carbon dioxide concentration at Cape Grim, Tasmania



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## Climate Change 2013: The Physical Science Basis

## **Summary for Policymakers**

- The work of 209 Lead Authors over the past 6 years
- 50 Review Editors from 39 countries
- More than 600 Contributing Authors from 32 countries

IPCC WGI Fifth Assessment Report September 27, 2013 http://www.ipcc.ch/index.htm#.Um8cHD-4aP8

### **Perturbation of the Global Carbon Cycle**



By anthropogenic activities, averaged globally for the decade 2002–2011 (PgC/yr)

urce: <u>Le Quéré et al.</u> 012; <u>Global Carbon</u> <u>Project 2012</u>

# **Key findings**

- CO<sub>2</sub> is the strongest factor in climate change compared with other factors
  - Its relative contribution has further increased since the 1980s & by far outweighs the contributions from natural factors



From IPCC Fifth Assessment Report- Summary for Policy Makers, Figure SPM 4

# **Key findings**

- New information supports earlier conclusions:
  - Strong confidence many observed climate changes are unusual or unprecedented on time scales of decades to many hundreds of thousands of years
- Widespread warming is observed from the surface of the Earth throughout the troposphere; the stratosphere is cooling
  - Warming has been particularly marked since the 1970s.
     Each of the last three decades significantly warmer than all preceding decades since 1850
- Changes in many extreme weather & climate events observed
  - Level of confidence in these changes varies widely depending on type of extreme & regions considered. Overall the most robust global changes are seen in measures of temperature

# Observed global mean land + ocean surface temperature anomalies, from three data sets



Anomalies are relative to the mean of 1961–1990

From IPCC Fifth Assessment Report- Summary for Policy Makers, Figure SPM 1

# **Key findings**

- Paleoclimatic data provide a multi-century perspective of temperature
  - Indicates that 1981–2010 was very likely the warmest 30year period of the last 800 years

## • Stronger evidence that:

- Ice sheets/glaciers are losing mass globally
- Arctic sea-ice cover is reducing, snow cover is decreasing & Northern Hemisphere permafrost is thawing
- Unequivocal that global mean sea-level is rising
  - Evident from tide gauge records & satellite data



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# **Key findings**

- Model projections of many quantities providing an indication of changes later in the 21<sup>st</sup> century
  - The confidence in these projections is often assessed to be lower for the near-term than for later in the 21st century
- Projections that by mid-21<sup>st</sup> century the rate of global warming begins to be more strongly dependent on the emissions scenario
  - For RCP4.5, 6.0 and 8.5, warming is projected to at least *likely* exceed 2°C with respect to pre-industrial by 2100, and about as *likely as not* to be above 2°C warming for RCP2.6

# Global average surface temperature projections relative to 1986–2005



Four Representative concentration pathways (RCPs)

RPC8.5 forcing >8.5 W/m<sup>2</sup> by 2100,rising after RPC6.0 forcing stabilized at ~6 W/m<sup>2</sup> after 2100 RPC4.5 forcing stabilized at ~4.5 W/m<sup>2</sup> after 2100 RPC2.6 Forcing peaks at ~3 W/m<sup>2</sup> before 2100 then declines November 13, 2013

From IPCC Fifth Assessment Report- Summary for Policy Makers, Figure SPM 7



#### From IPCC Fifth Assessment Report- Summary for Policy Makers, Figure SPM 7

## **Global mean sea-level rise**



## Key south east Australian findings

- Multiple lines of evidence indicate that tropical weather systems are expanding southward, considerably influencing SE Australia climate
- There is evidence that the southern storm tracks that historically brought reliable cool season rainfall to southern Australia have shifted southward

Results of the SEA Climate Initiative: http:// www.seaci.org/

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## The climate change issue



## **Climate change is about us**

- There remains a reluctance to respond to this evidence reflecting the way we individually:
  - Assess risk
  - View what constitutes a rational argument
  - Construct views of the way the physical world is
  - Rationalise in the face of conflict with our constructed views
  - Are impacted by vested interests

We use coping mechanisms to avert unwanted emotions instigated by the climate-change storyline & struggle under the weight of conservative societal structures

Not surprising therefore the formulation of a nationally shared/strategic view of what we need to do in terms of emissions abatement seems to be insurmountable

This is a human behavioural issue as much as a physical science & engineering one



"The great enemy of the truth is very often not the lie -- deliberate, contrived and dishonest, but the myth, persistent, persuasive, and unrealistic. Belief in myths allows the comfort of opinion without the discomfort of thought"

## John F. Kennedy (1917 - 1963)

"No matter what they tell us No matter what they do No matter what they teach us What I believe is true"

Words of Jim Steinman in the popular Boy Zone love song, No Matter What

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## The real world

Log<sub>10</sub>(Energy consumption x 100/Net primary production)



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Pearman (2013). *Energy Policy*, 59C, 523-535 with Indian calculations added

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## **Planetary boundaries**

- The result, from a physical science perspective is that there are planetary boundaries to what we are doing or can do in a sustainable way
- Climate change is but one illustration of how we are approaching or have exceeded those boundaries

### Beyond growth: Why our economy is killing the planet New Scientist Oct 18, 2008

#### **Drivers**

- Population
- GDP
- Foreign investment

#### Demand

- Motor vehicles
- Paper consumption
- Fisheries exploitation

1900

- Water use

1850

#### Impacts

1750

- $-CO_2$  concentration
- Northern hemisphere temperature

1800

- Ozone depletion
- Species extinction
- Loss of tropical rainforest and woodland

2000

1950

## A safe operating space for humanity



Rockström et al. (2009) Nature 461, Sept.

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## **Probability of exceeding 2°C**

 Allowing for climate sensitivity & global cumulative greenhouse-gas emissions, 2000–2049

CO <sub>2</sub> equivalent (Gt)	Probability of exceeding 2°C (%)	
1,356	8–37	
1,500	10–43	
1,678	15–51	
2,000	29–70	

Meinshausen et al. 2009, 458 1158-1163. doi:10.1038/nature08017

## Australia's equitable share

### **Questions:**

- What carbon budget does Australia have available for the period 1990-2100 with different effort sharing approaches?
- What effect does the reduction starting year have on possible future emissions trajectories?
- How does the emissions target pathway provided by global effort sharing approaches relate to realistic future emissions development in Australia?

## Australia's equitable share

- Australia:
  - Has already spent substantial share of its "fair" carbon budget
  - Needs to reduce emissions rapidly & drastically
- The "fair share" emission target levels in 2020 vary between 41% and 27% below the level in the year 2000
- All scenarios show that Australia needs to reach near carbon neutrality in the long term, in order to remain within the allocated emissions budgets

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# Overall objective to get from where we are to where we need to be:

- Without major economic or social dislocations
- Capturing opportunities to build a new economy & related social structures
- Achieving win-win outcomes in an holistic strategy for the future

# Cost of transforming the energy sector is relatively small, see e.g.

- The Intergovernmental Panel on Climate Change: http://www.ipcc.ch/ipccreports/ar4-wg3.htm
- Nicholas Stern Report to UK Government: www.hmtreasury.gov.uk/independent\_reviews/ stern\_review\_economics\_climate\_change/stern\_review\_report.cfm
- Australian Business Roundtable on Climate Change: http://www.businessroundtable.com.au/pdf/F078-RT-WS.pdf
- The McKinsey Company Report: www.mckinsey.com/ clientservice/ccsi/pdf/ Australian\_Cost\_Curve\_for\_GHG\_Reduction.pdf

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# Securing a clean energy future, 2011

Securing a clean future

http://www.cleanenergyfuture.gov.au/wp-content/uploads/2011/07/securing-a-clean-energy-future-summary.pdf

# Securing a clean energy future



### A carbon price alone is not enough!

## This is more about a future energy strategy

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# **Emissions trading**

- A market-based approach to control pollution Also known as cap and trade
- Provides economic incentives for achieving reductions in the emissions
  - Used for minimising emissions of sulphur
- Carbon Pollution Trading Scheme, CPRS
  - Introduced by the Labor Government and nearly with bipartisan support in 2010
    - Brought down Malcolm Turnbull
- The European Union Emissions Trading Scheme in place since January 2005; currently at less than \$20 per t CO<sub>2e</sub>

# Recent changes in electricity generation and emissions



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## Contributing factors —

Intervention Home insulation Efficient light bulbs Solar feedback tariffs/panels Public awareness???

Market

Price hikes (market at work) Carbon price scare campaign Commercial advertising???



## What we need to do

- Adaptation is necessary
  - We cannot avoid some substantial change- too much time has already been lost
  - We need to build resilience in the face of change
- Mitigation is necessary
  - It is too dangerous to allow global warming of > 2°C
  - Australia should play its fair share in this task
- Understand why, thus far, our responses have been weak?

# Mitigating

- Energy efficiency- demand management
- Renewable & low carbon options
- Leaving fossil fuels in the ground
- Holistic examination of energy options
  - Technical potential
  - Economic costs
  - Environmental and societal acceptability
  - Delivery on time of energy and emissions reduction
- A portfolio of options that manages remaining uncertainties

# Mitigating

- Market-based options driven market settings policy:
  - A price on carbon in a trading scheme with caps on total emissions
    - Leading to 20% reduction of emissions by 2020; >80% by 2050
- Renewable energy target
- Energy efficiency target – Transport fuel efficiency target
- Take example from the European Union, the United Kingdom, China, etc.

## **Green Growth and China**

- GDP-oriented criteria for evaluating economic performance could obstruct progress of the 5-year plan
  - Shift measure of economic success from GDP-focus to broader set of sustainability metrics
  - "Without radically changing the mindset .... of our officials, it would be difficult to achieve the goals set by the five-year plan"
- China will incorporate targets set out in the 5-year plan :
  - Increase non-fossil fuels to 11.4%; reduce energy consumption & CO<sub>2</sub> emissions per unit of GDP by 16% and 17% respectively by the end of 2015
  - Improve energy efficiency of coal-fired power plants; shift towards cleaner gas plants; increase investment in high-speed rail & alternative fuel vehicles

### Chinese Premier Wen Jiabao, March 14, 2011

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