IPS Workshop

26 February 2010

Climate Change:

How can Singapore Maintain a Balance between Economic Growth, Greenhouse Gas Emissions and a Habitable Environment?

NUS Lee Kuan Yew School of Public Policy IPS Institute of Policy Studies

CLIMATE CHANGE: SCIENCE, ECONOMICS, POLICY AND POLITICS

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Outline

- ***What is climate change (aka global warming)?***
- What is the evidence for climate change?
- Who/What is causing climate change?
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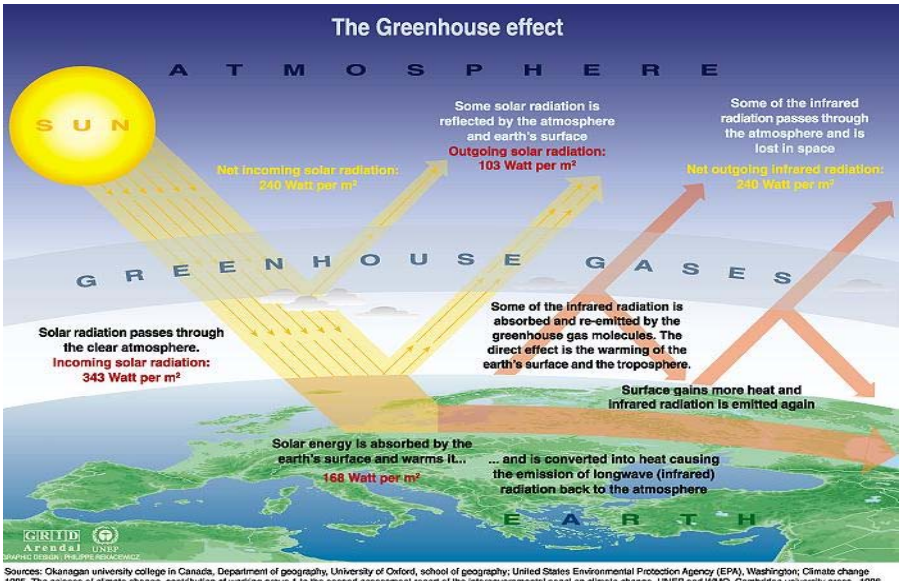
The Greenhouse Effect (1)

- The warming of the atmosphere by heat reflected from the earth is called the **greenhouse effect**.
- The greenhouse effect actually makes the earth habitable. Without the greenhouse effect, the earth would be much colder!
- Main greenhouse gases (GHGs) in the atmosphere include CO_2 , CH_4, N_2O, CFCs.
- Increased concentration of GHGs causes more heat to be retained in the atmosphere and more heat to be reflected back to the earth surface and this will lead to a rise in average global temperatures (global warming).

The Greenhouse Effect (2)

- Greenhouse effect is a natural geophysical process, it allows us to exist on earth.
- The gases known as greenhouse gases naturally found in the atmosphere are: water vapour, carbon dioxide, methane, nitrogen oxide, ozone, and chlorofluorocarbons (CFCs).
- These gases trap heat close to the earth's surface
- Without the greenhouse effect, the earth's surface temperature would be –180^{o}C!
- The natural greenhouse effect warms the temperature of the atmosphere to 15 ^{o}C at the Earth's surface.
- This natural warming allows water to exist on the Earth's surface, the basis of life support.

The Greenhouse Effect (3)



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

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"Warming of the climate system is unequivocal"

- R.K. Pachauri, Chairman, IPCC

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Climate Change?

- IPCC 4th Assessment (February 2007) states:

"Warming of the climate system is **unequivocal**, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"

Source: IPCC, *Climate Change 2007: The Physical Science Basis, Summary for Policymakers*, 5/2/2007

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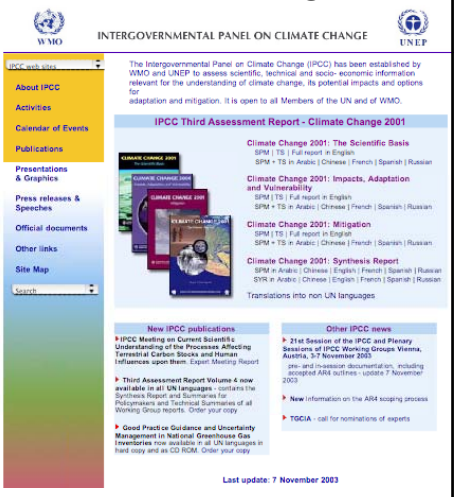
IPCC - scientific basis for climate change

Intergovernmental Panel on Climate Change (IPCC) established in 1988 by United Nations Environment Programme and World Meteorological Organization for assessing **"scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change."**

Though IPCC organized within political institutional framework, basically a **scientific body**—made up of leading scientists from around the world. In order to keep to its scientific mandate and maintain scientific objectivity, IPCC avoids making policy recommendations or shaping research programs.

However, since assessments of IPCC are the most comprehensive and balanced evaluations of climate change, its work is single most important foundation on which climate policy is built



www.ipcc.ch

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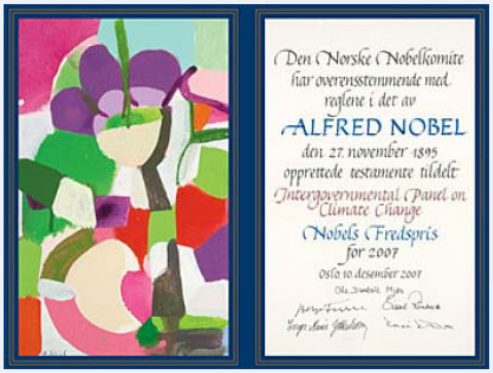
The IPCC is honored with the Nobel Peace Prize



Oslo, 10 December 07
The Intergovernmental Panel on Climate Change and Albert Arnold (Al) Gore Jr. were awarded of **the Nobel Peace Prize** "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

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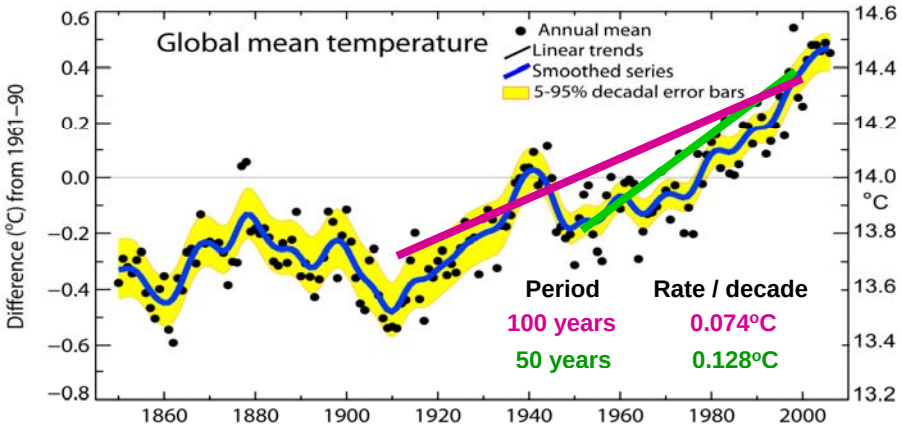
Changes in global average surface temperature



Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

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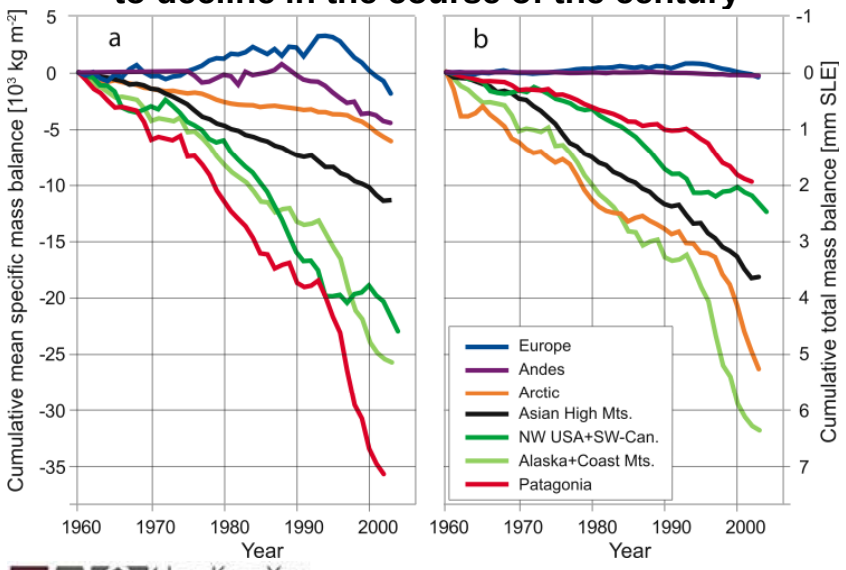
Source: IPCC 12

Water supplies stored in glaciers are projected to decline in the course of the century



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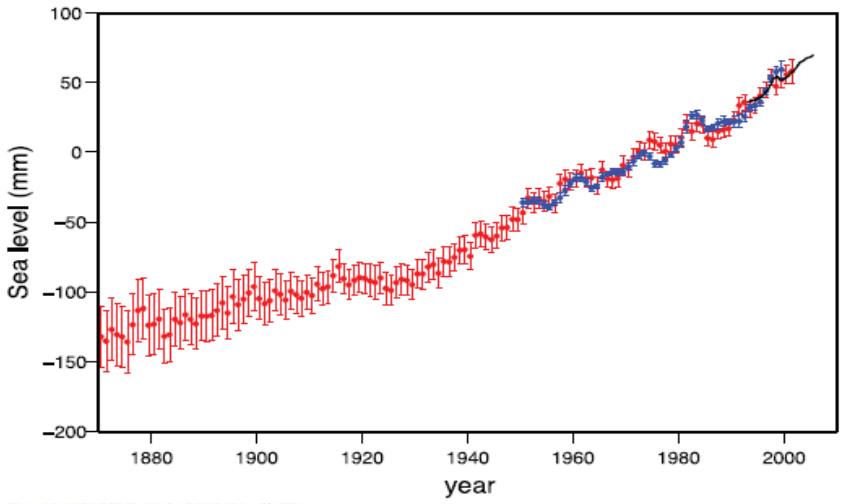
Source: IPCC 13

Global average sea level has risen since 1961 at a rate of 1.8mm/yr and since 1993 at 3.1mm/yr



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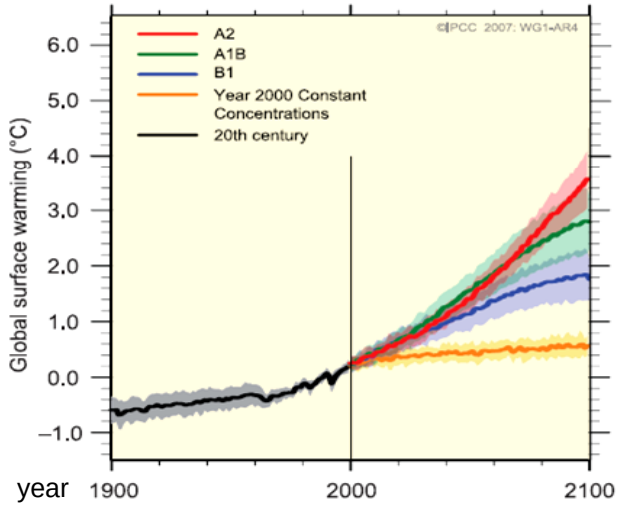
Source: IPCC 14

Ranges for predicted surface warming



Continued emissions will lead to further warming of 1.8ºC to 4ºC over the 21st century

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Source: IPCC 15

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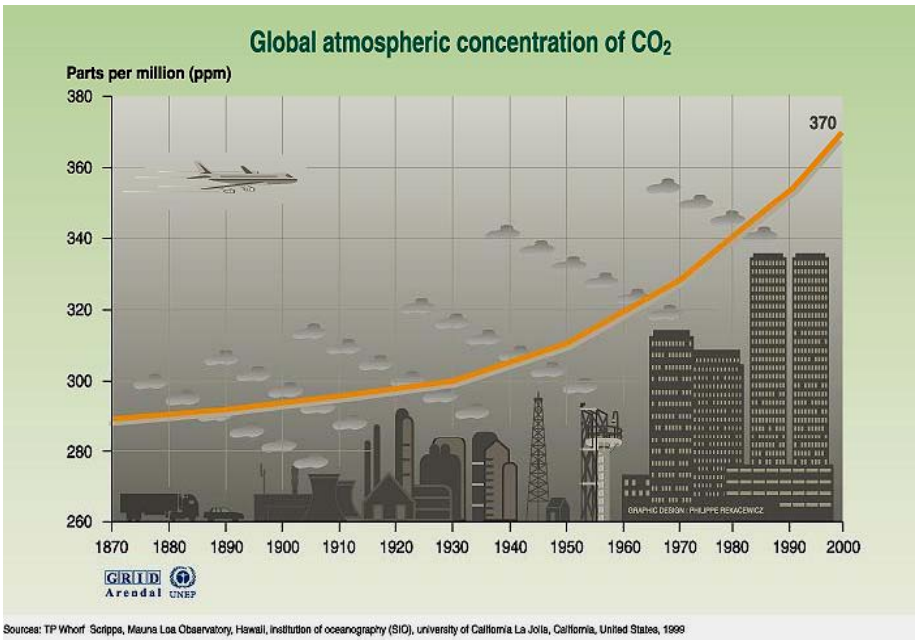
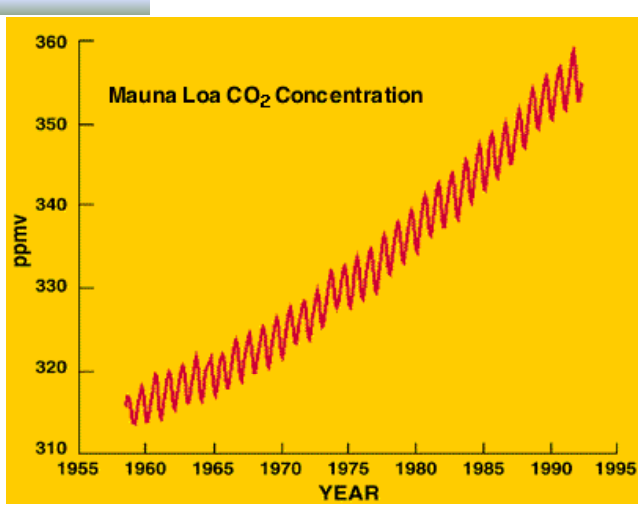
- ✓ Emissions from human activities are increasing the concentration of atmospheric GHGs
- ✓ Enhanced greenhouse effect occurs due to atmospheric buildup of GHGs that are released by human activities
- ✓ The main sources of GHG emissions are:
  - ❖Burning of fossil fuels (coal, oil, natural gas)
  - ❖Industrial activities
  - ❖Food production activities
  - ❖Burning and exploiting forests
  - ❖Waste landfills

The concentration of CO_2 in the atmosphere has increased from 295 parts per million (ppm) in 1870 to 370 ppm in 2000 (next slide..)



Why is CO2 rising?



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IPPC's review of latest scientific research concludes "The balance of evidence suggests a discernible human influence on global climate".

- An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.
- Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.
- Confidence in the ability of models to project future climate has increased.
- There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

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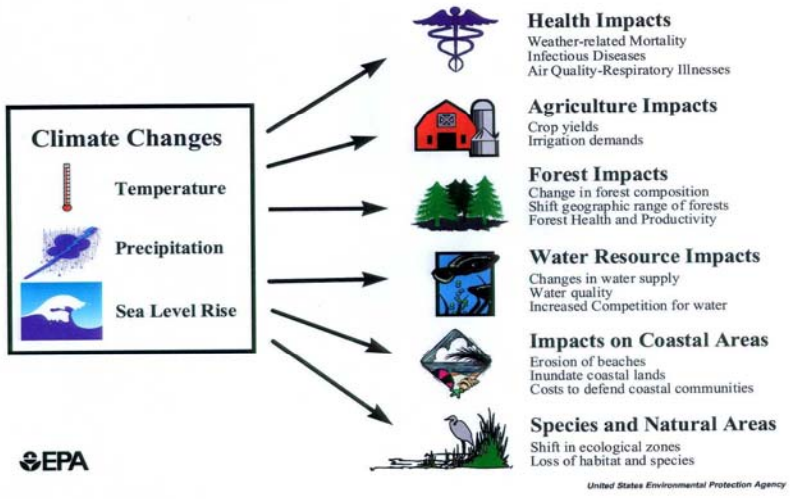
Potential Climate Change Impacts



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Observed impacts in South Asia

Intense Rains and Floods

- Serious and recurrent floods in Bangladesh, Nepal and N-E India in 2002, 2003 and 2004
- Rainfall in Mumbai (India), 2005: 1 million people lost their homes

Droughts

- 50% of droughts associated with El Niño
- Droughts in Orissa (India) in 2000-2002: crop failures, mass starvation affecting 11 million people

Cyclones / Typhoons

- Increasing intensity of cyclones formation in Bay of Bengal and Arabian Sea since 1970
- Cyclone Nargis in Myanmar, 2008: 100 000 deaths

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Impacts on human health

- Endemic morbidity and mortality due to **diarrhoeal disease** primarily associated with floods and droughts.
- Greater spread and toxicity of **cholera** due to increase in temperature of coastal water.
- Increased **deaths, disease and injury** due to heat waves, floods, storms, fires and droughts.

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Impacts on food production

Crop yields could increase up to 20% in East and Southeast Asia while they could decrease up to 30% in Central and South Asia by 2050.

In India, wheat yields could decrease by **5-10%** per one-degree rise in temperature.

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Impacts on water resources

Glacier melt projected to increase flooding, rock avalanches and to affect water resources within the next two to three decades

Salinity of groundwater especially along the coast, due to increases in sea level and over-exploitation

In India, gross per capita water availability will decline from 1820 m^3/yr in 2001 to **1140 m^3/yr** in 2050

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Impacts on coastal areas

Coastal erosion and inundation of coastal lowland as sea level continues to rise, flooding the homes of millions of people living in low lying areas.

In India, potential impacts of 1 m sea-level rise include inundation of 5,763 km^2.

Significant losses of coastal ecosystems, affecting the aquaculture industry, particularly in heavily-populated mega-deltas.

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"the greatest market failure the world has seen"

An unusual externality:

- Effects are global
- Effects persist decades and centuries into the future
- Potentially very large risks (damages)
- High degree of uncertainty regarding both science and economics of climate change
- Irreversible damages and costs of mitigation

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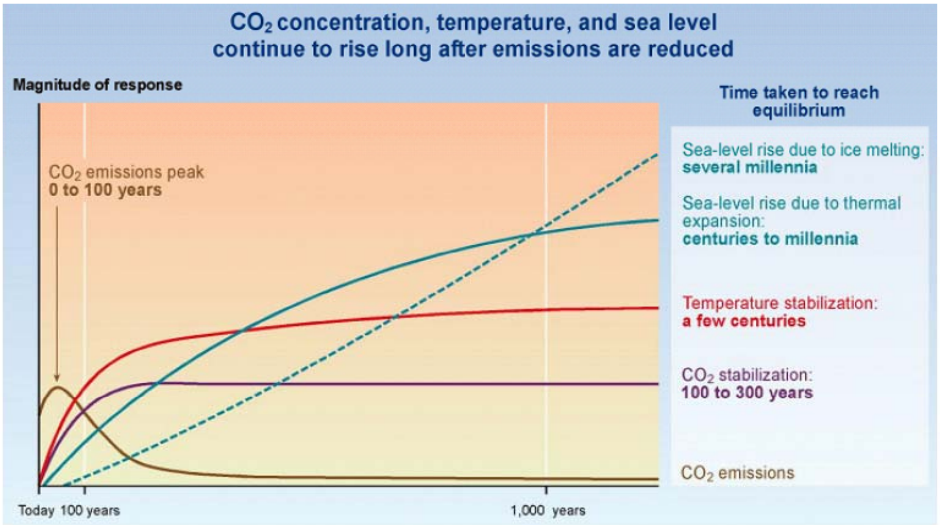
Time Lags in Climate Response



Source: IPCC, *Climate Change 2001 - Synthesis Report*

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Stabilisation scenarios

Global mean temp. increase (ºC)	Stabilization level (ppm CO_2-eq)	Year CO_2 needs to peak
2.0 – 2.4	445 – 490	2000 – 2015
2.4 – 2.8	490 – 535	2000 – 2020
2.8 – 3.2	535 – 590	2010 – 2030
3.2 – 4.0	590 – 710	2020 – 2060

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Source: IPCC 31

Costs of Mitigation

- Current CO2e concentration is 430 ppm
- Propose stabilizing CO2e at or below 550 pm
- At 550ppm, 0.5 probability of < 3°C rise by 2100, and unlikely that rise > 4° (relative to pre-industrial); under BAU a 0.5 probability of 5°C rise
- Assuming emissions peak in 2020, can achieve 550 pm with annual emissions cuts of 1 – 3% thereafter
- 10 year delay doubles annual rate of emissions decline required

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Means of Reducing GHG Emissions

- Increasing efficiency of energy use
- Increasing efficiency of energy production
- Adopting low carbon technologies for power, heat, and transport, including CCS
- Reducing demand for emissions-intensive goods and services
- For non-fossil fuel emissions:
  - reducing deforestation
  - changing agricultural practices
- Augmenting carbon sinks—reforestation and afforestation

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Policy Options for Reducing GHG Emissions

- Establishing a *credible* carbon price
- Removing fossil fuel subsidies
- Technology policy—R&D and deployment assistance
- Removing barriers to behavioral change
- "Carbon finance"–financial assistance to developing countries
- Promoting adaptation
- Preserving/augmenting carbon sinks

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Incremental solutions will not help

- Vast number of people live in energy poverty (e.g., 56% of rural Indian households have no access to electricity)
- By 2030 India will need to expand its energy capacity to 400GW = today's combined capacity of Japan, South Korea and Australia (IEA)
- Price tag $1.25 trillion
- Extra cost for clean energy investments in all developing countries, up to $60billion/year
- Combined 2008 revenue of top 7 oil companies $1.9 trillion (ExxonMobil, Shell, BP, Total, Chevron, PB, Saudi Aramco)

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The economic view

- The fundamental problem is the climate change externality – a "global public good"
- Economic participants (millions of firms, billions of people, trillions of decisions) need to face realistic carbon prices if their decisions about consumption, investment, and innovation are to be correct.

1. To be **effective,** we need a market price of carbon emissions that reflects the social costs.
2. Moreover, to be **efficient**, the price must be universal and harmonized in every sector and country.

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… is also the IPCC view!

- "An effective carbon price signal could realise significant mitigation potential in all sectors.
- Modeling studies show global carbon prices rising to 20-80 US$/tCO$_2$-eq by 2030 are consistent with stabilisation at 550 ppm CO$_2$-eq by 2100.
- Induced technological change may lower these prices ranges to 5-65 US$/tCO$_2$-eq in 2030."

-IPCC, 4th Assessment Report, Summary for Policymakers, p. 18.

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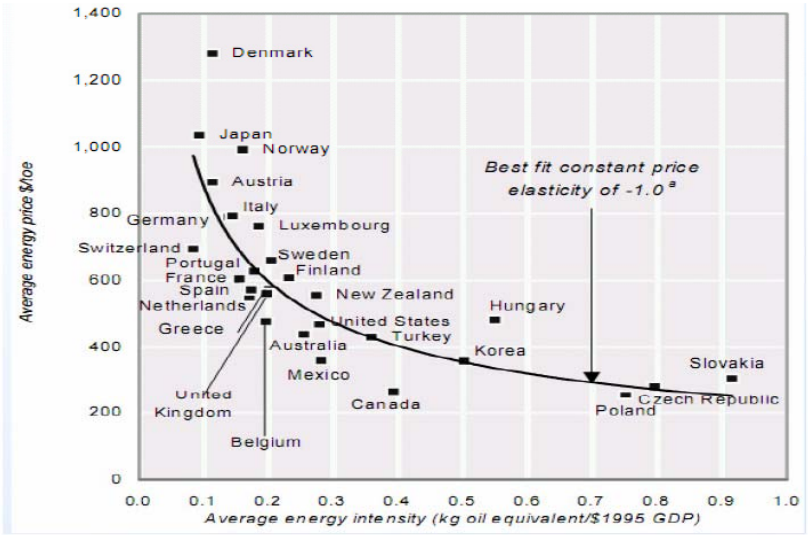
Importance of Price Signals



Source: Newbery, D.M. (2003). Sectoral dimensions of sustainable development: energy & transport. *Economic Survey of Europe 2.*

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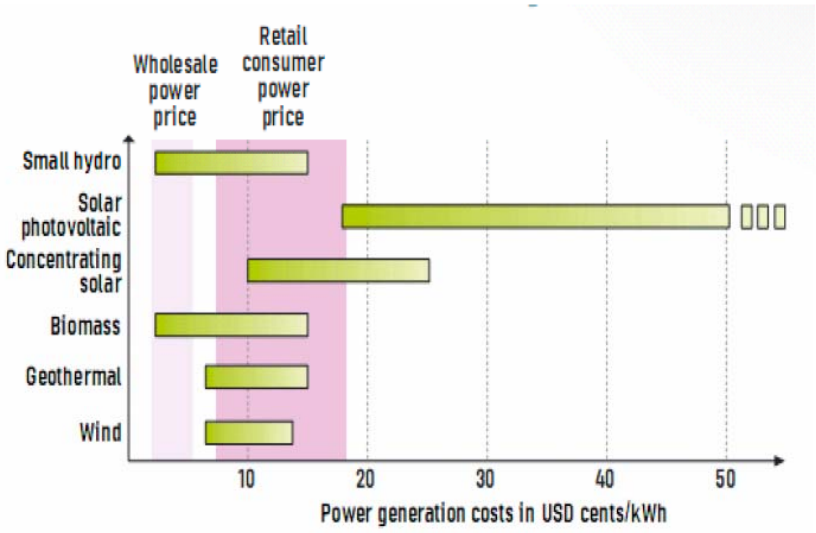
Cost Competitiveness of Selected Renewables



Source: International Energy Agency, *Renewables in Global Energy Supply*, January 2007.

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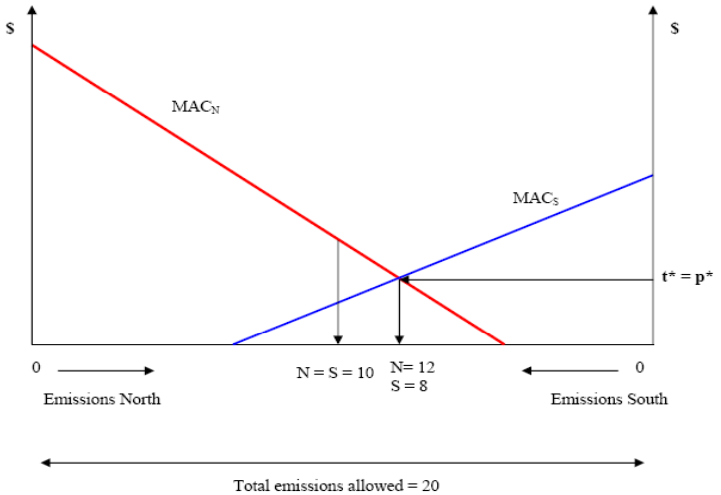
A cost effective abatement policy



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Cap-and-trade + equity based allocation: an illustration

- Per capita emissions of CO_2 7 tons annually (6 billion people)
- Halving emissions by 2050 ➔2-3 tons per capita (9 billion people)
- US at present approx. 20 tons, EU/Singapore 10, China 3.5, and India 1.1
- Upper bound on 'hot air' sold by India: 1-2 billion tons? Plus abatement?
- Will it always remain 'hot air'? (growth in emissions)

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Stabilizing permit prices

- Permit prices will pay a key role
- $30-40/ton make technologies such as CCS commercially viable
- Desirable to let prices stay within a 'band' (floors/ceilings-safety valves)
- 'Price band' safeguards interests of buyers (North) and sellers (South)

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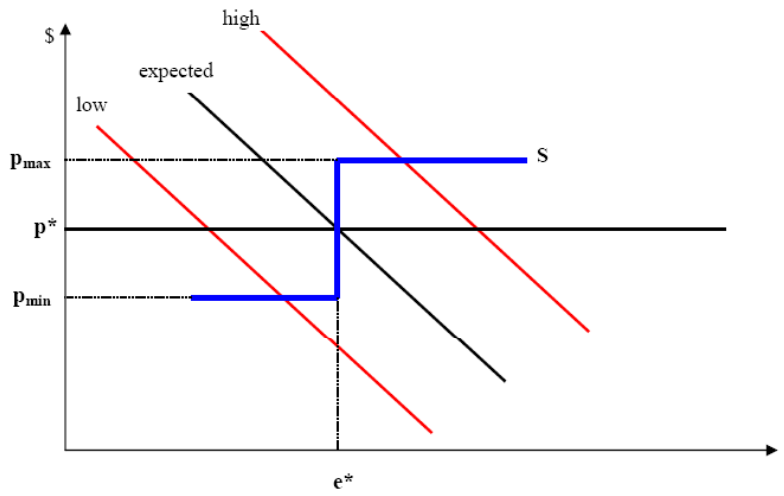
Modified cap and trade system



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Implications for income transfer

- The agreement is ultimately about money
- 'Carbon flows' could be US$50-100bn p.a. by 2030 (*a la* Stern)
- Still a win-win for North and South
- Cheaper abatement options for North (in South)
- But North can't 'buy' its way out. Will also have to cut emissions at home (though less than that required without North-South trading)
- South takes on binding targets but it's a loose cap

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Top GHG emitting countries

CO_2, CH_4, N_2O, HFCs, PFC, SF_6

Country	$MtCO_2$ equivalent	% of World GHGs
1. United States	6,928	20.6
2. China	4,938	14.7
3. EU-25	4,725	14.0
4. Russia	1,915	5.7
5. India	1,884	5.6
6. Japan	1,317	3.9
7. Germany	1,009	3.0
8. Brazil	851	2.5
9. Canada	680	2.0
10. United Kingdom	654	1.9

Source: World Resources Institute, ***Navigating the Numbers***, 2005.

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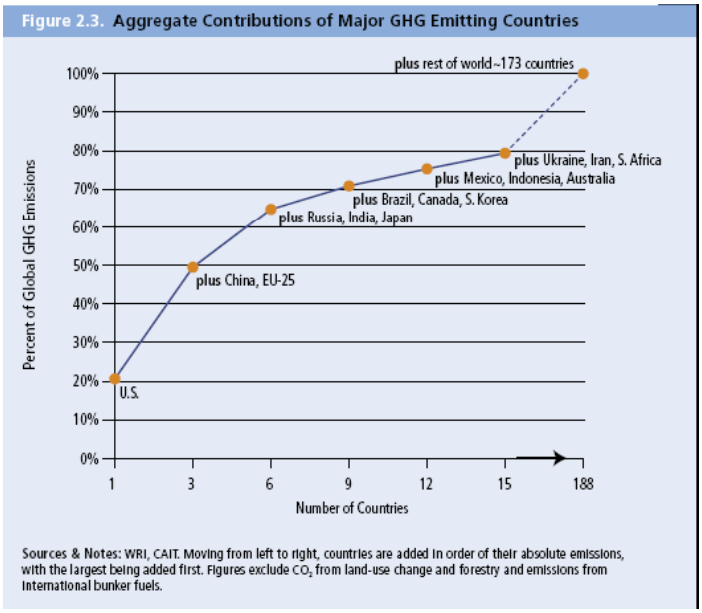

Source: World Resources Institute, *Navigating the Numbers*, 2005.

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Global Response

- The First World Climate Conference recognized climate change as a serious problem in 1979
- A number of intergovernmental conferences focusing on climate change were held in the late 1980s and early 1990s
- In 1990 IPCC (Panel of 2,500 scientists) released its first assessment report concluding that:

  "*Climate change is real and human activities are contributing to it.*"

Global Response and the United Nations Framework Convention on Climate Change

- **UNFCCC is the basis for global efforts to combat global warming (supported by IPCC).**
- The UNFCCC objective is *"Stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous antropogenic human-induced interference with climate system."*
- The Convention sets out some guiding principles:
  - Precautionary principle
  - **"Common but differentiated responsibilities"**
  - Acknowledge need of developing countries for sustainable development

UNFCCC

- Signed by 154 countries (plus EC) in 1992 at Rio de Janeiro. To date, 189 countries have ratified the Convention.
- The Convention entered into force on 21 March 1994.
- The uppermost body of the Convention is the Conference of the Parties (CoP), which is responsible for achieving its objectives.
- CoP held its first session in Berlin (Germany) in 1995. The Parties meet every year.
- CoP-3 in Kyoto (Japan) in 1997 established the Kyoto Protocol.

The Kyoto Protocol

- An agreement by developed countries to reduce GHG emissions.
- Adopted at CoP3 at Kyoto (1997). Ratified by Russia on Nov 18, 2004. **Entered into force Feb 16, 2005.** US only developed country that has not ratified it.
- Developed countries have to reduce GHG emissions by 5.2% compared to their 1990 level over the period 2008-2012.
- No targets for developing countries.
- Reduction targets cover 6 main GHGs: CO2, CH4, N2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

Summary so far…

- ✓ Human activities are increasing the concentration of GHGs in the atmosphere.
- ✓ The increase of GHG concentration will lead to unprecedented increase in average global temperature.
- ✓ Rising temperature are predicted to lead to disruptions in climate patterns, have adverse impacts on food supply, fresh water resources, human health, coastal areas, species and natural areas.
- ✓ The international community has worked together to create an agreement on how to address climate change known as the UNFCCC.
- ✓ The Convention is a United Nations agreement to stabilize greenhouse gases in the atmosphere, at a level that would prevent dangerous changes to the climate.
- ✓ To date, 189 countries have ratified the climate change convention.
- ✓ The Kyoto Protocol is the first concrete step toward cutting GHG emissions.

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Thinking globally, acting locally…

- …the journey of a thousand miles begins with one step
- …it is better to light a candle than to curse the darkness
- …"you must be the change you wish to see in the world" (Gandhi)

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7 Day Carbon Challenge (Govt. of Queensland)

- Day 1 – Reduce your waste (reduce, reuse, recycle)
- Day 2 – Switch to green power
- Day 3 – Change your light bulbs (CFLs)
- Day 4 – Check your thermostat!
- Day 5 – Think before you eat (no meat once a week)
- Day 6 – Reduce car travel (bicycle, public transport)
- Day 7 – Economise on water (laundry, etc.)

Source: http://www.climatesmart.qld.gov.au/get_involved/low_carbon_diet_-_for_community_groups

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1.6 billion people lack access to electricity
33% live in India

LIGHTING A BILLION LIVES

Enabling a billion lives to access light from solar technologies

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Solar lantern

Each solar lantern:

- **Saves about 40-60 litres of kerosene per year**
- **Mitigates 145 kg CO_2 emissions per year**

Alternately:

- **Saves about 182.5 kWhr of electricity per year**
- **Mitigates 157 kg CO2 emissions per year**

Gandhi was once asked if he expected India to attain the same standard of living as Britain. He replied:

It took Britain half the resources of the planet to achieve this prosperity. How many planets will a country like India require!

To conclude

- Global collective action is required to address climate change
- A modified cap-and-trade regime with initial allocation based on per capita entitlements offers win-win opportunity for North and South
- Volatility of permit prices can be addressed through a price ceiling and floor (price band)
- Safeguards interests of buyers and sellers
- Promotes investment in non-carbon technologies
- Likely income transfers to sellers large but not in a relative sense

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