WNA Worldwide Overview on:

Nuclear's Health, Safety and Environmental (HSE) Issues and Challenges

URAM-2009

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World Nuclear Association

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Qualitative Overview of HSE Issues
Front-End

	Mining			Milling	Conversion	Enrichment
	Open Pit	U/G mine	ISL			
	U ore	U ore	U solution	U sol/U conc	U form	U form
Occupational H&S						
• Hazard						
- Conventional			-	-	-	-
- Chemical	-	-	-			
- Radioactive			-			-
- Criticality	-	-	-	-	-	
Environment						
• Footprint		-	-		-	-
• Hazard						
- Chemical	-	-				
- Radioactive	-	-	-	-	-	-
- Heavy Metals		-			-	-
Waste						
• LLW					-	-
• ILW	na	na	na	na	na	na
• HLW	na	na	na	na	na	na
• UNF	na	na	na	na	na	na

H&S - Health & Safety
U/G mine - Underground mine
U sol - Uranium solution; U conc - Uranium concentrate
LLW - Low level waste
ILW - Intermediate level waste
HLW - High level waste
UNF - Used Nuclear Fuel

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Qualitative Overview of HSE Issues
Front-End

Occupation H&S

- Conventional risk and radiation risk higher for underground mines

Environment

- Chemical risk higher for conversion and enrichment

Waste

- LLW amounts higher for open-pits and mill tailings

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Qualitative Overview of HSE Issues
Nuclear Fuel, Nuclear Power and Back-End

	Fuel Fabrication	Nuclear Power	Reprocessing/Recycling
	UO2	U fuel	UNF
Occupational H&S			
• Hazard - Conventional - Chemical - Radioactive - Criticality	- - -	- - -	- -
Environment			
• Footprint • Hazard - Chemical - Radioactive - Heavy Metals	- - - -	- - - -	- - - -
Waste			
• LLW • ILW • HLW • UNF	- na na na	 na 	 na

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Qualitative Overview of HSE Issues
Nuclear Fuel, Nuclear Power and Back-End

Occupation H&S

- Radiation risk higher for nuclear power and reprocessing/recycling

Environment

- Nothing particular

Waste

- Risk higher for used nuclear fuel (though not a waste) and for HLW

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HSE Issues Outlook

No key HSE issues are foreseen for the global expansion of nuclear fuel cycle and power

- **Greater performance is expected from plant upgrades and new plants**

Overcoming a few key HSE challenges would greatly facilitate this expansion

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HSE Challenges

1. World Challenge on Environmental-Health Protection
a) Reality check: Main HSE Drivers
b) Reality check: Energy->Climate Change->HSE
c) Overall protection benefits from nuclear energy in this challenge

2. Reposition already safe nuclear technologies as the Main Driver for the deployment of nuclear energy
- No need for *a priori* set safety criteria that unduly challenge technologies beyond the notion of protection

3. Convey integrated HSE management - including an harmonized and integrated set of IAEA safety standards

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HSE Challenges

4. Fix imbalanced RP policies for public exposure at very low doses (<1mSv/y)
   - RP stringency for nuclear industry only is not sound

5. Clearer Communications on:
- Major nuclear accident
- Radiation risk
- Nuclear waste
- Non-proliferation

There are high public expectations that nuclear industry management can clearly articulate “easy to understand” views on these topics

6. Better address new uranium projects in countries without sufficiently developed regulatory regimes

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HSE Challenges
1a. Reality Check: Main HSE Drivers

1. Climate change
2. Air pollution (all kinds)
3. Water pollution (all kinds)
4. Intense industrial activities (chemical, oil/gas, agriculture, fishery, forestry, etc.)
5. Urban developments

…

100 th? Exposure to radiation => localised and inconsequential

'n' th? Nuclear waste management and disposal => " " " "

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HSE Challenges
1b. Reality Check: Energy & Climate Change-HSE

What do you know about the world challenge on Energy & Climate Change, and the related planet-wide public health and environmental protection consequences?

- Clearer views, especially on the realistic orientations to take on board for progressing, is paramount

- Due to the urgency to act, cannot afford to hide behind dogma, or to only offer ambiguous and superficial views

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The Biggest Broad Challenge

A new challenging era

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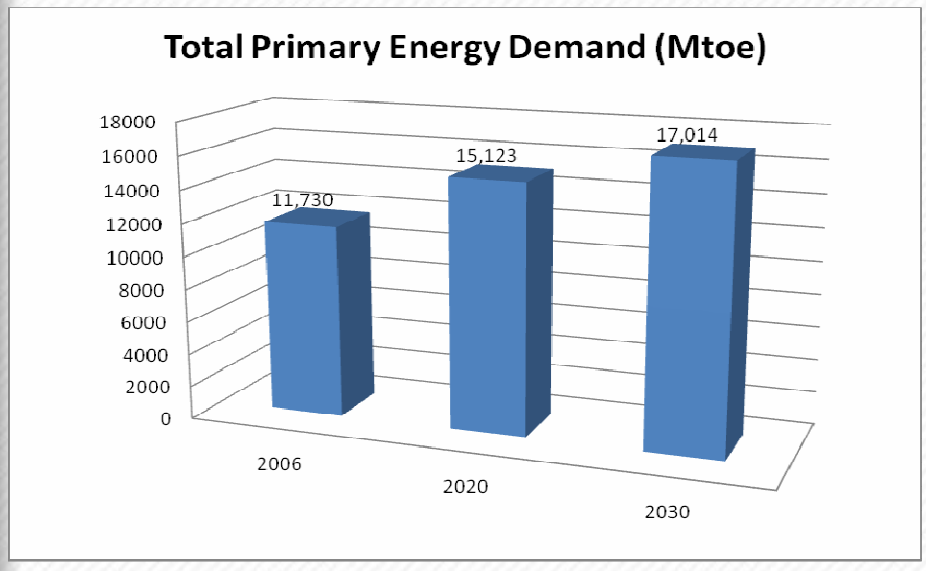
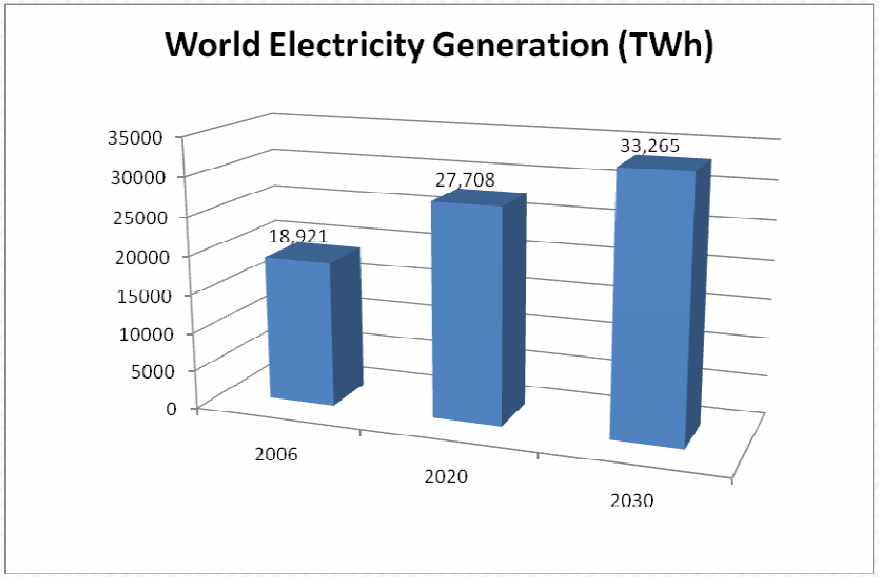
The Biggest Broad Challenge

Securing energy and electricity generation supplies over the long term





Average growth (2006-2030) ≈ 1.6% per year

+45% over 2006-2030 from ≈ 12,000 to 17,000 Mtoe

Average growth (2006-2030) ≈ 2.5% per year

+75% over 2006-2030 from ≈ 19,000 to 33,000 TWh

World population:

1950: 2.5 billions; 2009: 6+ billions; 2050: 9 billions

Mtoe - Million tonnes of oil equivalent
TWh - Terawatt hour

Source: International Energy Agency (IEA) 2008, Reference Scenario

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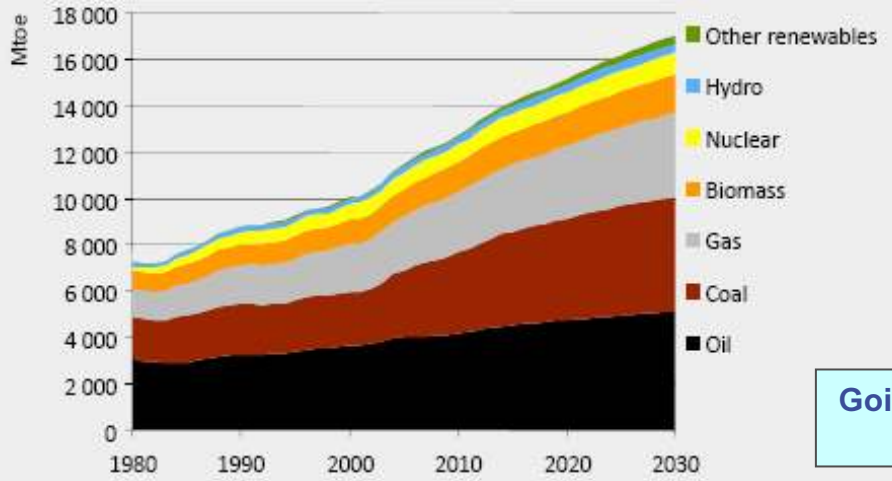
The Biggest Broad Challenge

Securing energy and electricity generation supplies over the long term

International Energy Agency's Press Presentation: 4/12/08

World primary energy demand in the Reference Scenario: this is unsustainable!

World Energy Outlook 2008



Going from 12,000 to 17,000 Mtoe over 2006 to 2030

World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

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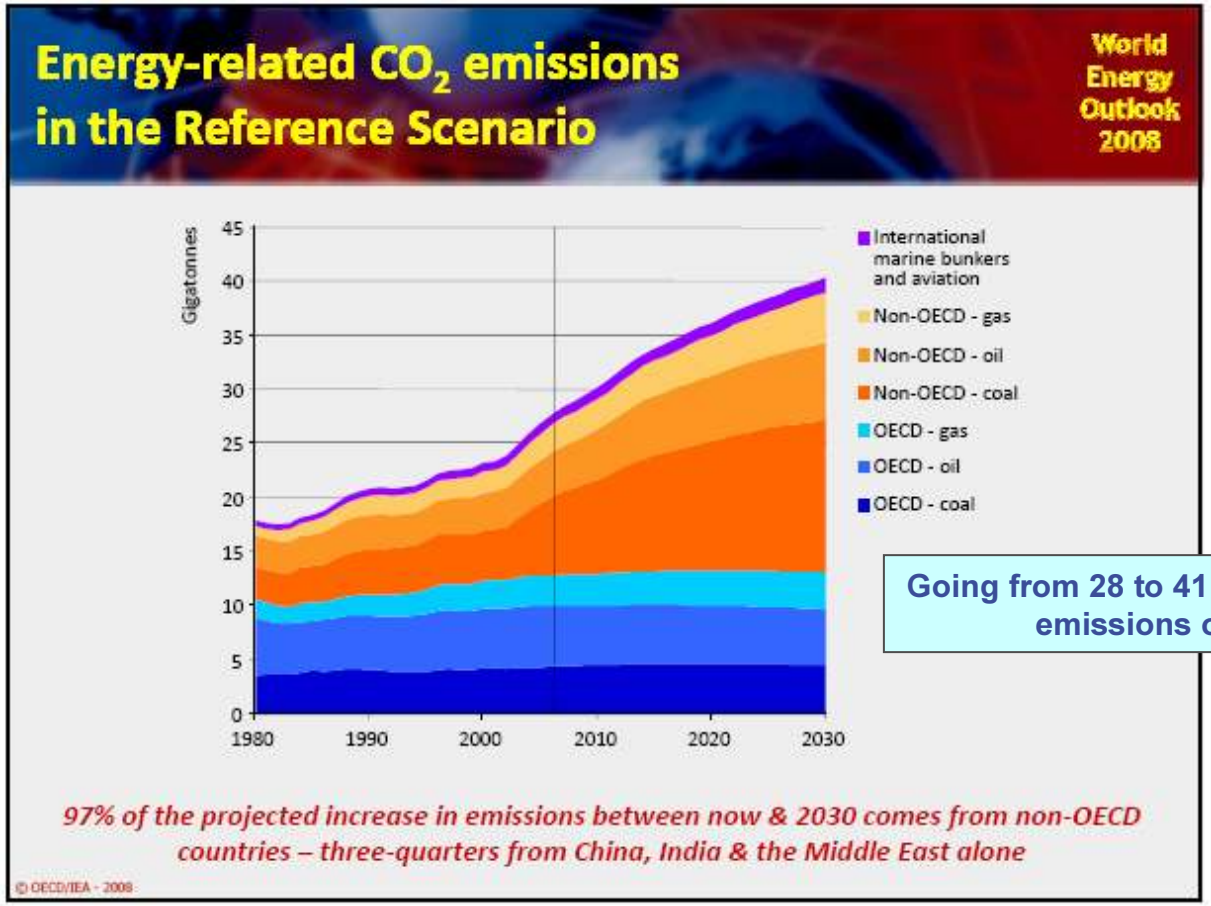
The Biggest Broad Challenge

Securing energy and electricity generation demands over the long term

IEA's Presentation to Press: 4/12/08



Going from 28 to 41 Gt of CO2 energy-related emissions over 2006 to 2030

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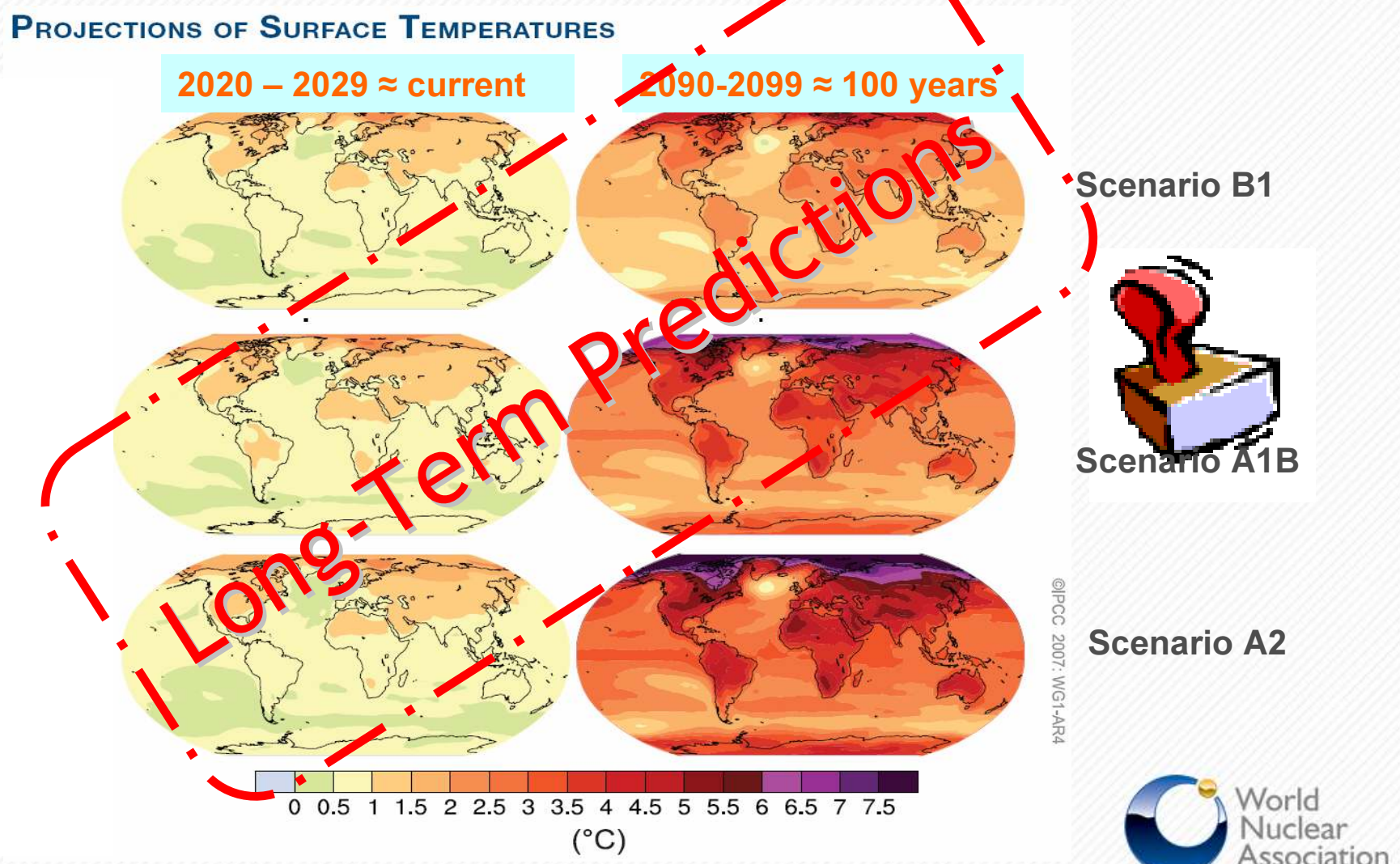
Gt : Gega tonnes = 1 billion tonnes

The Biggest Broad Challenge

Long-term Climate Change Consequences from Greenhouse Gases



Source: IPCC AR4

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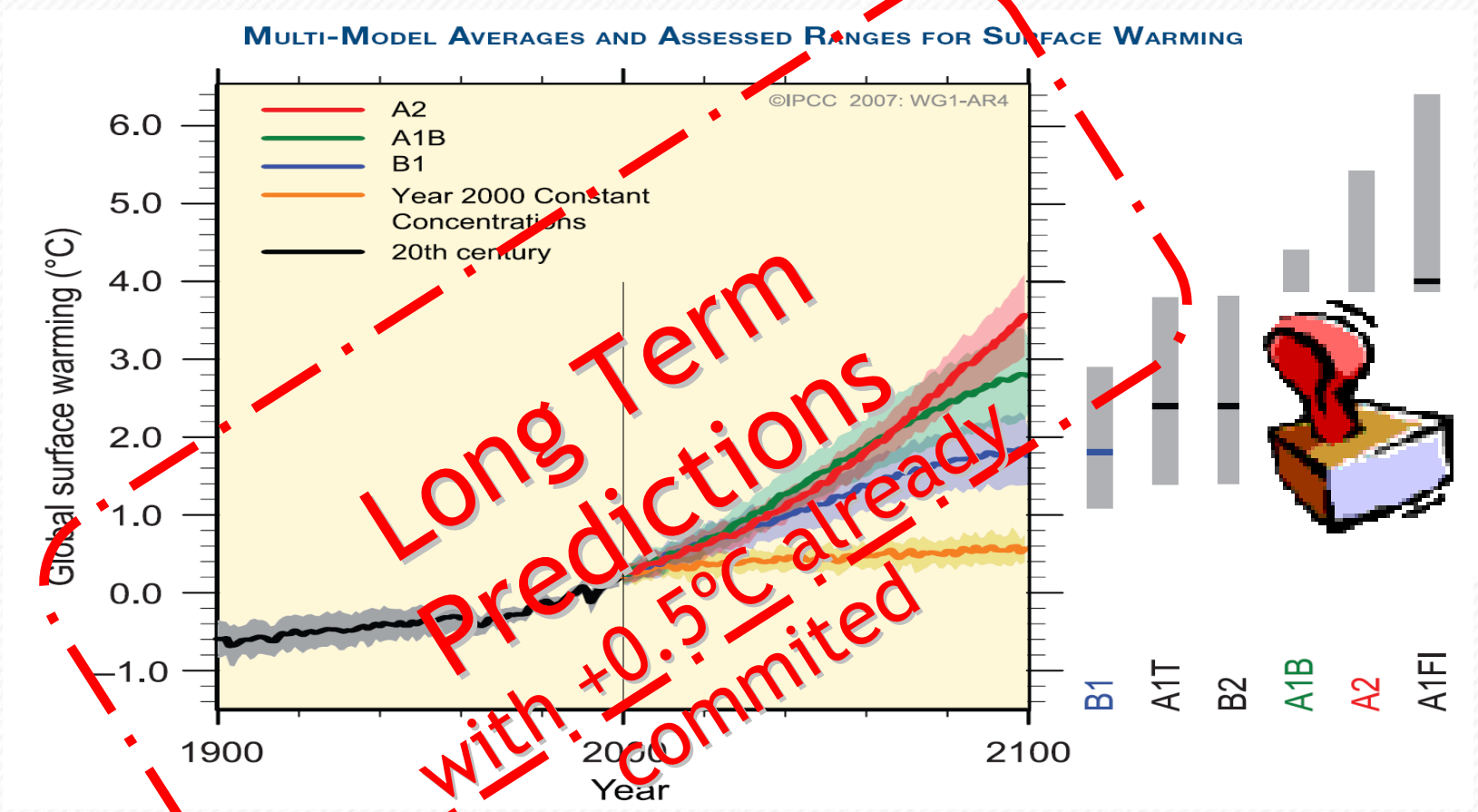
The Biggest Broad Challenge

Long-term Climate Change Consequences from Greenhouse Gases



Source: IPCC AR4

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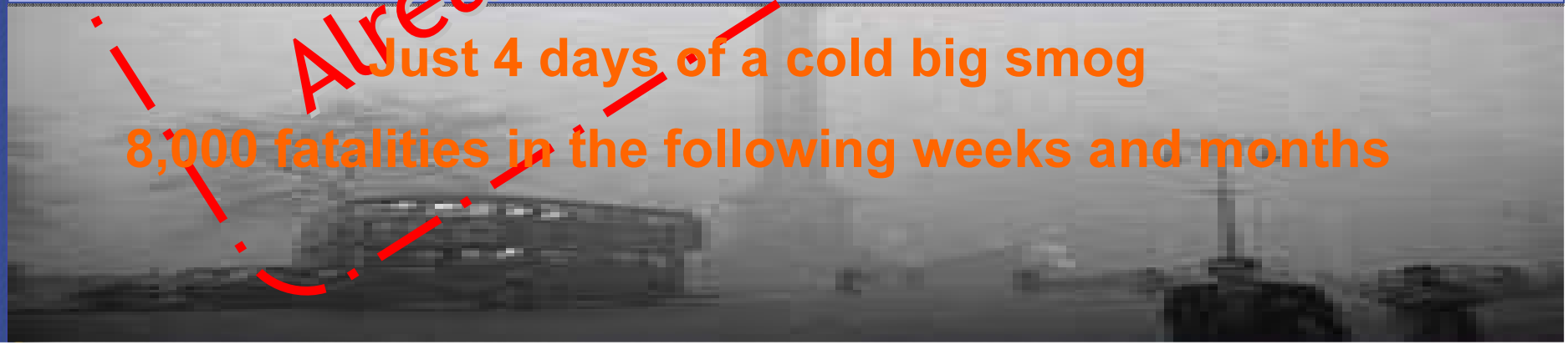
In the nearer term, let's also not forget air quality

Already quite deteriorated in many major cities (1 - 10+ M people)

Already occured

A reminder of history: London 1954 Big Smog due to heavy coal combustion (1+ M people)



World Challenge on Energy & Environment-Health

At the core of this World Challenge:

1. Choices in low-carbon Energy Sources

2. Climate Change

3. Environmental and Health Protection

International organisations such as the UN and the OECD as well as governments are urged to act/help

- UN/IAEA and OECD/NEA are of particular relevance for nuclear energy

UN - United Nations
IAEA - UN's International Atomic Energy Agency
OECD - Organisation for Economic Co-operation and Development
NEA - OECD's Nuclear Energy Agency

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World Challenge on Energy & Environment-Health

Main outcomes of the:

- Intergovernmental Panel on Climate Change (IPCC)
  - Series of comprehensive studies
  - http://www.ipcc.ch/ipccreports/assessments-reports.htm
- International Energy Agency (IEA)
  - World Energy Outlook 2008
  - http://www.worldenergyoutlook.org/

Recognizing that such comprehensive knowledge is fundamental to overall efficiency in planet-wide human health and environmental protection

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IPCC Statements

Intergovernmental Panel on Climate Change (IPCC)

Over Two Decades, a Series of 4 Key IPCC Comprehensive Studies

1) **FAR 1990**: "*little* observational evidence of a *detectable anthropogenic influence* on climate"

2) **SAR 1995**: "The balance of evidence suggests a *discernible human influence* on the climate of the 20th century."

3) **TAR 2001**: "There is new and stronger evidence that most of the warming observed over the last 50 years is *attributable to human* activities."

4) **AR4 2007**: "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".

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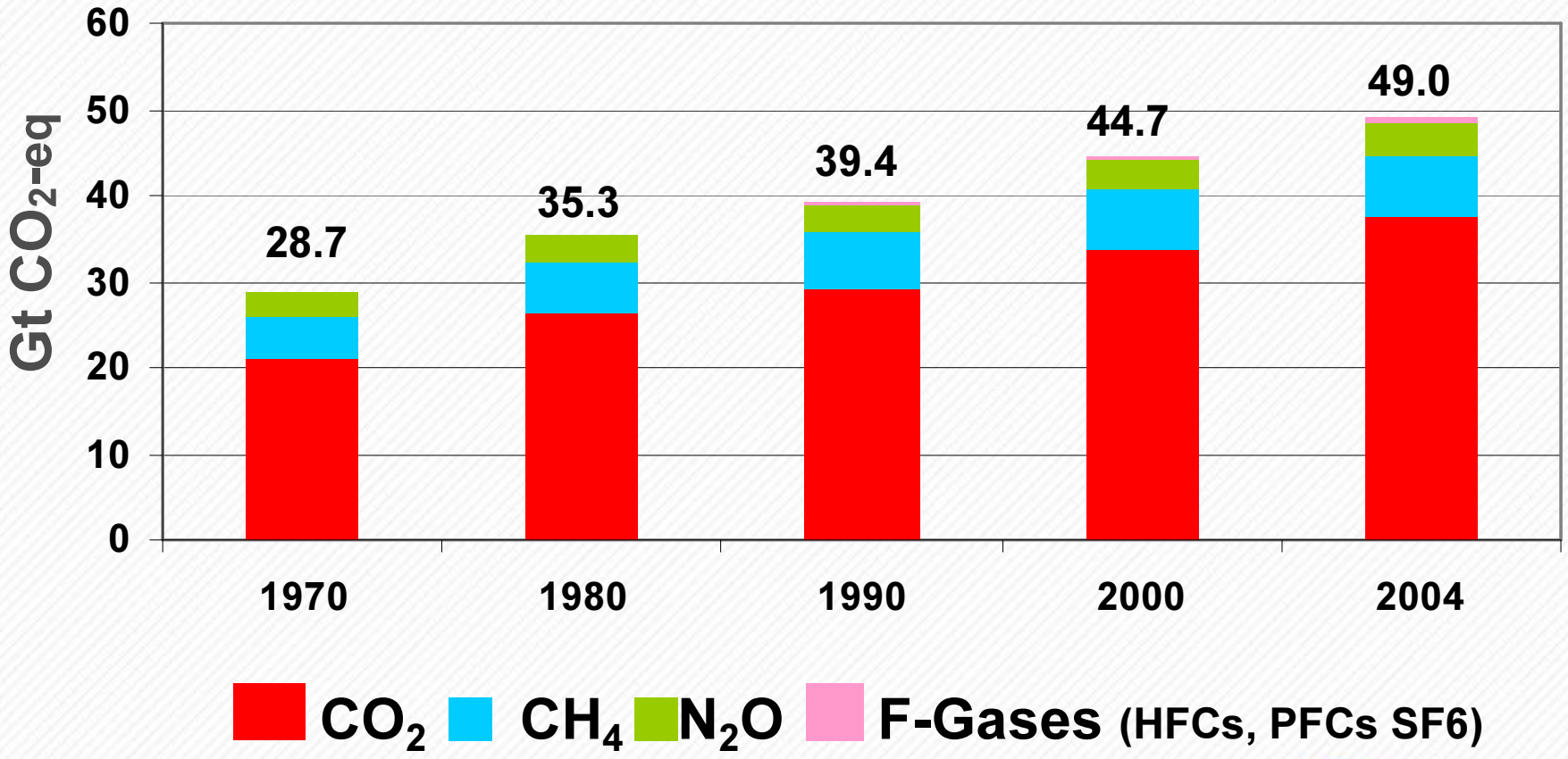
1970-2004: Anthropogenic GHG Emissions



Gt : Gega tonnes = 1 billion tonnes; GHG: Greenhouse Gases

Source: IPCC AR4

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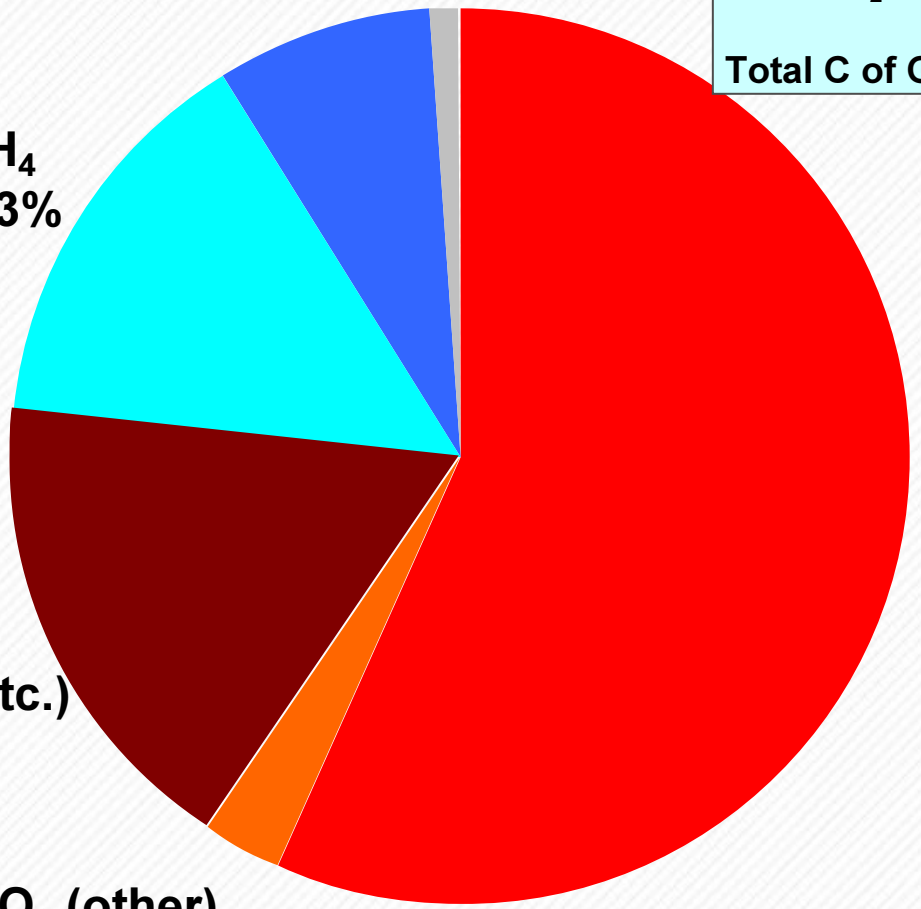
2004 Anthropogenic GHG Emissions by GHG



N_2O 7.9%

F-gases 1.1%

CH_4 14.3%

CO_2 (deforestation, decay of biomass, etc.) 17.3%

CO_2 (other) 2.8%

CO_2 fossil fuel use 56.6%

Total CO_2 –eq = 49 Gt

Total CO_2 of GHG = 76.7% = 37.6 Gt

Total C of GHG = 10.3 Gt

= 27.2 Gt of CO_2
or
= 7.4 Gt of C

Source: IPCC AR4

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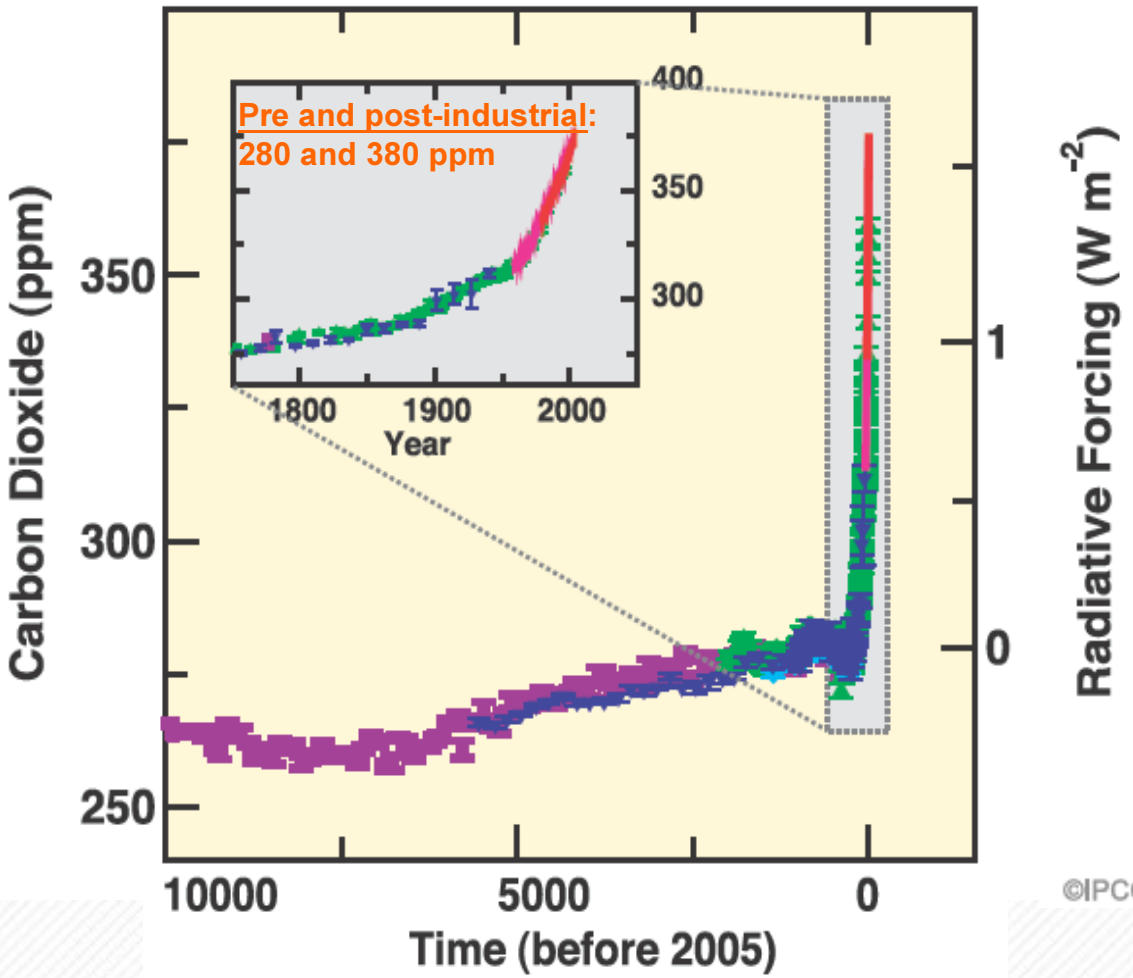
Observed Trends: Atmospheric CO_2 Concentrations

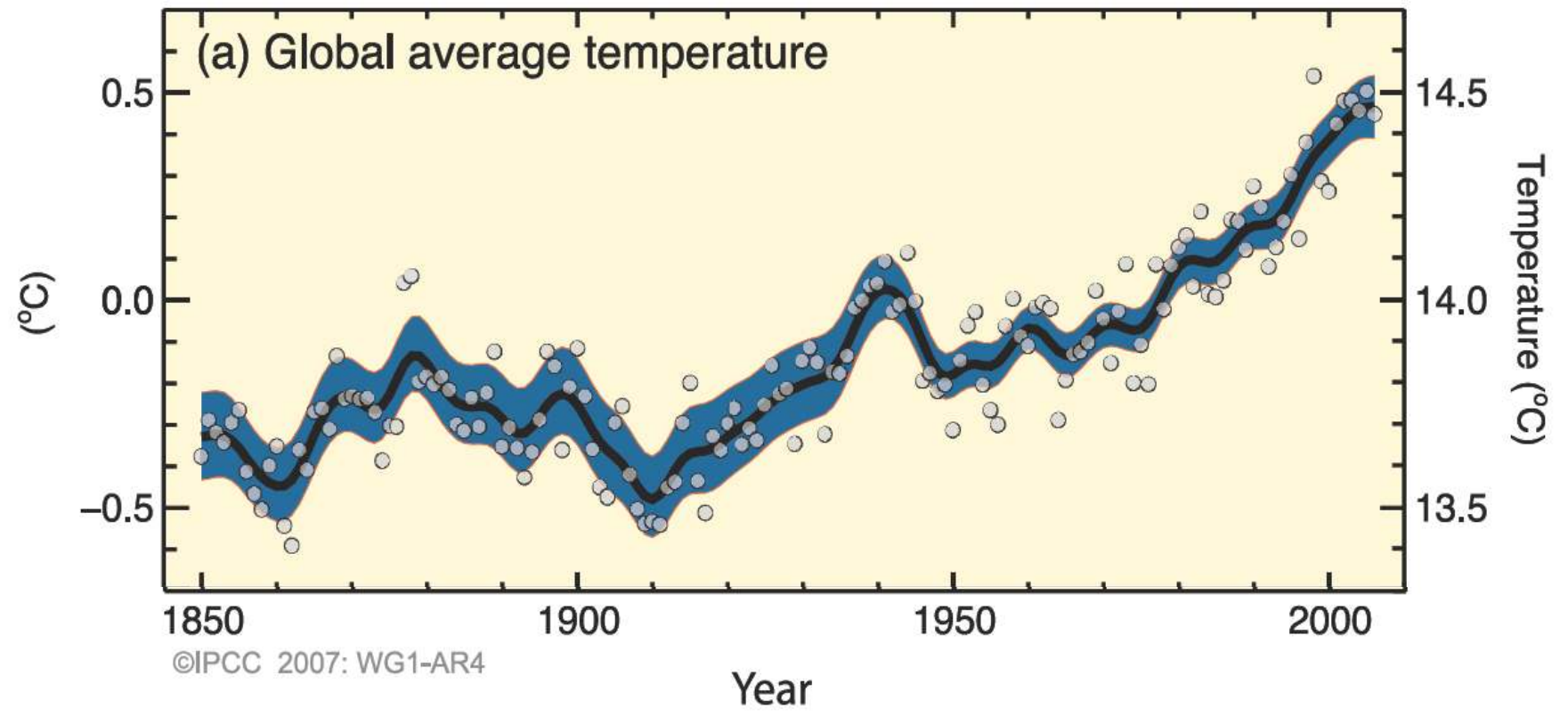
Changes in CO_2 from ice core and modern data



ppm: part per million

Similar graphs for other GHG: CH_4 and N_2O

Observed Trends: Global Average Mean Temperature



Approximate temperature increase since 1900 ≈ 0.7°C

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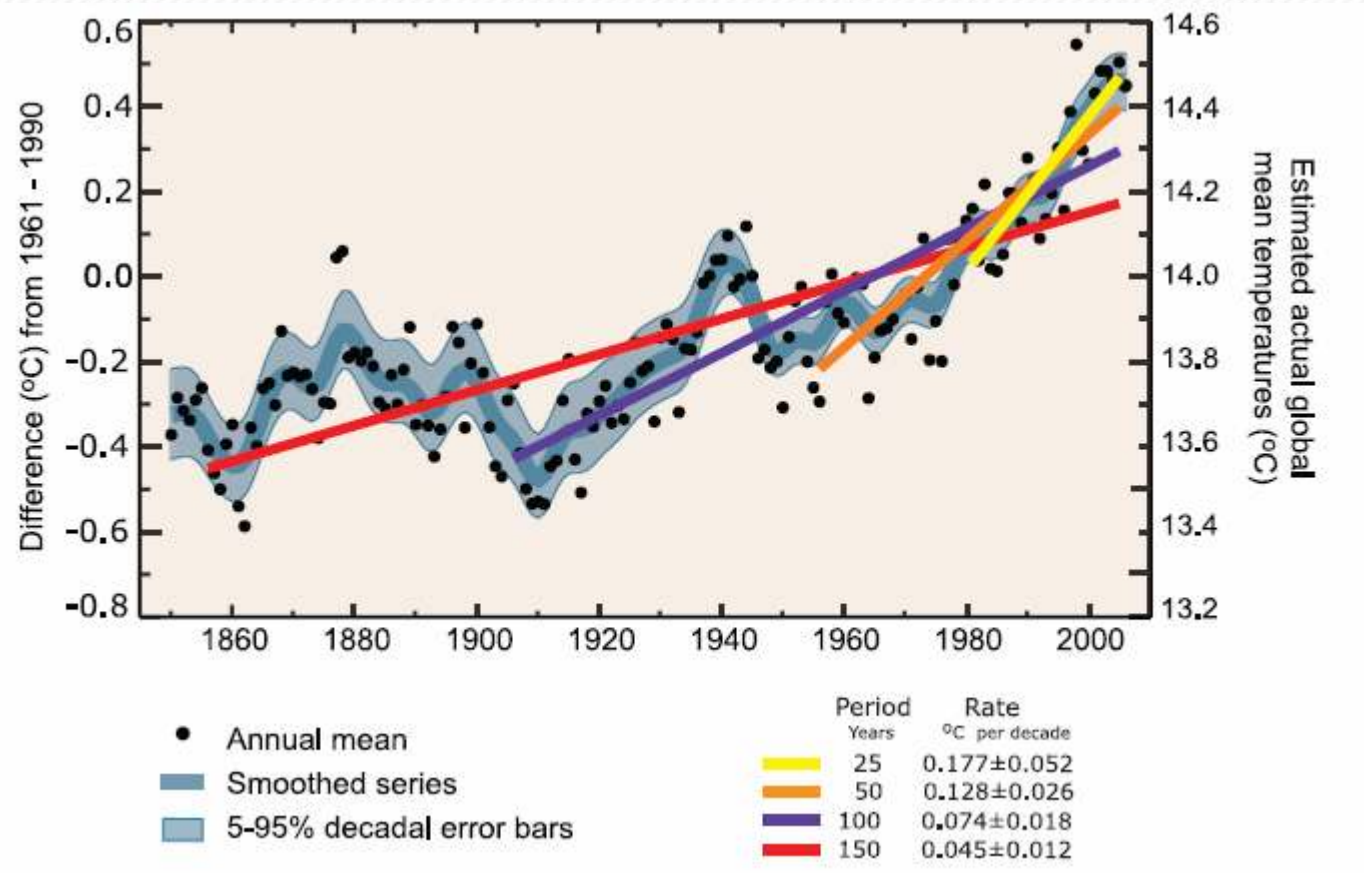
Source: IPCC AR4

Observed Trends: Global Average Mean Temperature



Rate of temperature increase (per decade) is much higher for last 25 years:

- **Absolute increase of 0.5-0.6ºC; increase rate now at 0.177ºC per decade**

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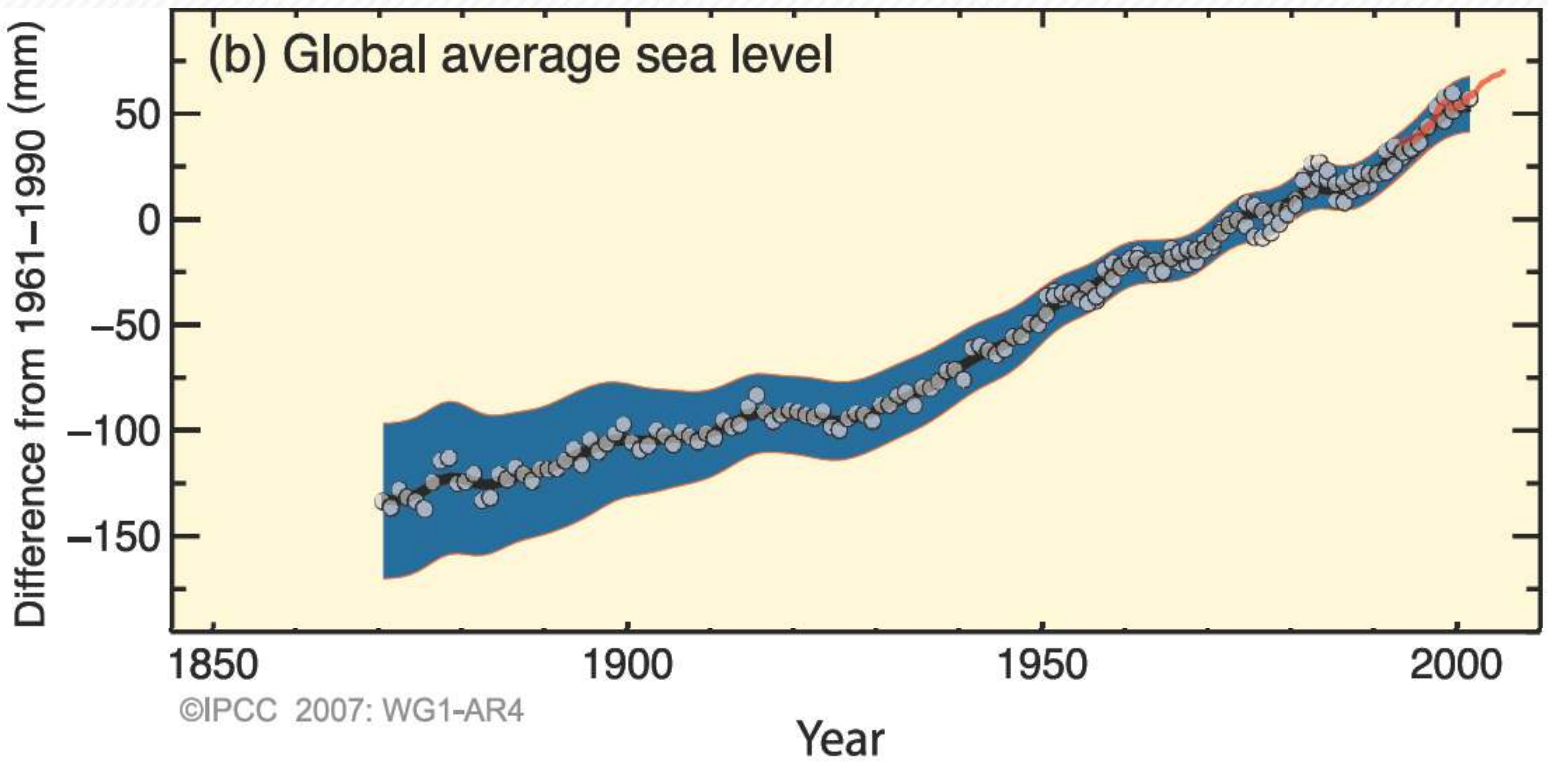
Source: IPCC AR4

Observed Trends: Global Average Sea Level



20th century estimates show that global average sea level rose at a rate of 1.7 mm/yr.

Based on more global and accurate data, since 1993 sea level has been rising at a rate of 3 mm/yr

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Source: IPCC AR4

mm/y: millimetre per year

Predictions: Increased Global Mean Temperature

Best estimate and ranges = Function (GHG atmospheric concentration)

Equilibrium CO_2–eq (ppm)	Temperature Increase (°C)		
	Best Estimate	*Very Likely* Above	*Likely* in the Range
350	1.0	0.5	0.6–1.4
450	2.1	1.0	1.4–3.1
550	2.9	1.5	1.9–4.4
650	3.6	1.8	2.4–5.5
750	4.3	2.1	2.8–6.4
1000	5.5	2.8	3.7–8.3
1200	6.3	3.1	4.2–9.4

+2° C at 450 ppm, +3°C at 550 ppm

Source: IPCC AR4

Predictions: Sea Level Rise

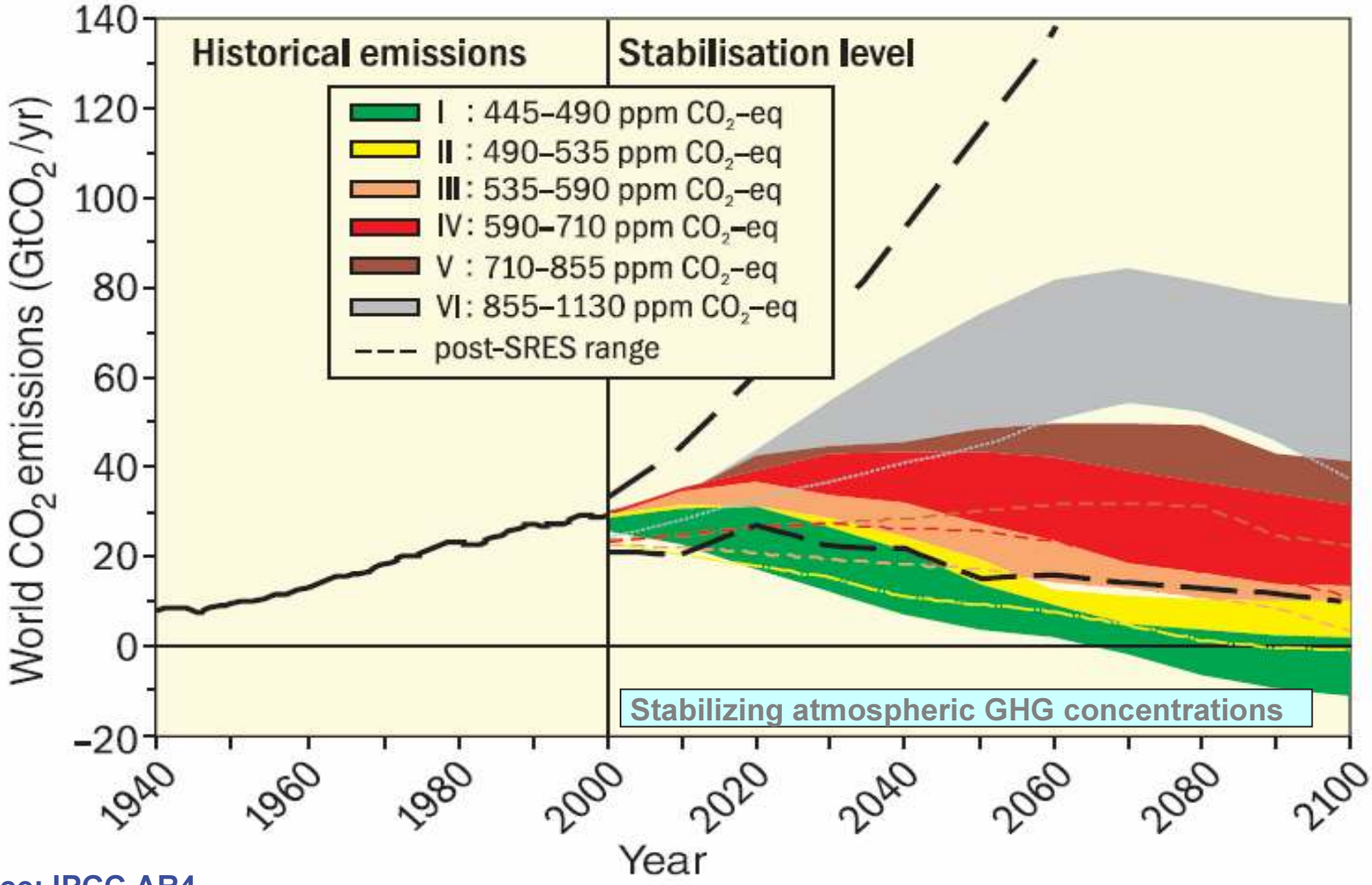
Function of global mean temperature (best estimate and ranges)

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

+0.2 to 0.6 metres (≈ 100 years relative to currently)!

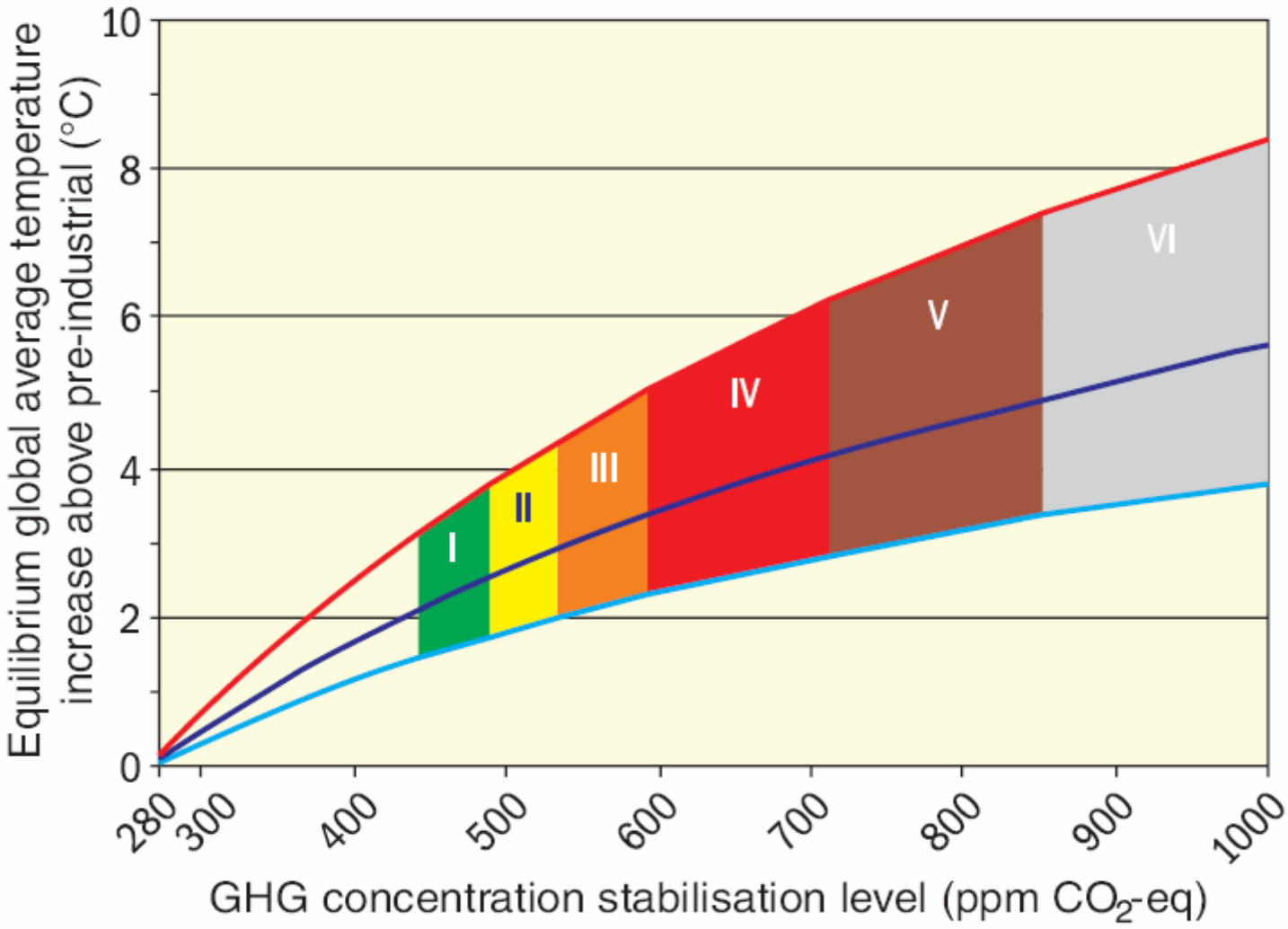
Source: IPCC AR4

Past and Future CO_2 Emissions Evolution Paths = Function (Atmospheric GHG Concentrations: CO_2 eq.)



Source: IPCC AR4

Predictions: Temperature Rise = Function (Atmospheric GHG Concentrations: CO_2 eq.)



Source: IPCC AR4

World Energy Outlook 2008

International Energy Agency - Press Presentation 4/12/08

Future of human prosperity depends on how successful we tackle two central challenges

- ***Securing the supply of reliable and affordable energy***
- ***Effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply***

Preserving catastrophic and irreversible damage to the global climate ultimately requires a major decarbonisation of the world energy

The 15th Conference of the Parties, to be held in Copenhagen in November 2009 (Nov 30-Dec11), provides a vital opportunity to negotiate a new global climate-change policy regime for beyond 2012

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World Energy Outlook 2008
IEA Presentation to Press: 4/12/08

Primary energy demand and CO2 energy-related emissions are unsustainable

World primary energy demand in the Reference Scenario: this is unsustainable!

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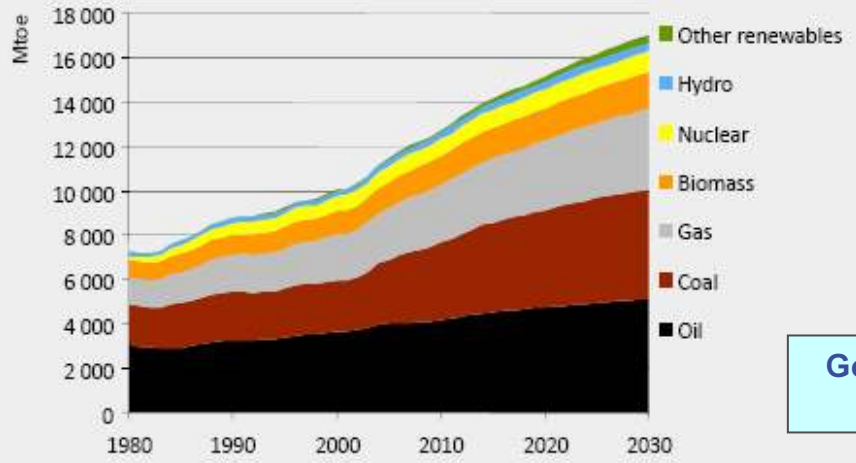

World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

Going from 12,000 to 17,000 Mtoe over 2006 to 2030

Going from 28 to 41 Gt of CO2 energy-related emissions over 2006 to 2030

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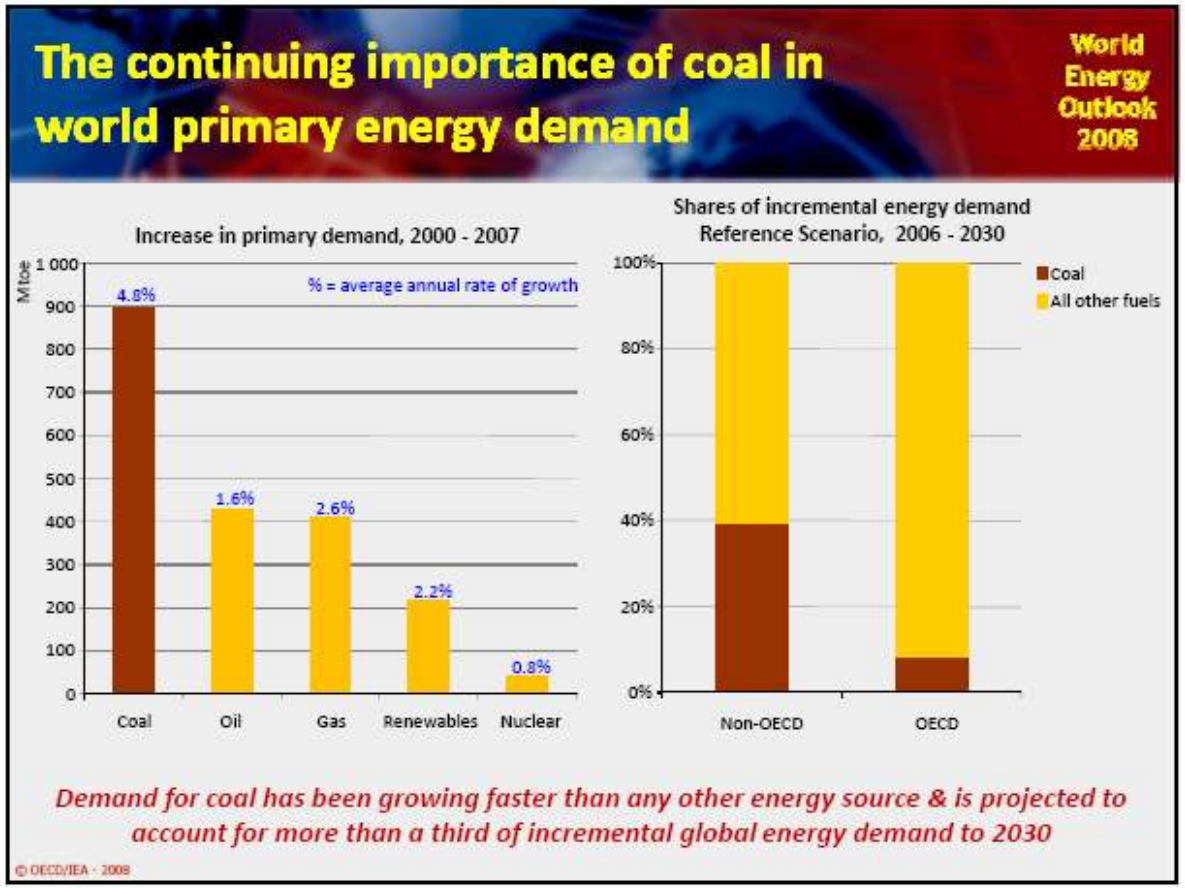
IEA Presentation to Press: 4/12/2008

Increase in primary energy demand:
=> Coal and Non-OECD countries prevail



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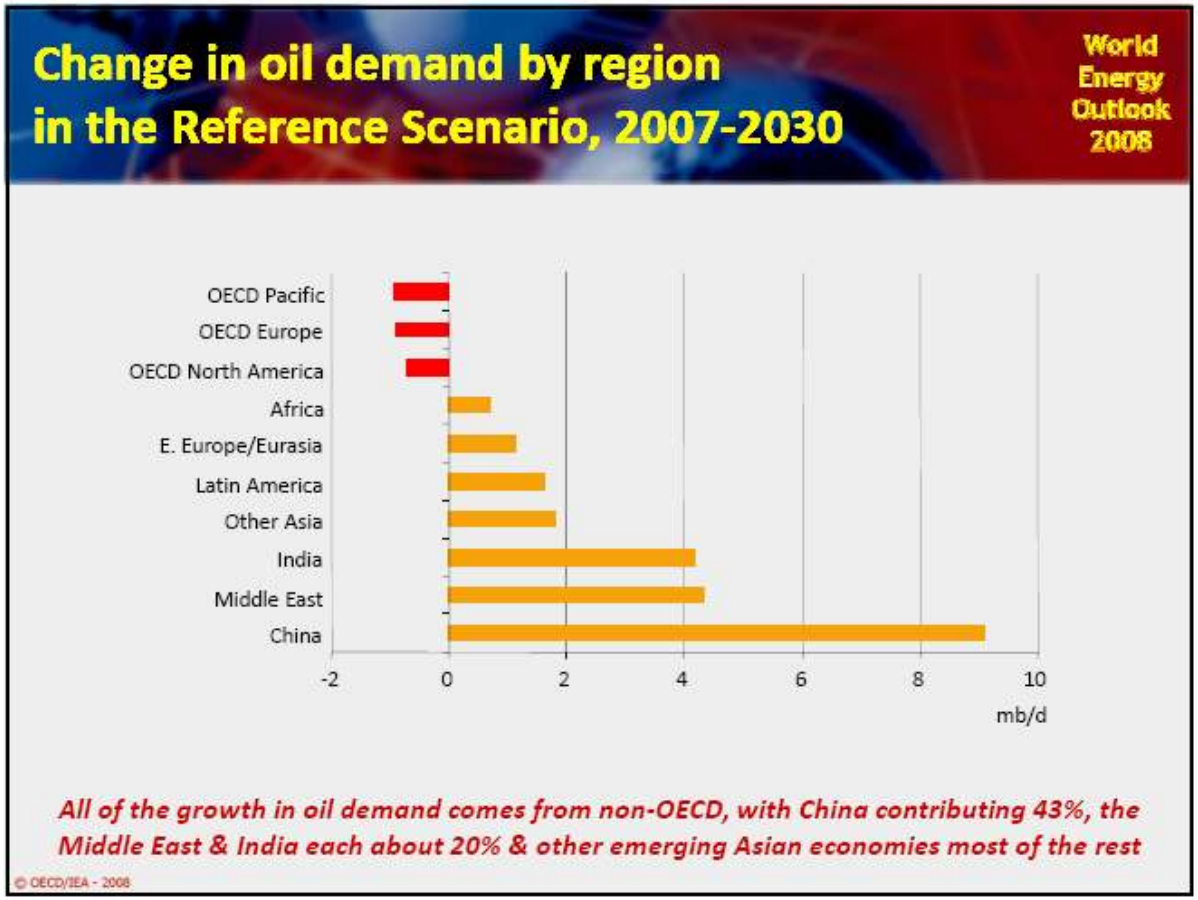
Oil demand driven by China, Middle East and India



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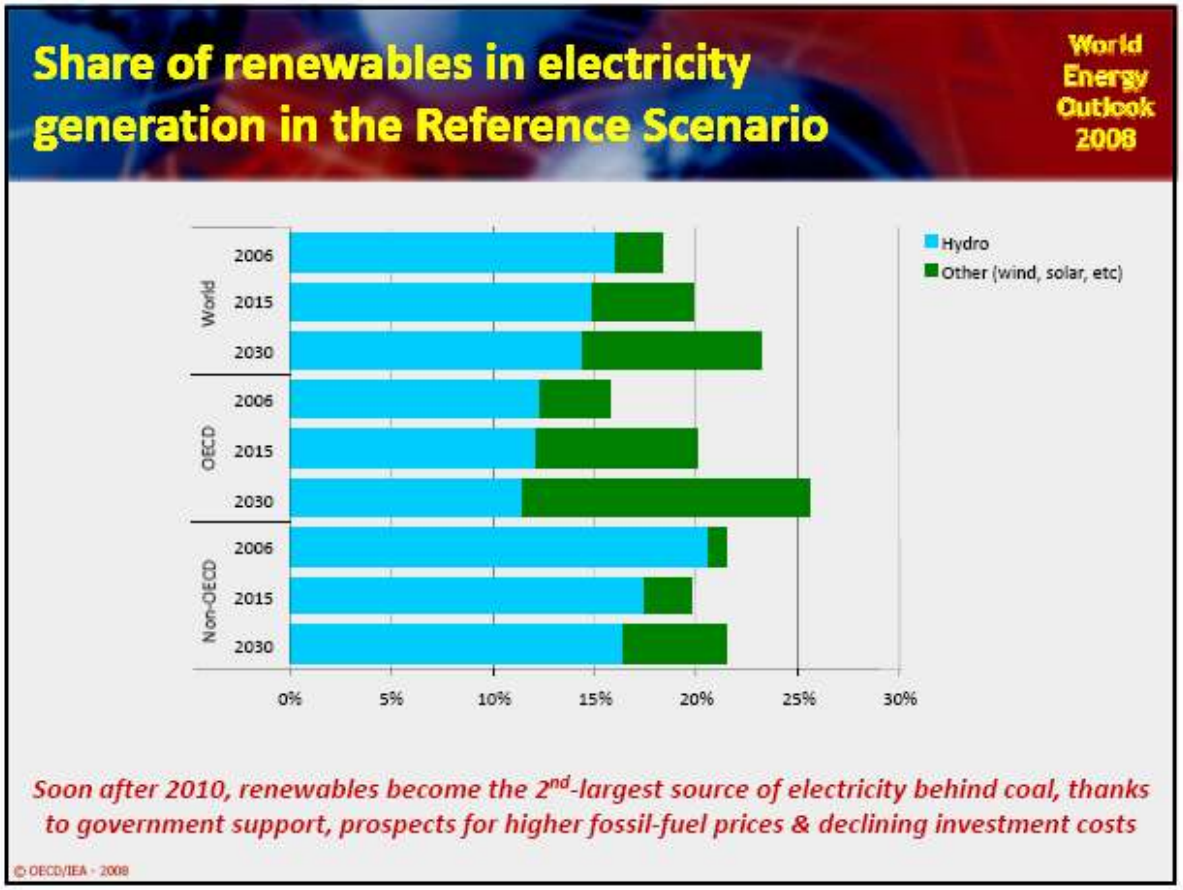
Renewable: Most of it is hydro (10-20% of electricity generation) and the rest is much smaller (<<10%)



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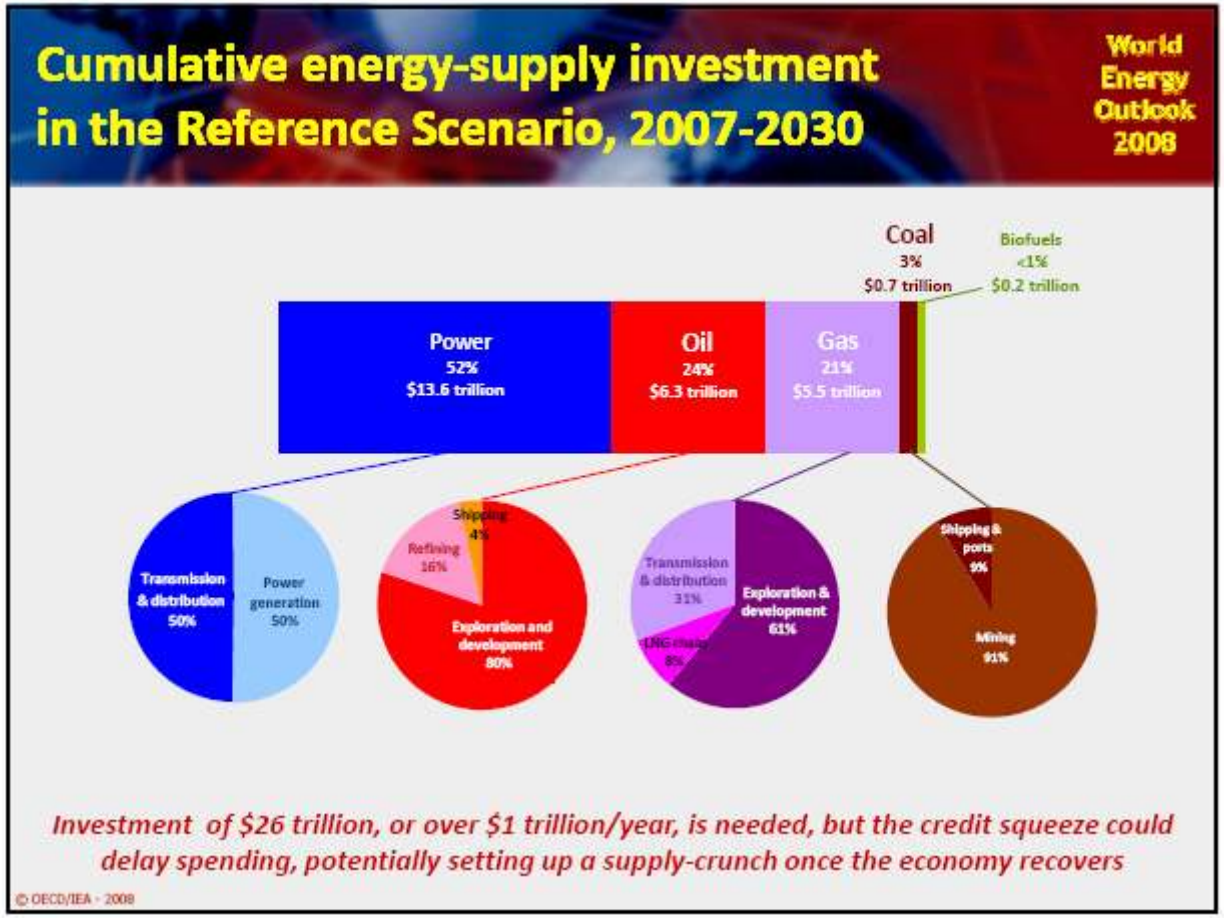
IEA Presentation to Press: 4/12/2008

+$26 trillion of investment (≈ 50% in power)



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World Energy Outlook 2008
IEA Presentation to Press: 4/12/2008

Three scenarios considered over 2006-2030:

1)fossil-fuel "business as usual" energy growth

2)550 and 450 ppm: stabilization of atmospheric CO2 concentrations

	Reference Scenario	550 ppm Scenario	450 ppm Scenario
Primary energy demand (2006-2030)	+1.6%/y	+1.2%/y	+0.8%/y
Temperature increase (->2100)	Up to +6°C	+3°C	+2°C
CO2 energy-related emissions by 2030	41 Gt	33 Gt	26Gt
Carbone capture and storage (CCS) by 2030	negligible	160 Gw	350 Gw

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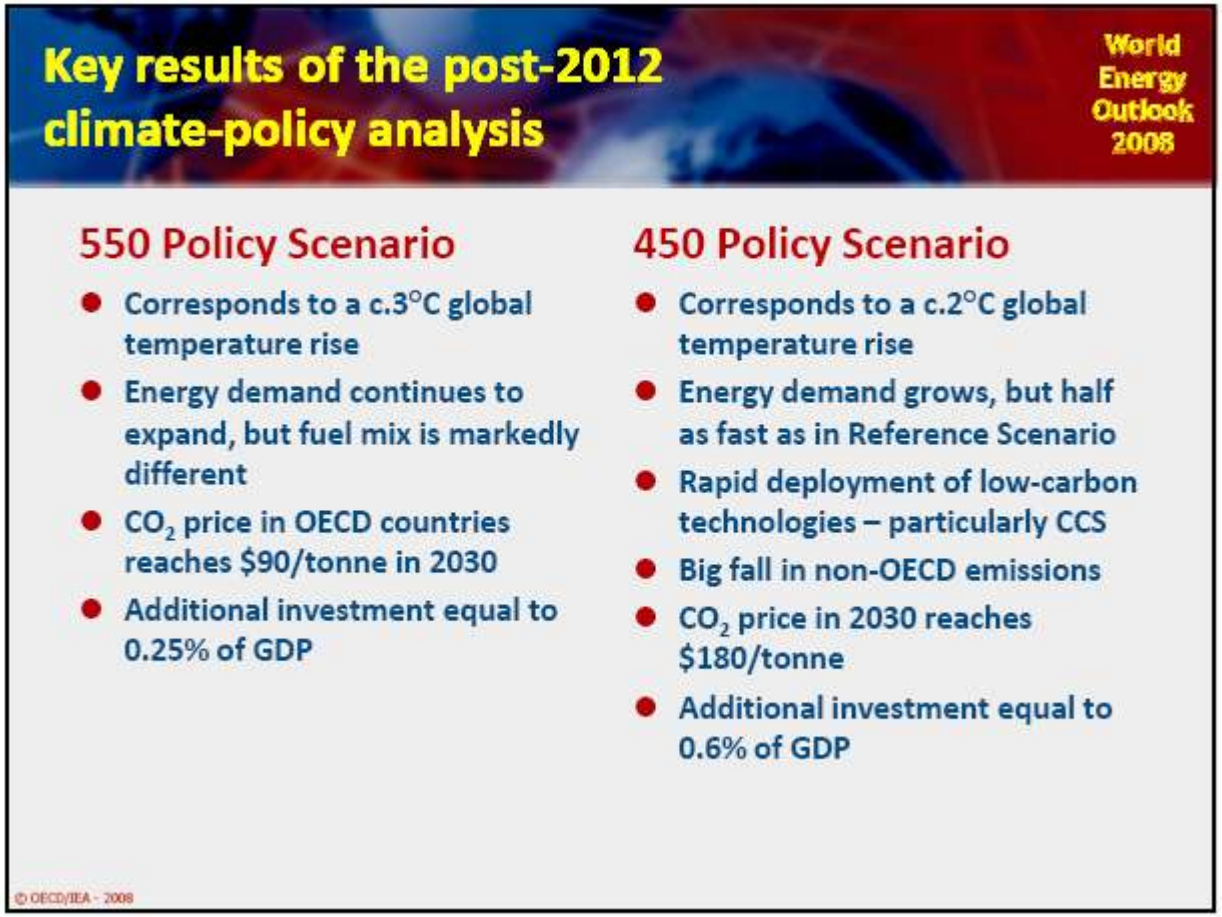
World Energy Outlook 2008
IEA Presentation to Press: 4/12/2008

Two scenarios considered to stabilize CO_2 atmospheric concentrations: ie.550 and 450 ppm



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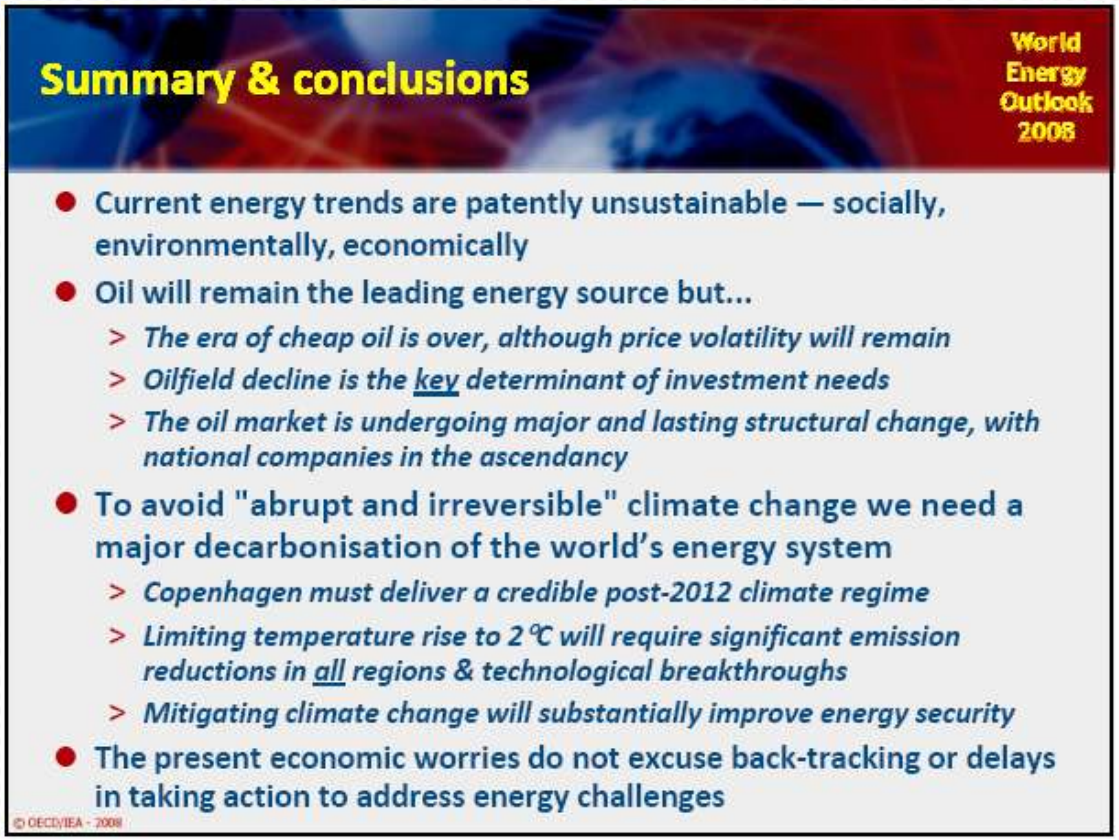
World Energy Outlook 2008
IEA Presentation to Press: 4/12/2008

A major decarbonisation of the world's energy system is needed. The Copenhagen conference (Nov-Dec 09) must deliver a credible post-2012 climate regime



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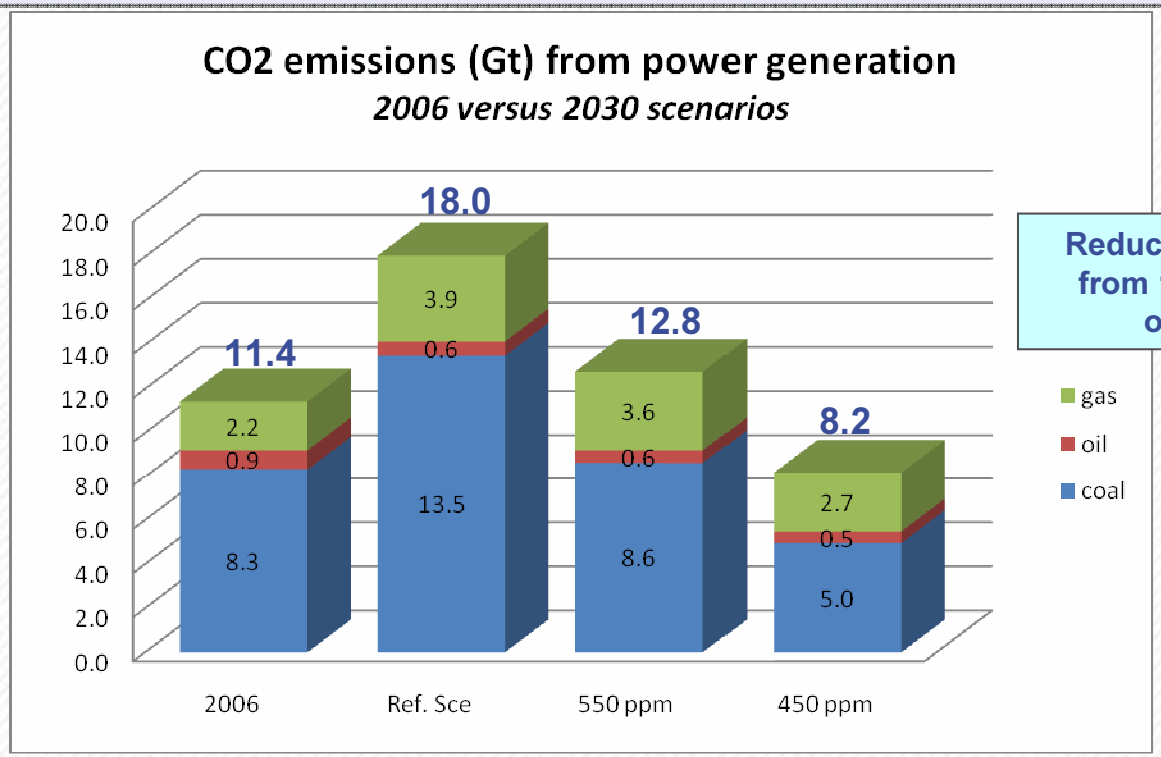
World Energy Outlook 2008
Power generation - CO2 emissions

With 41% of CO2 energy-related emissions (2006), power generation mix offer CO2 reduction opportunities

In short, this change means more renewable and nuclear, with less fossil fuel (CCS equipped)



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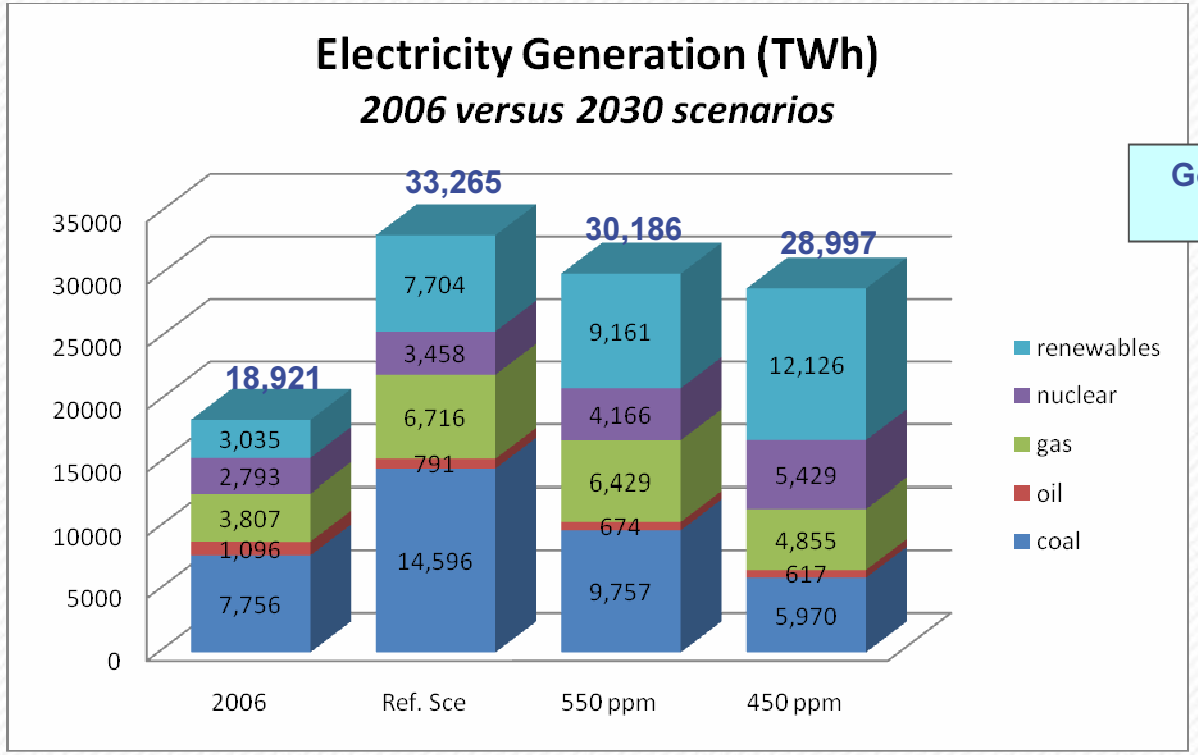
World Energy Outlook 2008
Power generation - Delivered

To achieve CO2 reduction by 2030, nuclear and renewable will increase, and fossil fuel will stay flat or decrease

The upside is more limited for hydro than nuclear



Going from ≈ 19,000 to 30,000 TWh over 2006 to 2030

Over 2006-2030:
Renewable ≈ x4
Nuclear ≈ x 2
Fossil fuel ≈ flat

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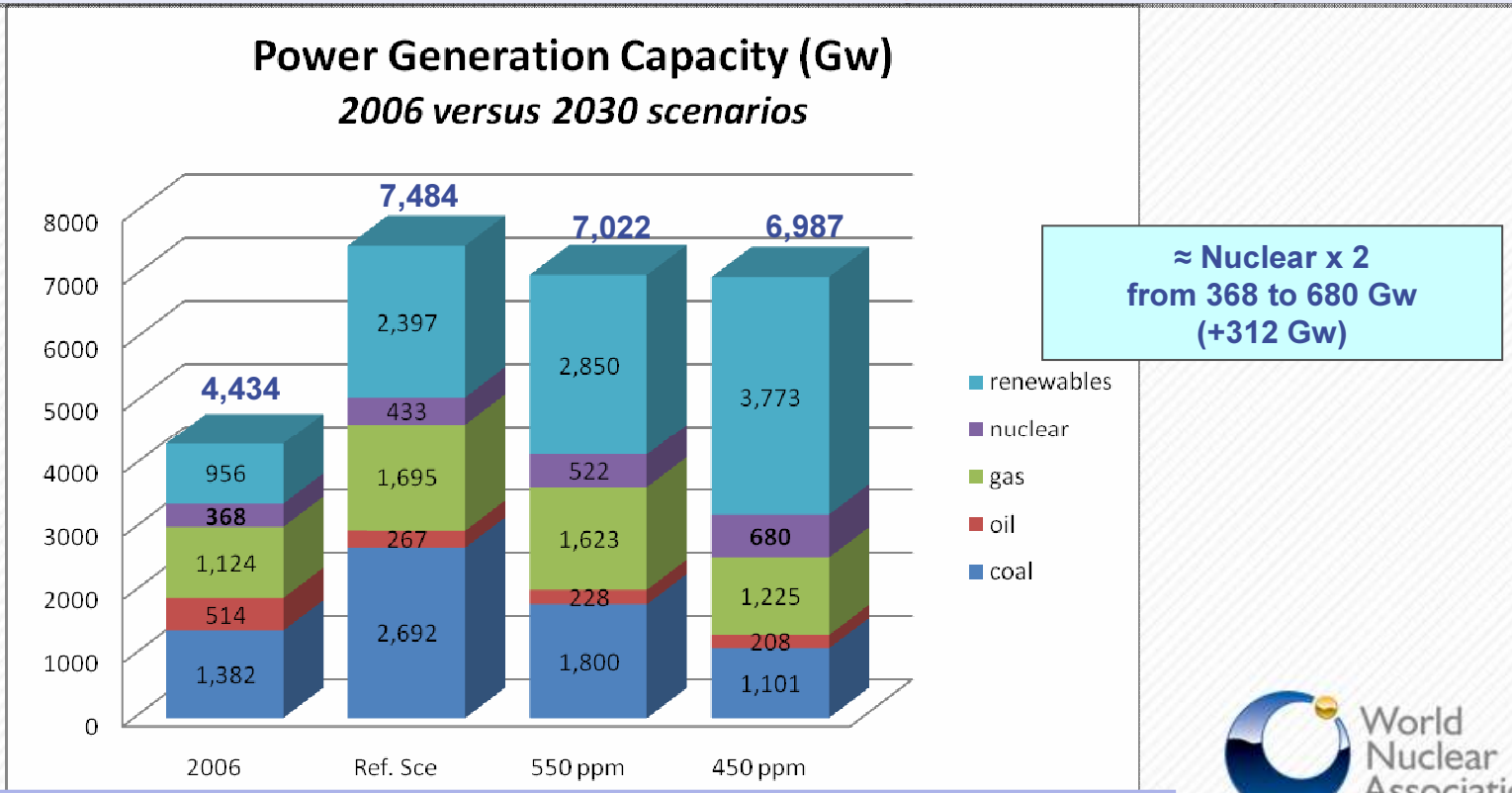
World Energy Outlook 2008
Power generation - Capacity

To achieve CO2 reduction by 2030, nuclear and renewable will increase, and fossil fuel will stay flat or decrease

An extra 312 Gw of nuclear is already foreseen by IEA



Note: 312 = 680 - 368 Gw = 8 to 13 new nuclear power plants (NPPs) per year

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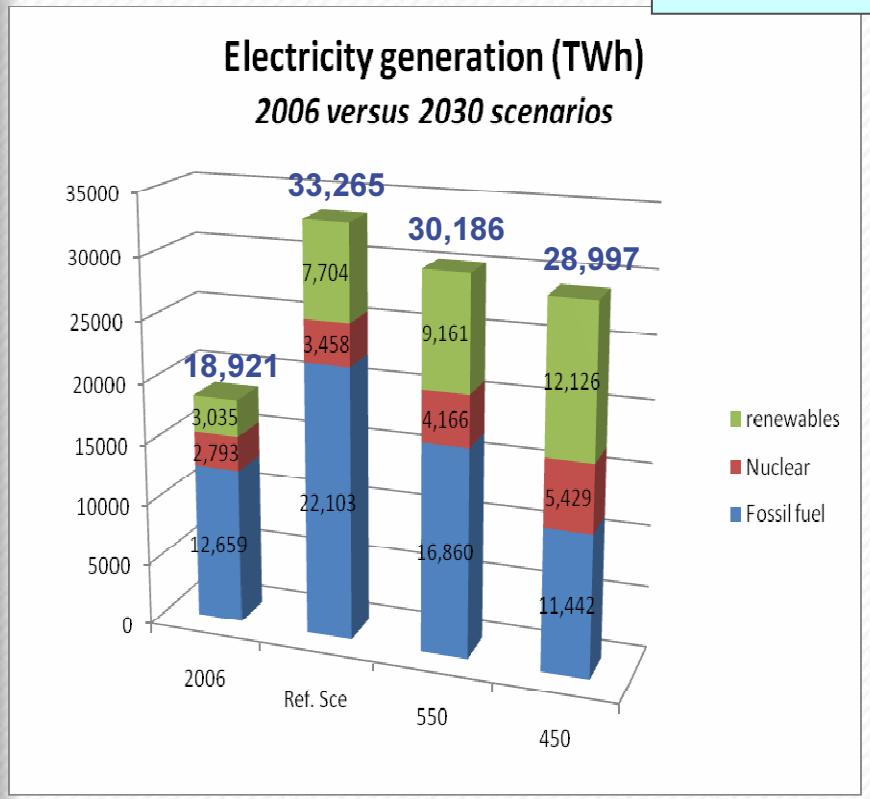
World Energy Outlook 2008
Electricity generation and CO2 emissions

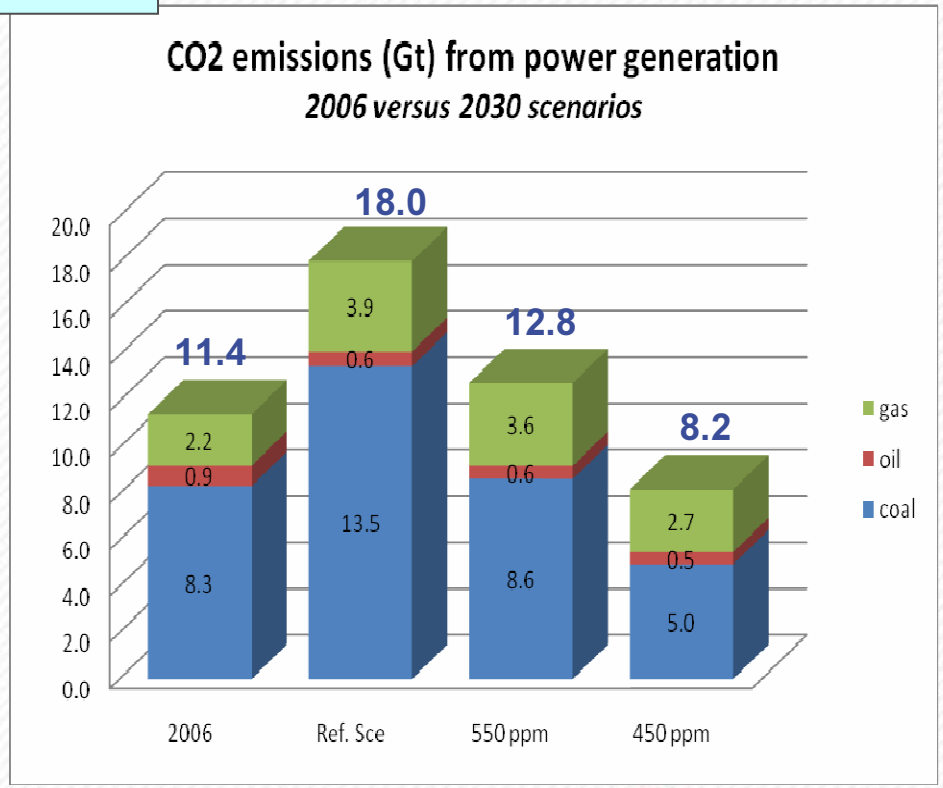
What if the challenges of CCS for fossil fuel and of the great expansion of renewable cannot be met in time? Is 'ready-to-deploy' nuclear sufficiently accounted for?

Going from ≈ 19,000 to 30,000 TWh over 2006 to 2030

Over 2006-2030:
Renewable ≈ x4
Nuclear ≈ x 2
Fossil fuel ≈ flat

Reducing CO2 emissions from 11 Gt down to ??? over 2006-2030





HSE Challenges
1c. Overall protection benefits from nuclear energy

Already, an extra 312 Gw of nuclear power by 2030 would help meeting the world CO2 reduction goal (450 ppm)

- The expected rate of new nuclear build is 8 to 13 NPP/y
- This would save 2.5 Gt of CO_2 emissions per year

In comparison to further deploying nuclear, the greatest challenges are:

- Developing and widely applying CCS to fossil fuel energy
- Considerably expanding renewable energy (hydro and others)

Achieving this within two decades adds to the challenge

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New nuclear build: Overall protection benefits

The option of further increasing 'ready-to-deploy' nuclear energy beyond 680 Gw (5,400 TWh) by 2030 is key: e.g.

Potential extra savings from nuclear energy		
TWh	**Gt CO2**	**Gw**
1,000	1	125
2,000	2	250
3,000	3	**375**

An extra 10 to 15 new NPPs/y over 2006-30

Would allow to overcome shortcomings concerning CCS for fossil fuel energy and the expansion of renewable energy

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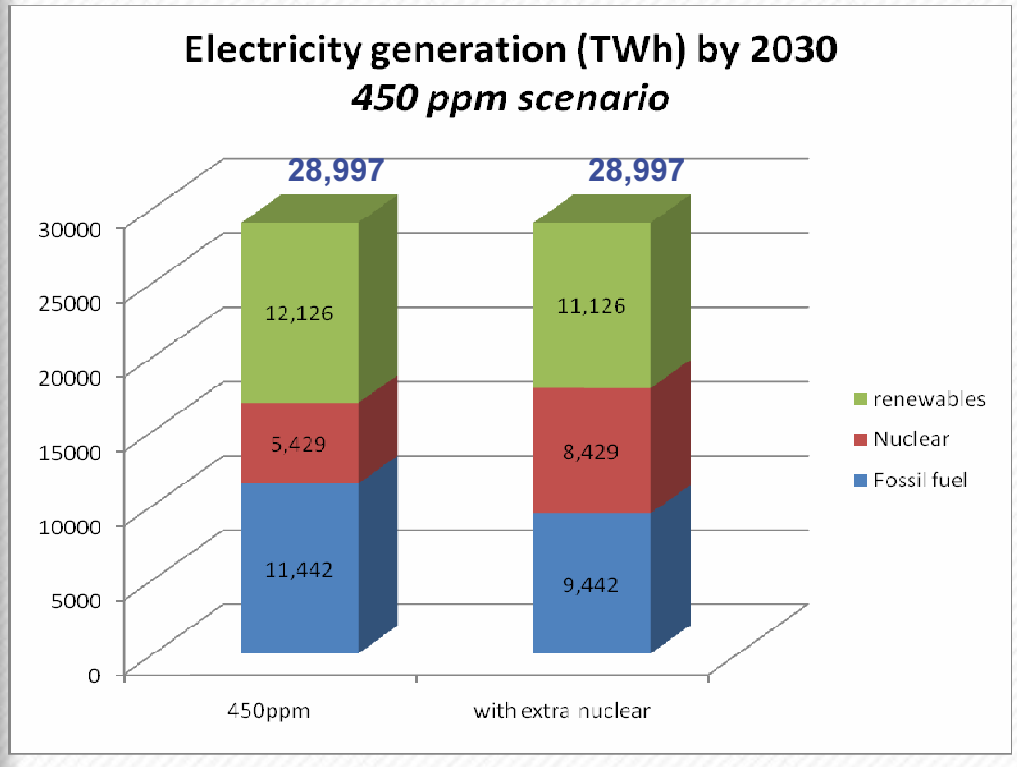
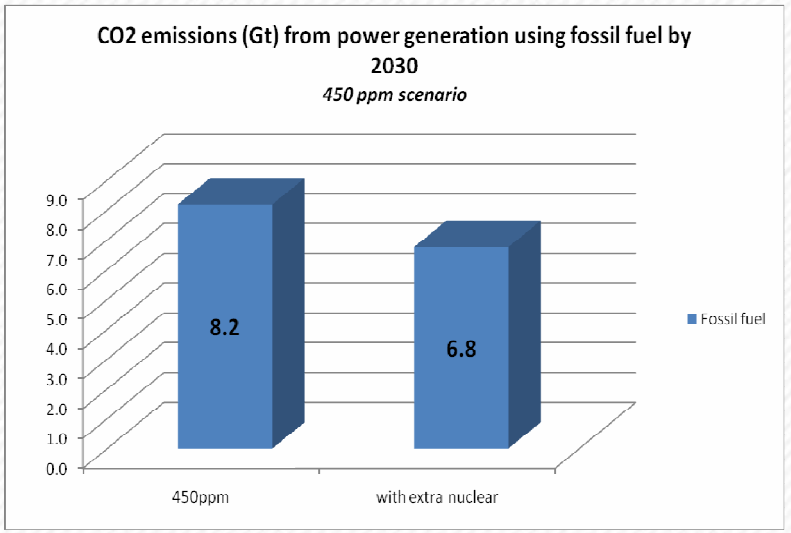
New nuclear build: Overall protection benefits

What would be the energy mix and CO_2 emissions if an extra 3,000 TWh (+375 Gw) of nuclear is added by 2030:

- Total nuclear : 8,500 TWh (1,055 Gw: 680 + 375)
- Equivalent reduction of 2,000 TWh from fossil fuel and of 1,000 TWh from renewable





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Climate Change &Environmental-Health Protection

As CO2 reduction targets should not be missed, by 2030, nuclear energy can reach up to 1,000 Gw (8,000 TWh)

- With 8 Gt of CO2 emission savings

This would help to overcome any shortcomings in developing CCS and in expanding renewable energies

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Towards a major decarbonisation =>nuclear power

Aiming for a more balanced mix of electricity generation by 2030: fossil fuel, renewable and nuclear (each 10,000 TWh)

Post-2030, decarbonisation will continue to augment with steadily increasing energy and power generation demands

Accounting for diverse clean-energy needs (electricity, heating, desalination, hydrogen, etc.), nuclear energy upside can be:

- 4,000 GW by 2050, and 8,000 Gw by 2100

•WNA Nuclear Century Outlook:

http://www.world-nuclear.org/outlook/clean_energy_need.html

Thank you for your attention
Questions?

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