

Why CCS?

Realities, threats and opportunities

Gøril Tjetland

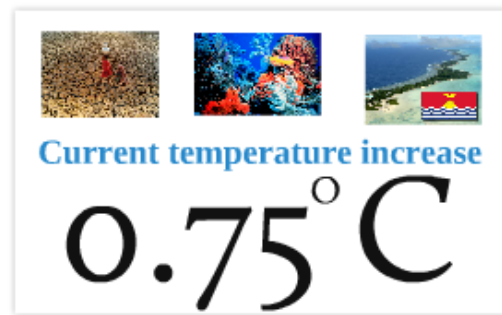
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Access this presentation at:
<http://prezi.com/hllhjisdwgdp/why-ccs/>

Why CCS?



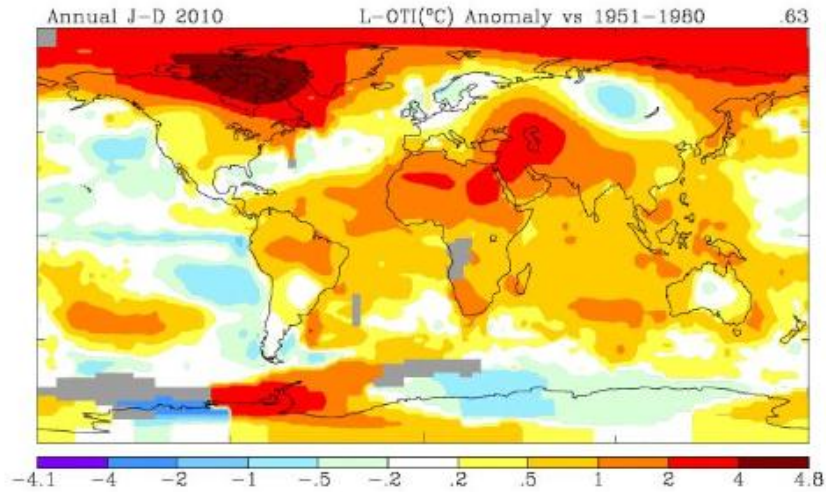
Climate change is already having a lethal effect on human beings, our livelihoods and infrastructure, and the ecosystems all life depends upon

GISS Surface Temperature Analysis

Sources and parameters: GHCN_GISS_HR2SST_1200km_Anom0112_2010_2010_1951_1980

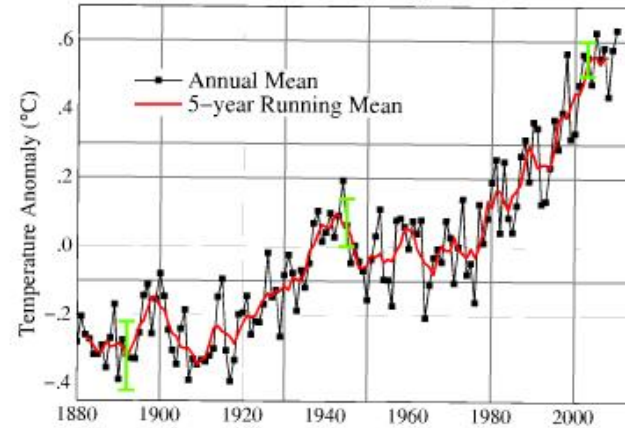
Note: Gray areas signify missing data.

Note: Ocean data are not used over land nor within 100km of a reporting land station.



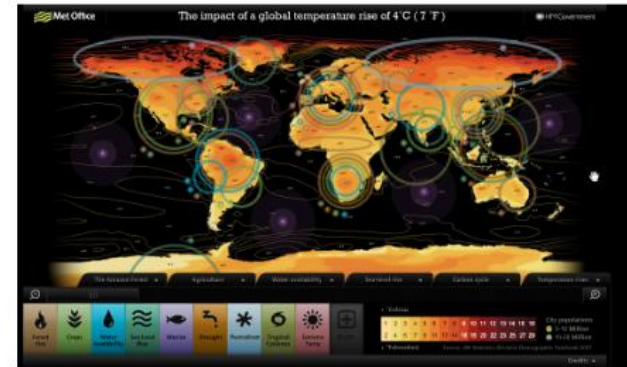
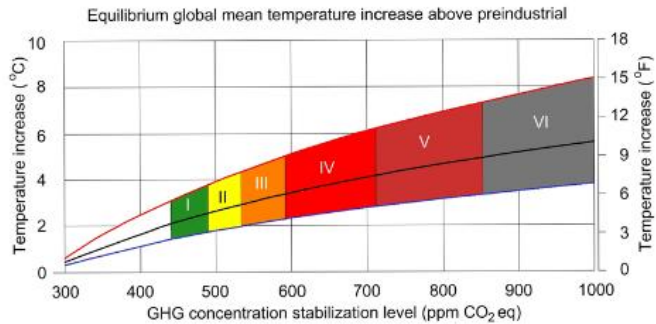
<http://data.giss.nasa.gov/gistemp/graphs/>

Global Land-Ocean Temperature Index



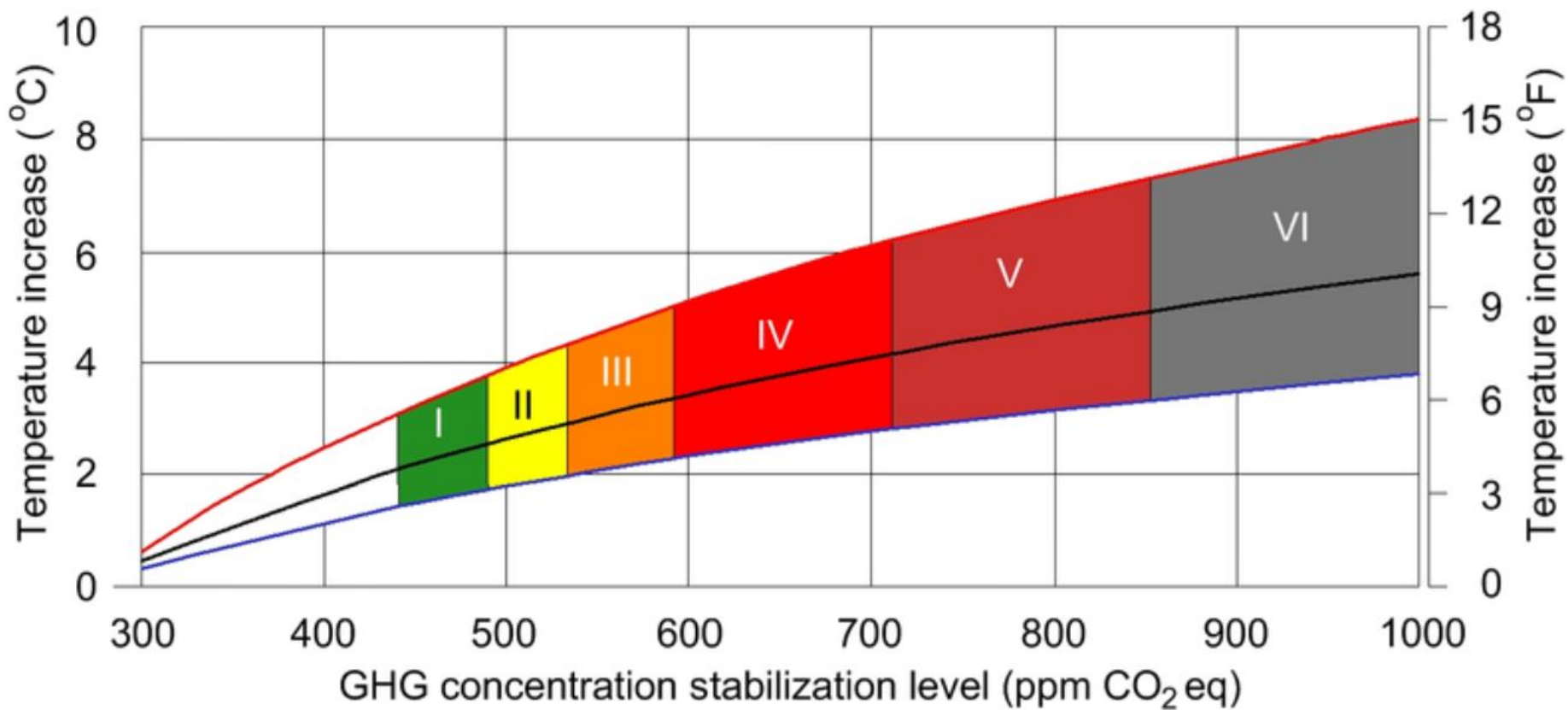
A question of great RISK

RISK =
probability x consequence



www.metoffice.gov.uk/hadobs

Equilibrium global mean temperature increase above preindustrial



In the meanwhile...



Emissions have increased by 3 percent per year since 2000

Global energy demand is projected to increase by 40% by 2030 (IPCC 2007) and by 45% by 2035 (WEO 2010) with current policies.

Atmospheric CO₂ concentrations should not exceed 350 parts per million (ppm). We are already at 394.35 ppm, increasing at 2.5 ppm per year

IPCC: stabilisation temperature at >3 C up

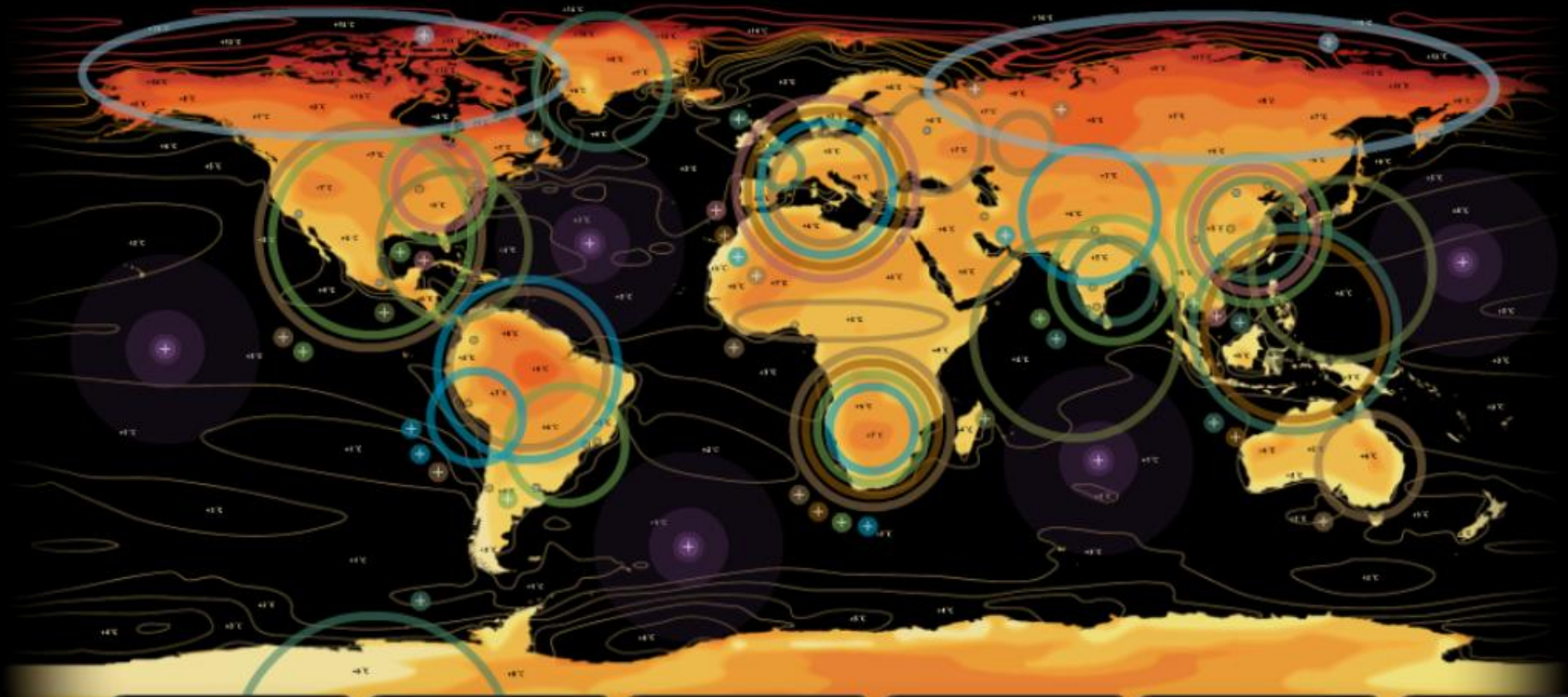
80-90% of global energy production is based on fossil fuel 2/3 of the global population requires greater access to energy in order to raise their standard of living

Global CO₂ emissions from the energy sector

- have increased by 40% from 1990 to 2008 (coal use by 52%)
- are projected to increase by 65% from 1990 to 2020 and by 92% from 1990 to 2030

Fossil fuels remain the dominant source of primary energy worldwide. They account for more than 3/4 of the overall increase in energy use between 2007 and 2030

The net emission transfers via international trade from developing to developed countries increased from 0.4 Gt CO₂ in 1990 to 1.6 Gt CO₂ in 2008, which exceeds the Kyoto Protocol emission reductions (Petersa et al 2011)



The Amazon Forest ▲

Agriculture ▲

Water availability ▲

Sea-level rise ▲

Carbon cycle ▲

Temperature rises ▲



Forest Fire



Crops



Water Availability



Sea Level Rise



Marine



Drought



Permafrost



Tropical Cyclones



Extreme Temp



Health

+ °Celsius

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	4	5	7	9	11	13	14	16	18	20	22	23	25	27	29

+ °Fahrenheit

Source: UN Statistics Division Demographic Yearbook 2007

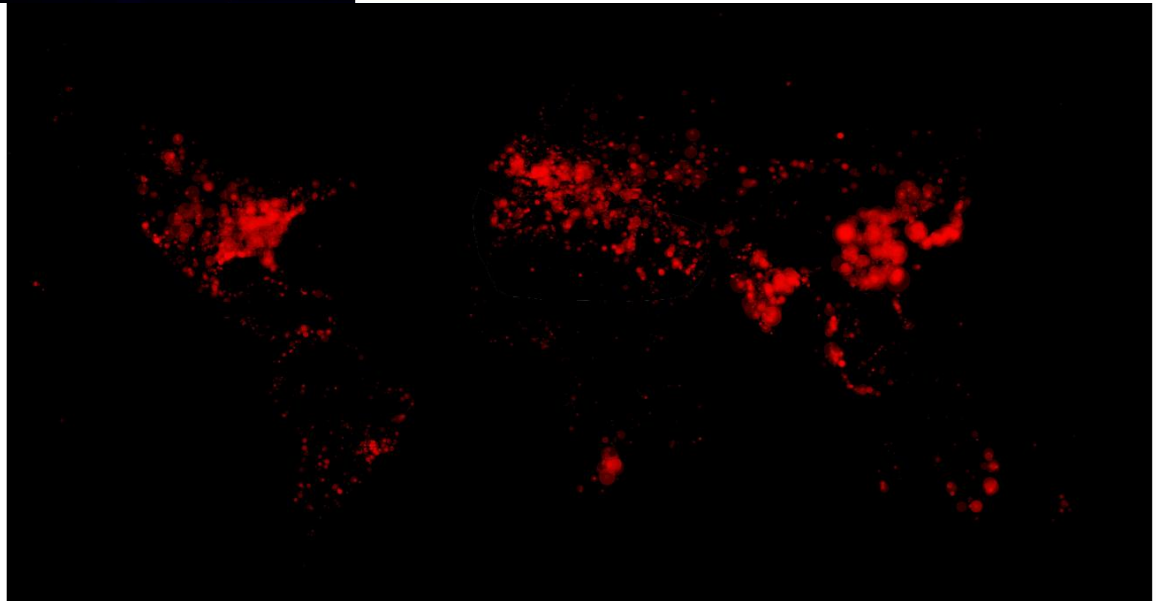
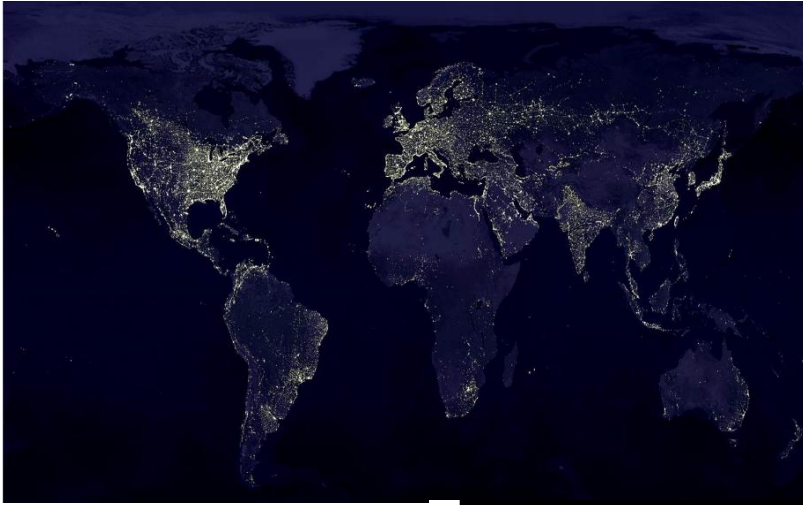
City populations

● 5-10 Million

● 10-20 Million

Credits ▲

A GLOBAL problem

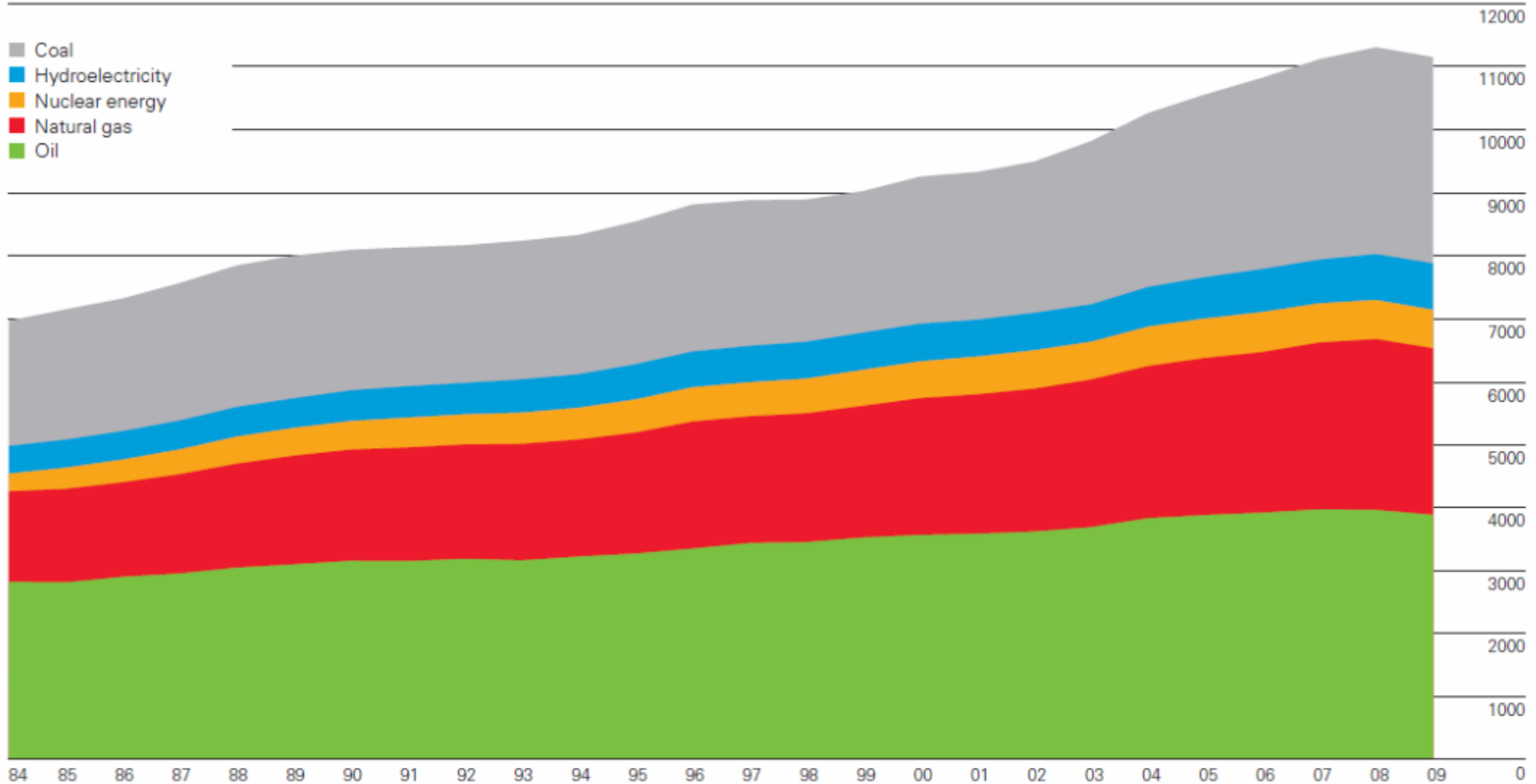


“ Climate change is happening more rapidly than anyone thought possible. Should humankind stop worrying about global warming and instead start panicking? My conclusion is that we are still left with a fair chance to hold the 2°C line, yet the race between climate dynamics and climate policy will be a close one.”

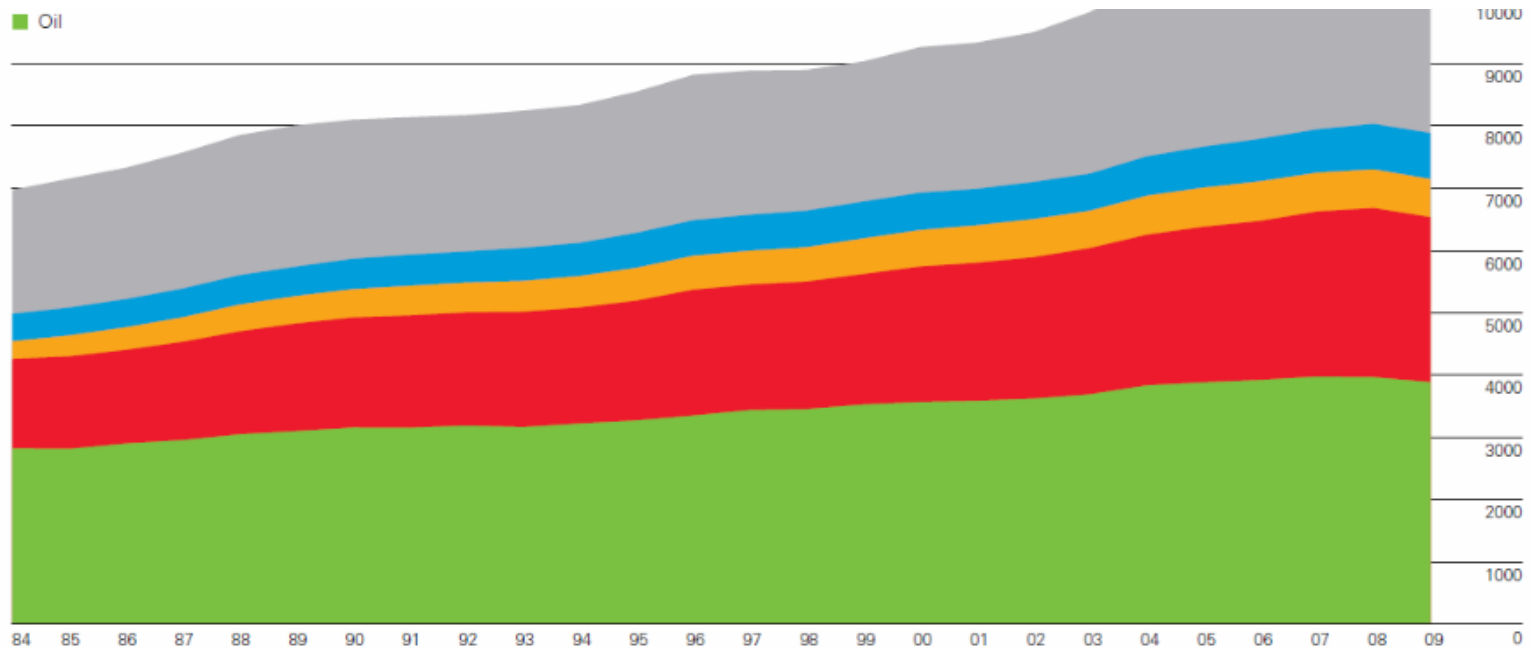
Hans Joachim Schellnhuber — Founding Director, Potsdam Institute for Climate Impact Research (PIK);
Member, Intergovernmental Panel on Climate Change (IPCC)

World consumption

Million tonnes oil equivalent



World primary energy consumption fell by 1.1% in 2009, the first decline since 1982. Consumption was weaker than average in all regions. While oil remains the leading fuel (accounting for 34.8% of global primary energy consumption), it continues to lose market share. Coal's share of global energy consumption was the highest since 1970.



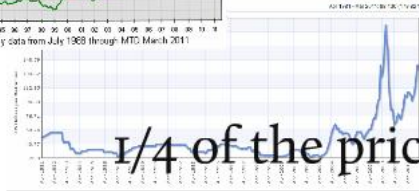
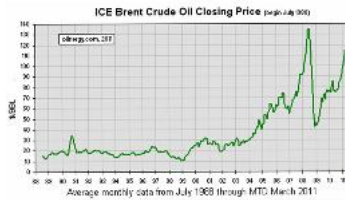
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BP statistical review 2010

IEA writes down demand (see WEO from 2004 to 2011) and IHS does not talk about oil peak anymore, but a peak in energy demand

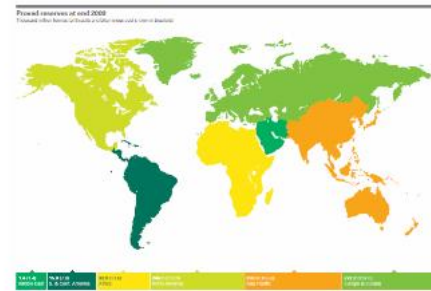
The scale of the challenge

"King Coal"



1/4 of the price of coal = 4.879 barrels of crude oil equivalent

Source: EIA, "Monthly Energy Review" (MERR), Table 1.1.1, "Crude Oil Production and Consumption in the United States" (2011).

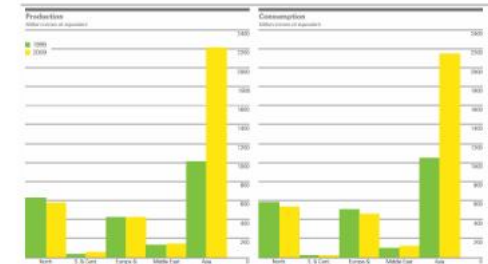


- Asia Pacific consumption 2009 = approx. 3 300 Mt coal
- Asia Pacific proven reserves = 260 000 Mt coal (of which 156 000 is anthracite and bituminous coal)
- Even if you double the consumption that's proven reserves for 40 years ..



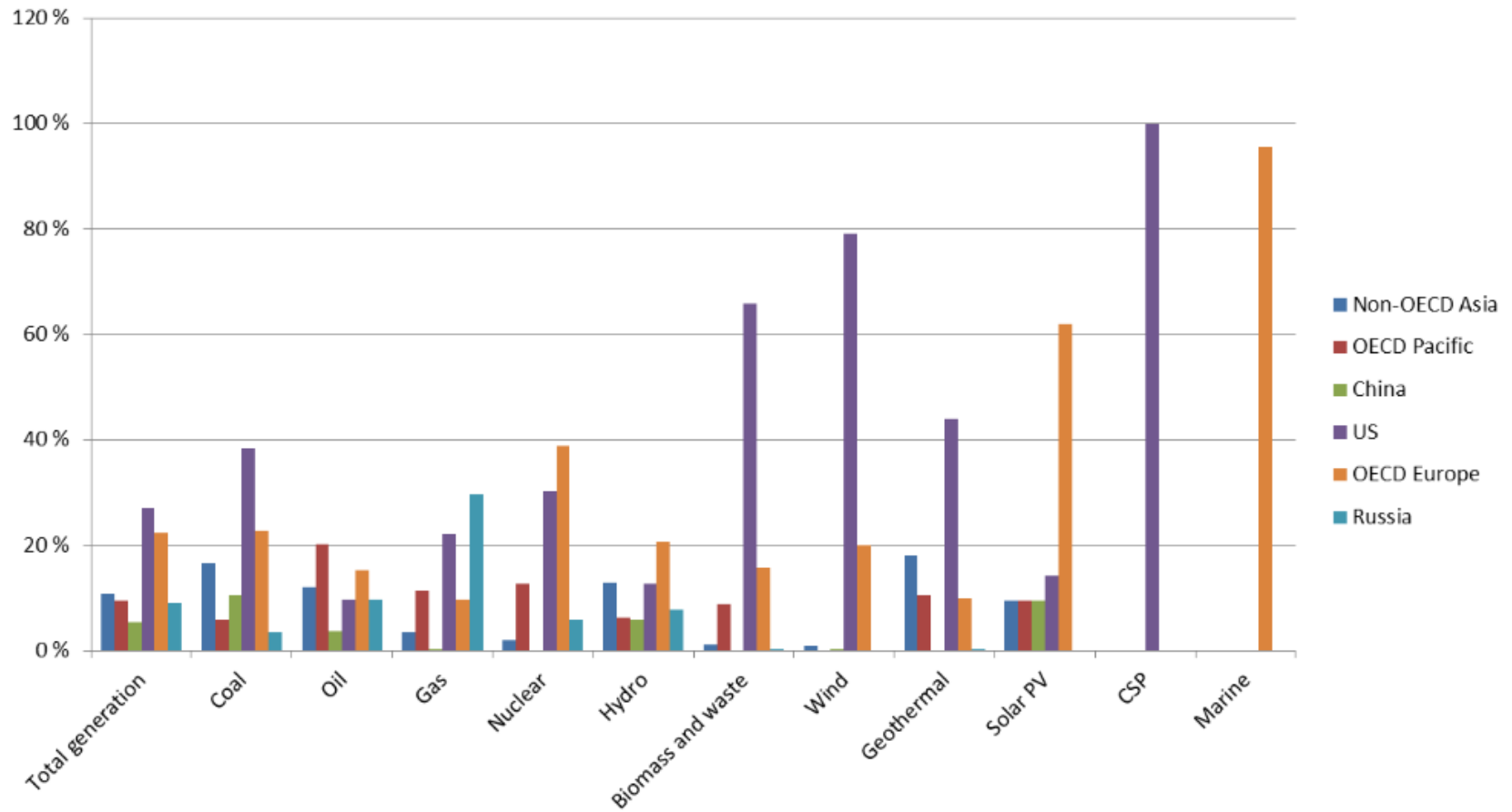
Coal covers (WEO 2010):

- more than 79 % of China's el gen
- 49 % of US` el gen
- 41 % of the world el gen

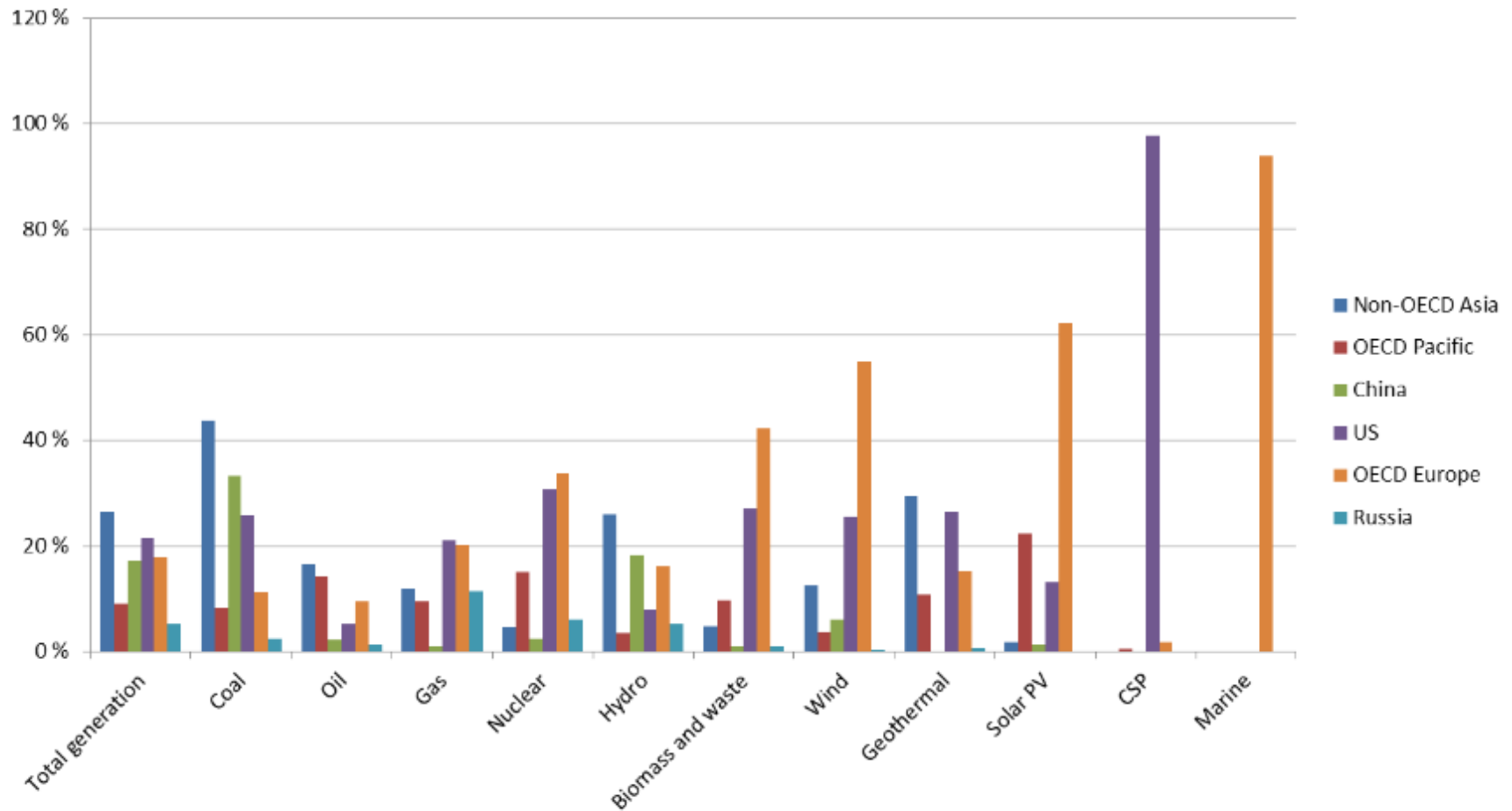


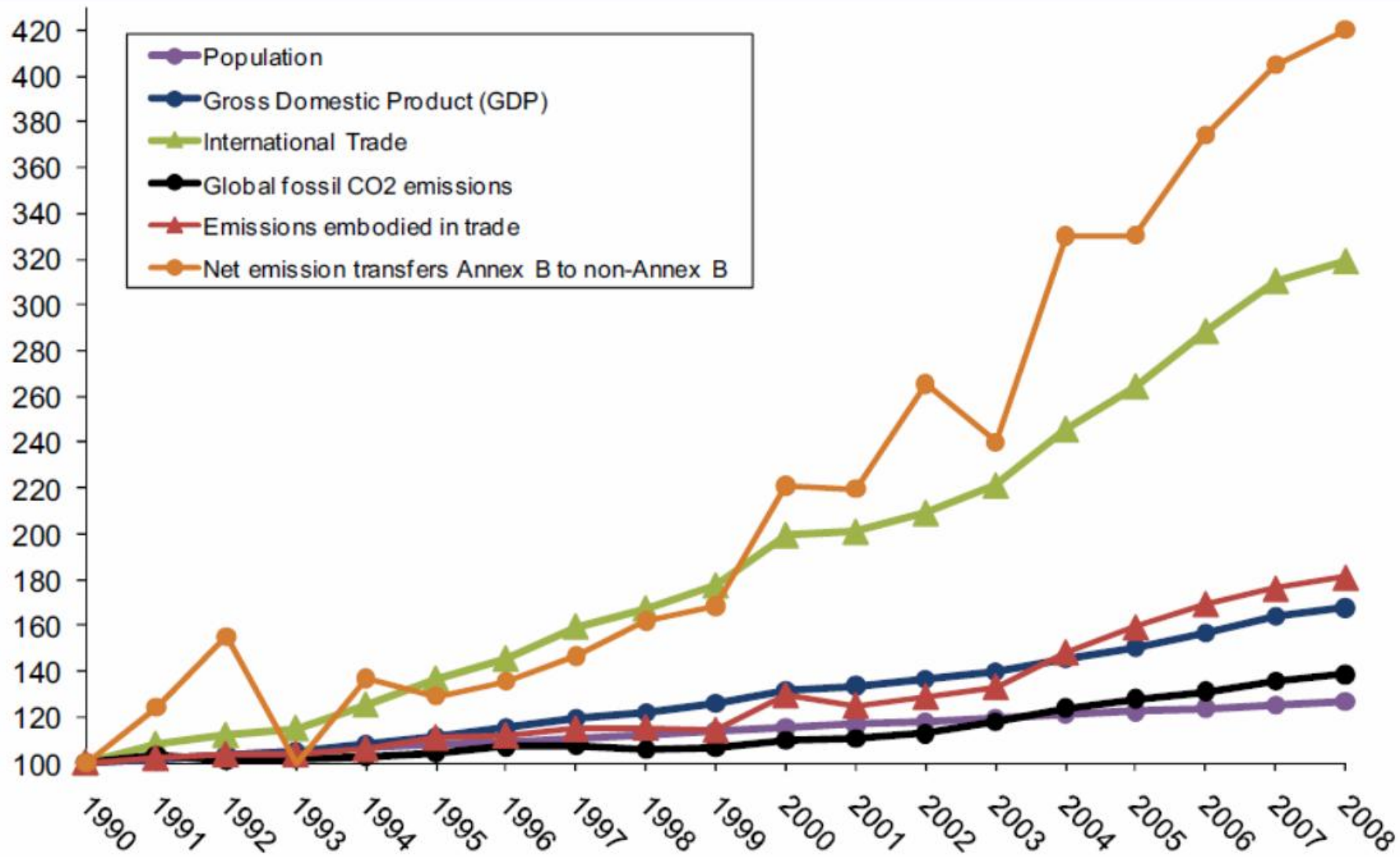
1 metric ton hard coal = approximately 2/3 metric tons of oil equivalent

World electricity generation (%) in 1990



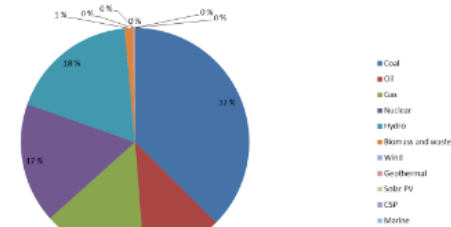
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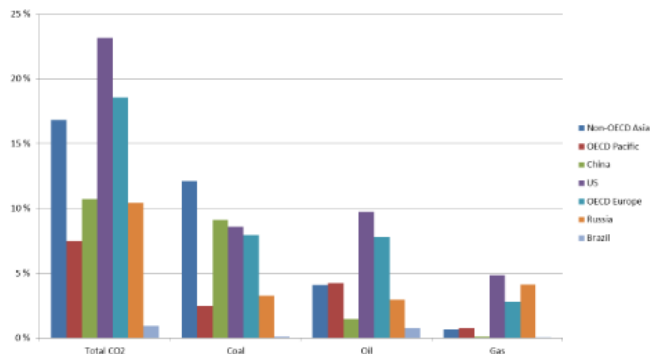


From fossil fuels	1990	2008	1990	2008
Total CO ₂	20 924	29 260	Of total	Of total
Coal	8 296	12 579	40 %	43 %
Oil	8 805	10 805	42 %	37 %
Gas	3 823	5 875	18 %	20 %

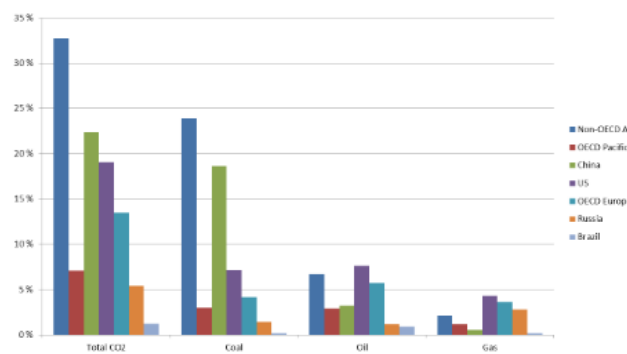
World electricity generation (TWh) (%) in 1990



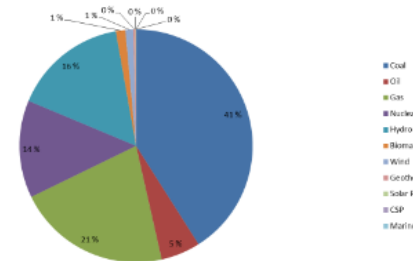
Total CO₂ emissions (Mt) 1990



Total CO₂ emissions (Mt) 2008

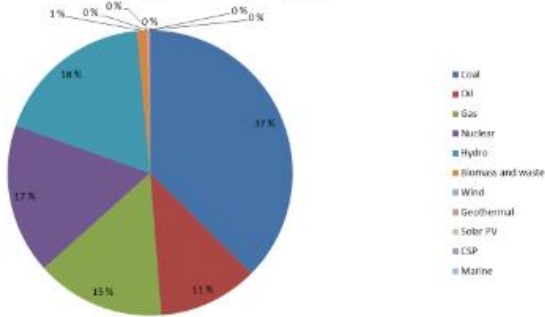


World electricity generation (TWh) (%) 2008

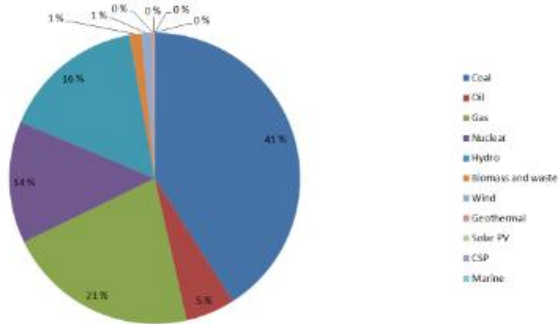


If you correct for GDP, population or any other parametre the picture is very different ...

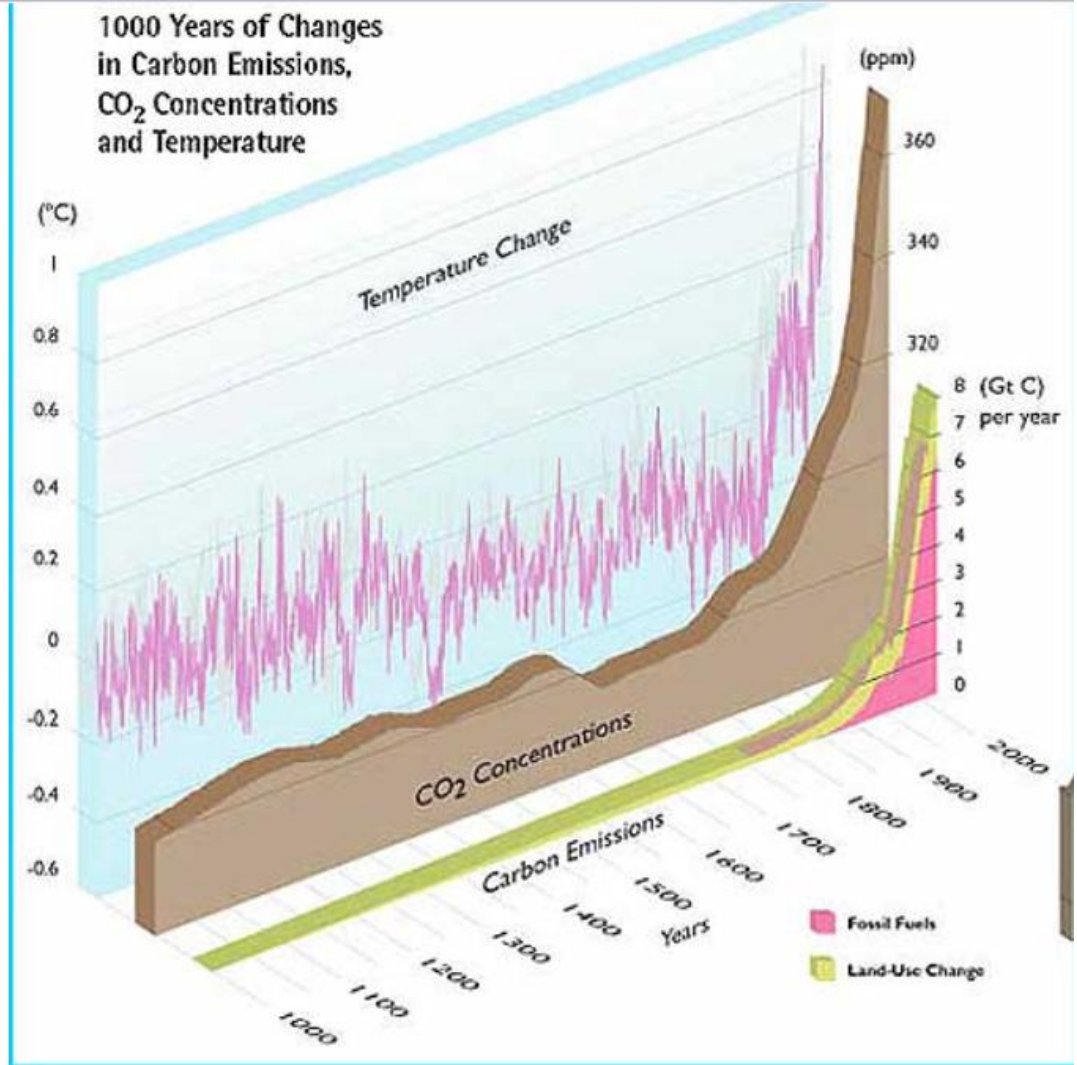
World electricity generation (TWh) (%) in 1990



World electricity generation (TWh) (%) 2008



1000 Years of Changes in Carbon Emissions, CO₂ Concentrations and Temperature



Financial crisis and job losses

Unsustainable practices leads to unsustainable jobs

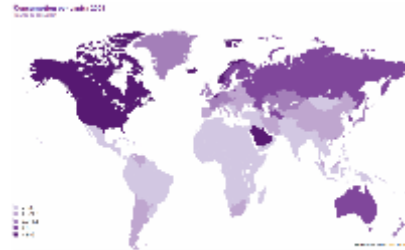
Need to create lasting jobs for a growing global work force

The Green Economy Initiative and the Global Green New Deal



source: Eric Usher, UNDP
www.unep.org/greeneconomy

Sustainable development is urgently needed



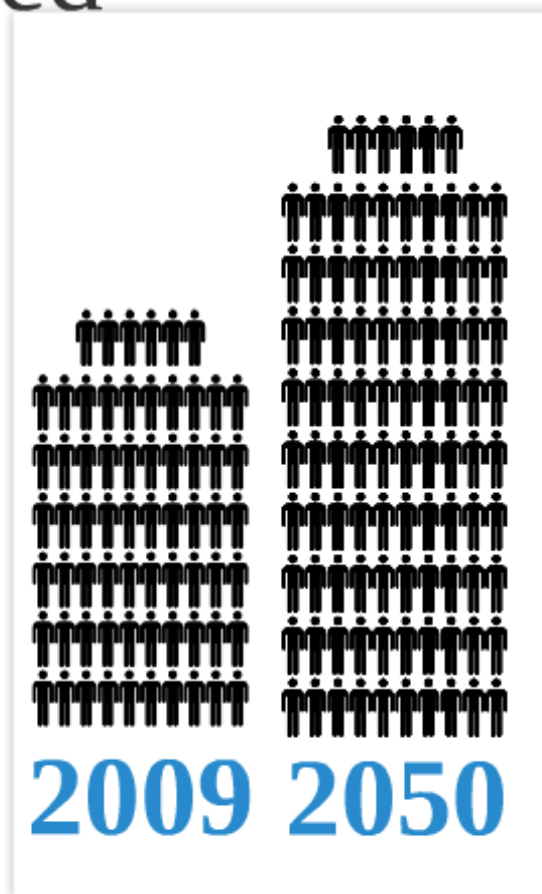
1,6 billion without access to electricity

2,5 billion rely on cow dung or firewood for cooking

80% live on less than \$3/day

Supported by a decreasing resource base

1 billion new workers in the next 10 years



We need to solve many problems in one!

Mitigate dangerous climate change by drastically and quickly reducing greenhouse gas emissions

Adapt infrastructure and livelihoods to tackle unavoidable climate change

Protect ecosystems and biodiversity & secure access to food and water

Create jobs & enable sustainable, economic development

Improve air quality & protect human health

Coal power plants

Refineries

CO₂ SOURCES

Pulp and paper

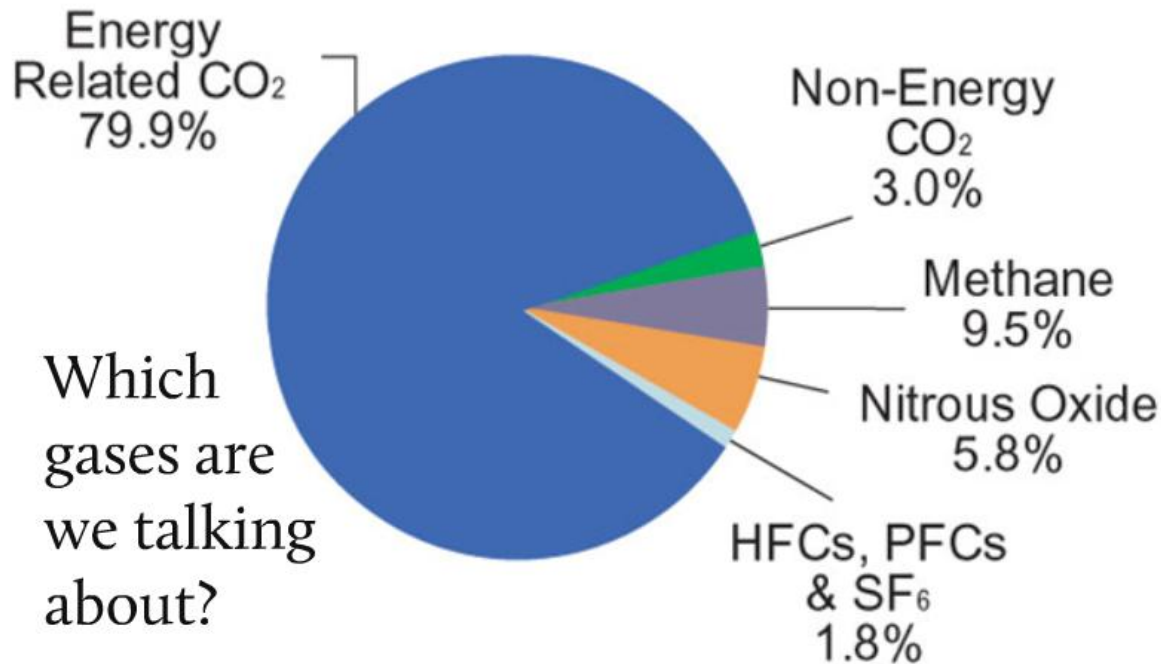
Cement kilns

Iron/steel factories

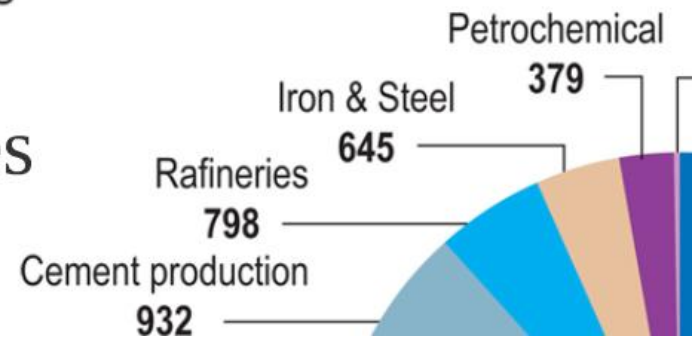
Gas power plants

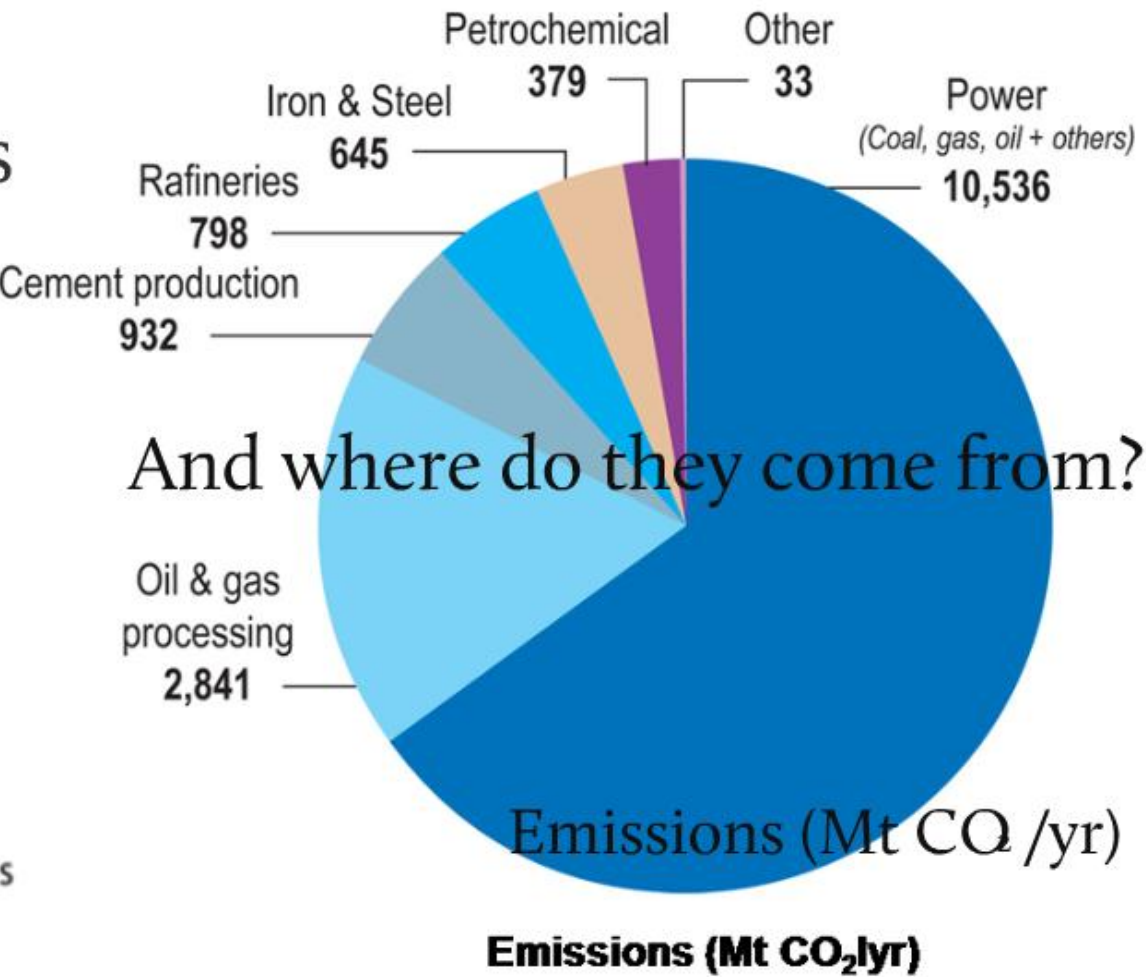
Chemicals

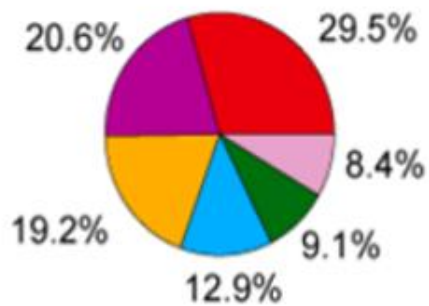
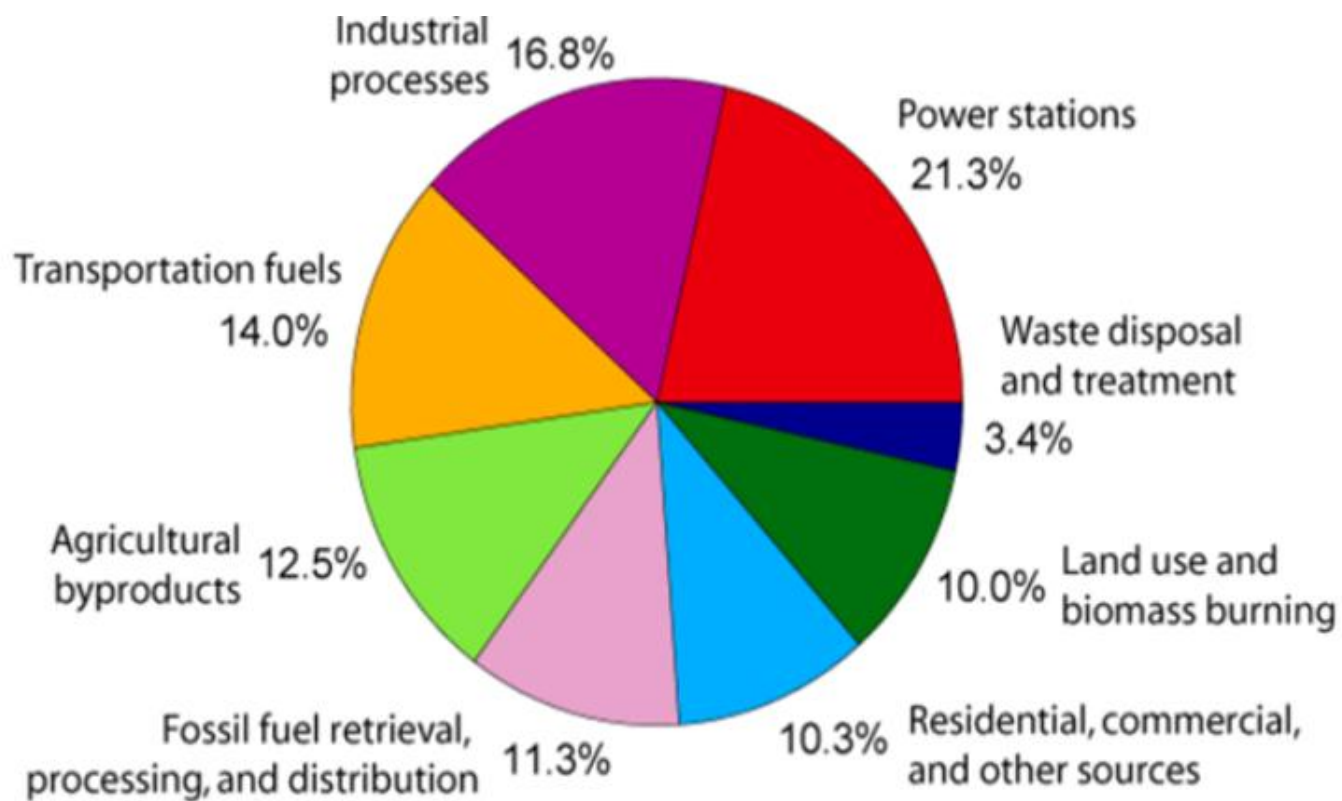




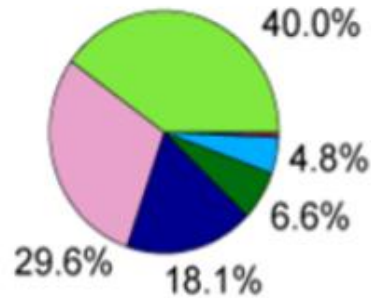
Data from IEA GHG databases



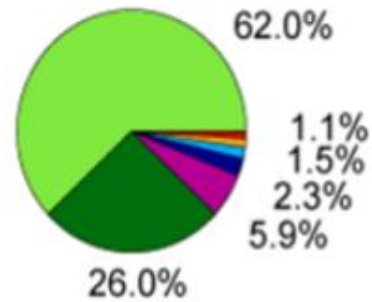




Carbon Dioxide
(72% of total)

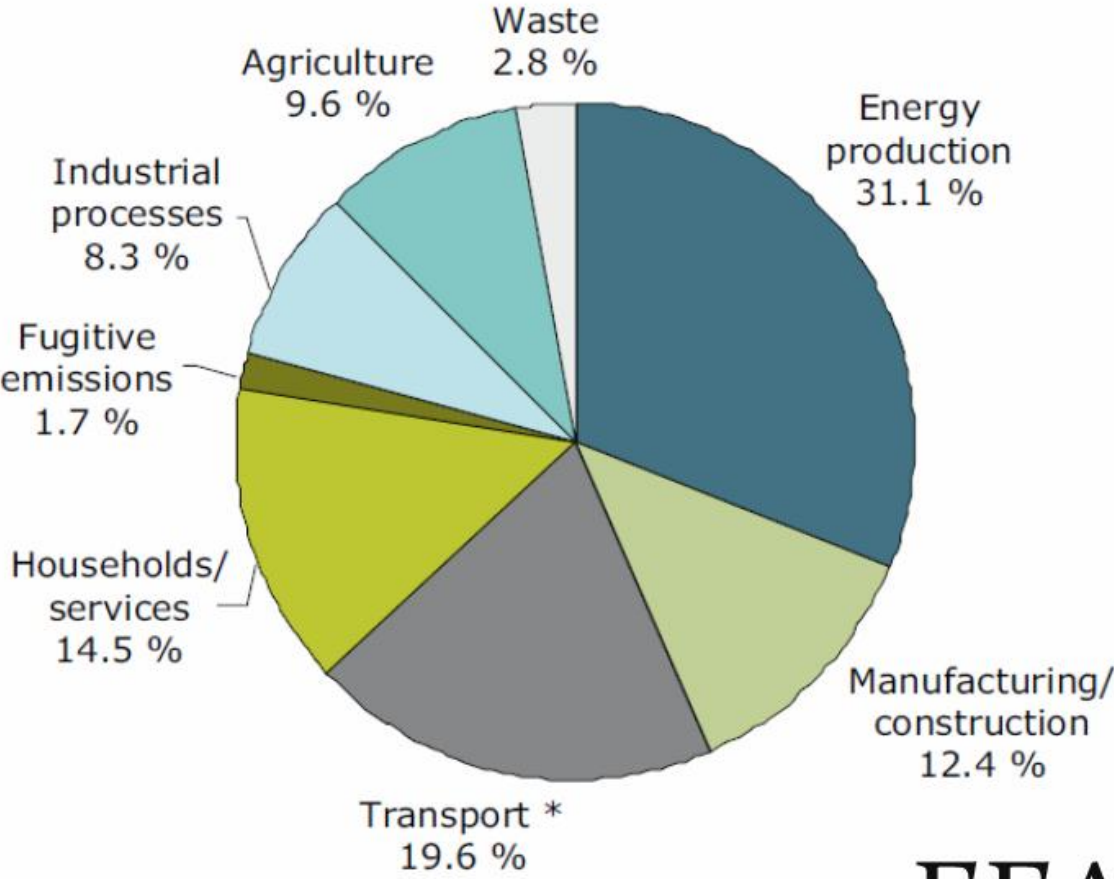


Methane
(18% of total)



Nitrous Oxide
(9% of total)

Total greenhouse gas emissions by sector in EU-27, 2008



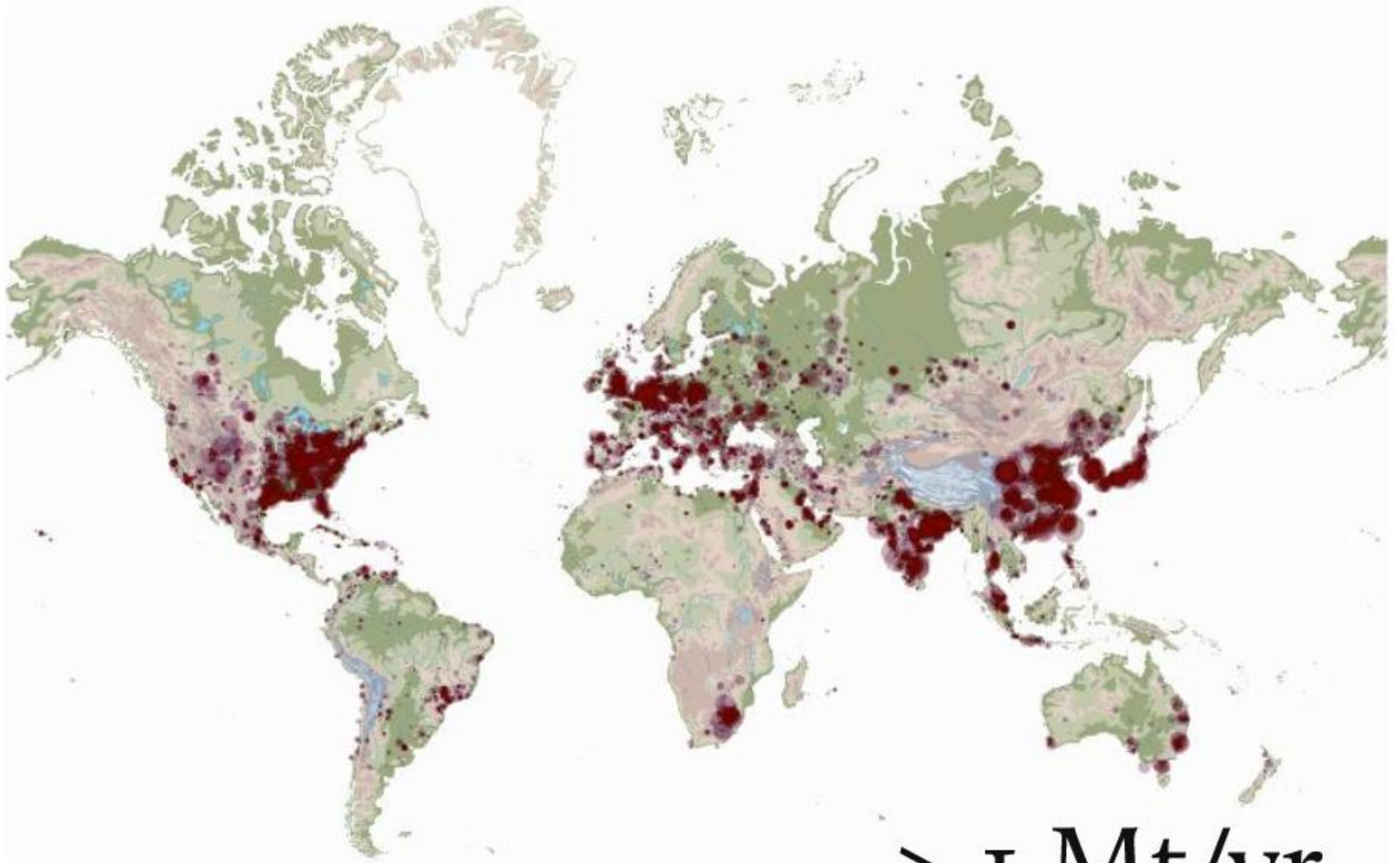
* Excludes international aviation and shipping (6 % of total GHG emissions)

EEA



The greatest CO₂
source is coal power
plants





> 1 Mt/yr

Process design

Post-combustion capture

- Capturing CO₂ from flue gas after combustion at atmospheric pressure.
- Wide range of applications in operation
 - Industrial manufacturing
 - Refinery and fuel transformation
 - Gas processing

- + Will suited for retrofitting
Does not interfere with existing process
- Lower separation efficiency

Pre-combustion capture

- Removing CO₂ from shifted syngas before combustion
- In commercial use in the chemical industry (ex: hydrogen and ammonia production from hydrocarbon feedstocks)
- Typical energy process design: Integrated Gasification Combined Cycle power plants

- + High separation efficiency
Lower operating costs
- Reliability concerns due to integrated process
Not well suited for retrofitting

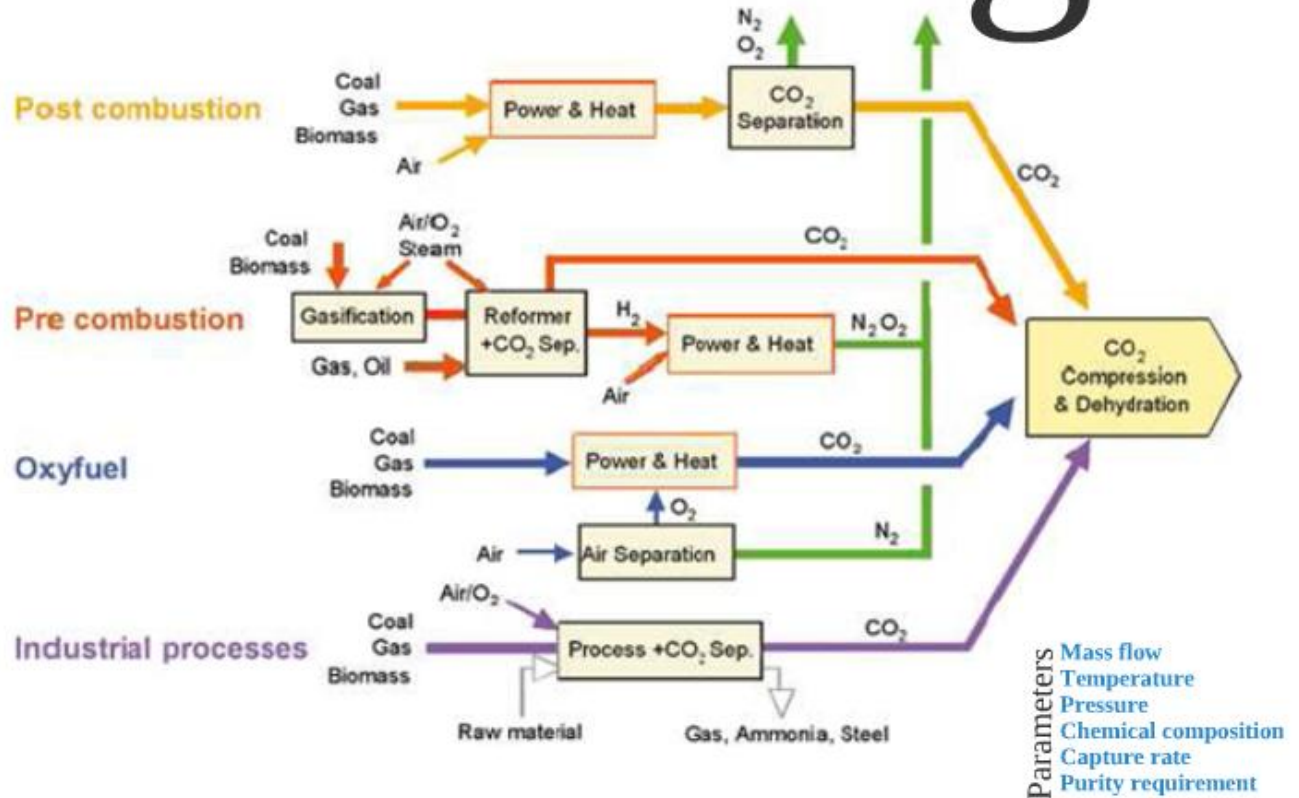
Oxyfuel combustion

- Combusting hydrocarbons in pure oxygen
- Oxygen produced in an air separation unit (ASU)
- Results: 70-85% CO₂ in flue gas, avoiding the need for CO₂ separation

- + Suited for retrofitting
Also dramatically reduces SOx and NOx emissions
- Less large-scale experience than alternatives

Industrial processes

- CO₂ capture from facilities producing cement, chemicals, aluminium, steel, paper, petrochemicals, wood products and numerous other products
- Post-combustion is the most viable option, but oxyfuel may also be viable for some processes



Electricity is just there,
- it comes out from the wall



isn't
understood!

End-of-pipe solution

-treats the symptom, not the root cause

A bad excuse for Business as Usual



Investments in coal



'Greenwashing'
of and by the coal industry

Coal
Coal
Renewable
Renewable

How is CCS typically understood?

Competes with and reduces investments in renewable energy

- justifies the transition to sustainable energy

Expensive!

Why spend so much money building the industry's complex?



is it SAFE?

Electricity is just there,
- it comes out from the wall



It
isn't
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End-of-pipe solution

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A bad excuse for

Business as Usual



investments in coal



'Greenwashing'

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Clean
Coal?



Sustainable
Fossil Fuels?

Competes with and reduces investments in
renewable energy

- postpones the transition to sustainable energy

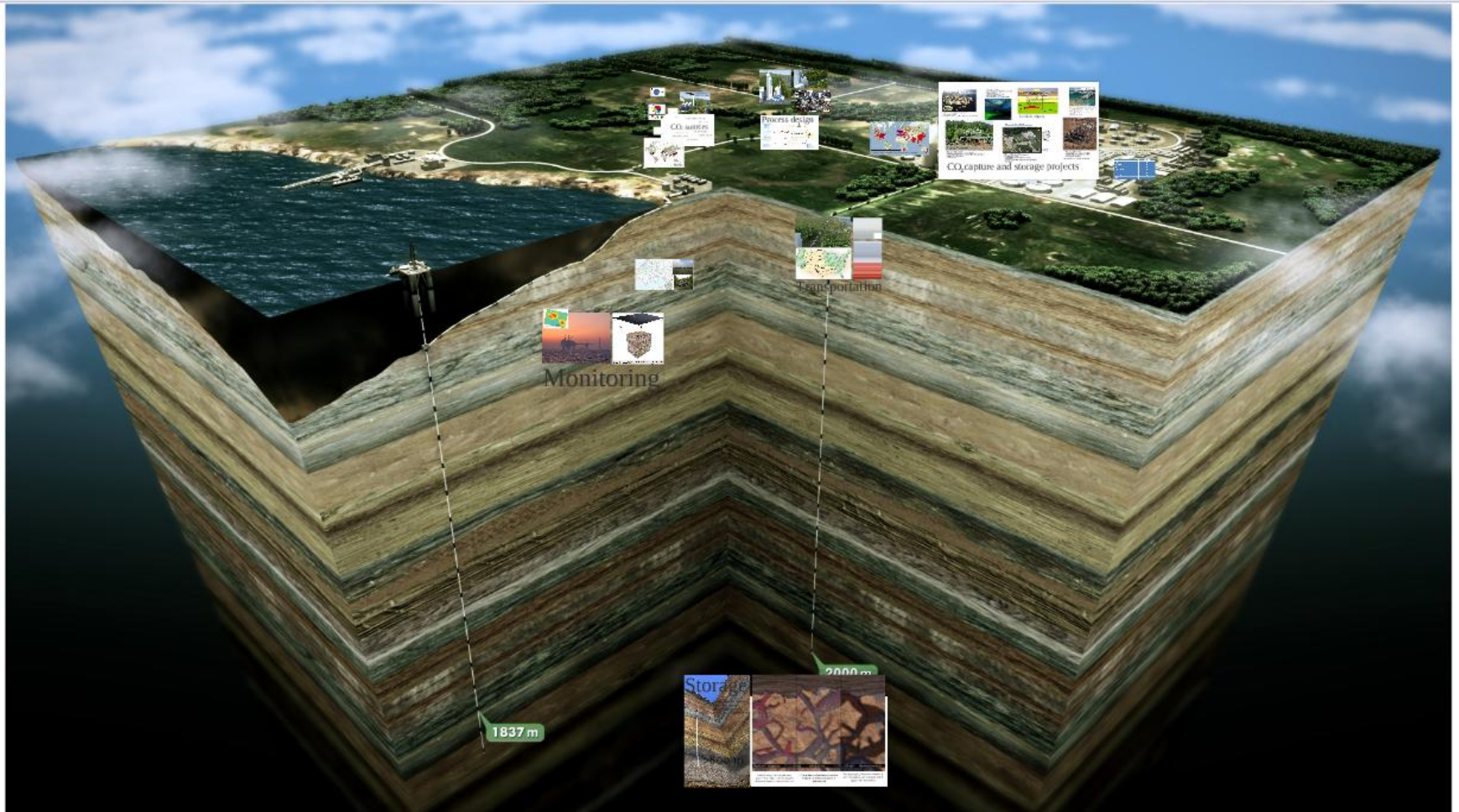
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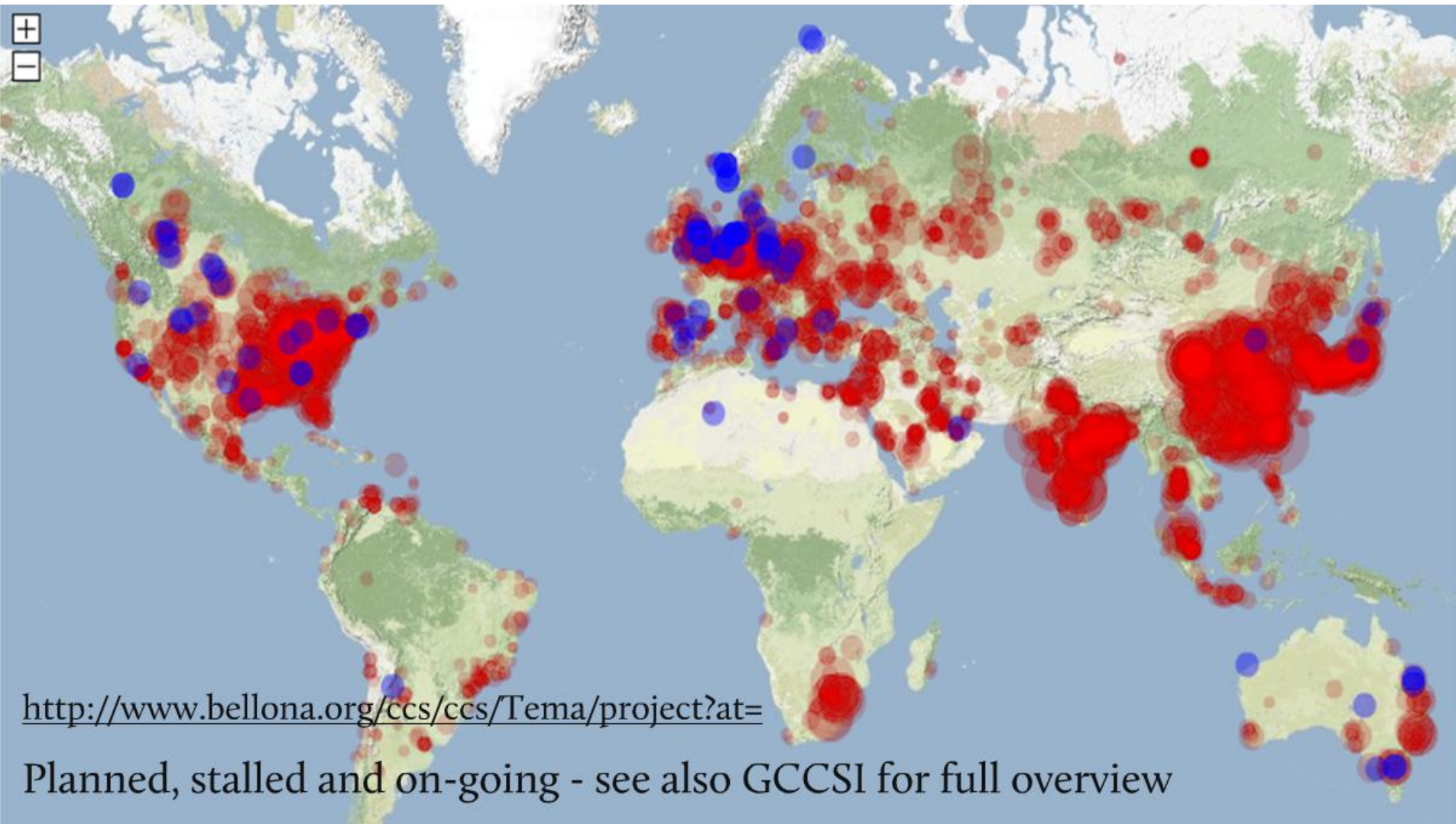
Why spend tax payer money to help the richest companies?



Is it **SAFE?**

So, what is CCS?





<http://www.bellona.org/ccs/ccs/Tema/project?at=>

Planned, stalled and on-going - see also GCCSI for full overview

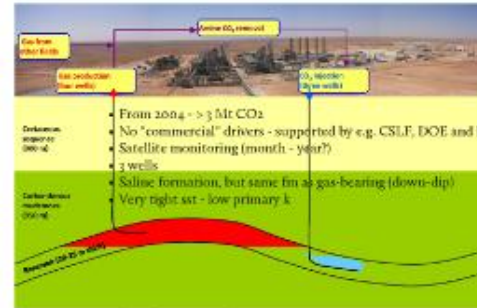
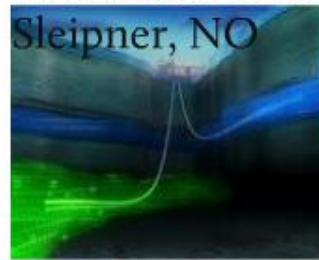
Mongstad, NO



- From 2012 -> tot capacity 100 000 t CO₂
- Demonstration project
- Only capture - from CHP plant + refinery - post-combustion

- From 1996 -> 11 Mt CO₂
- Commercial investment driven by CO₂ tax on NCS
- Saline fm storage sst
- 1 well - horizontal - approx. 1 Mt/yr
- Seismic monitoring (1-4 year?)
- Gas contains about 9.5% CO₂ prior to cleaning

Sleipner, NO



In Salah, Algeria



- From 2008 -> 0.7 Mt/yr is annual capacity, but is raising each year
- Commercial and technical drivers - CO₂ tax and to prevent freeze-out during the LNG cooling process (produced gas is between 5% and 8% CO₂)
- Seismic monitoring (1-4 year?)
- Sub-sea well-heads - 1 well - maybe new one coming
- Saline formation
- Very tight sst - very low primary k



Lacq, France

- Since 2010 - goal is 120,000 t CO₂
- Pilot project - only 2 year period - no commercial drivers?
- Seismic, soil monitoring, surface CO₂ detectors, microseismic, optical fibres etc
- Oxyfuel 30MW - 27 km transport
- Depleted gas field

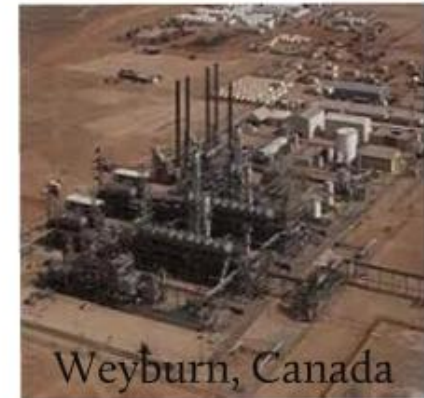
test site Ketzin, September 2008



Ketzin, Germany

DFZ, German Research Centre for Geosciences

- Since 2008 - more than 48,500 t of food grade CO₂
- Research project - CO₂ sink
- 1 monitoring wells, seismic and surface CO₂ detectors
- 1 injection wells
- 1,000 t of CO₂ from Schwarze Pumpe on its way (coal power plant)
- Track transport



Weyburn, Canada

- Since 2000 -> approx. 50000/d
- Commercial drivers - CO₂ - EOR - extended lifetime
- Soil monitoring (test project until 2005) + seismic
- 171 injection wells (alternating?)

Note: more than 100 CO₂-EOR projects in the world..

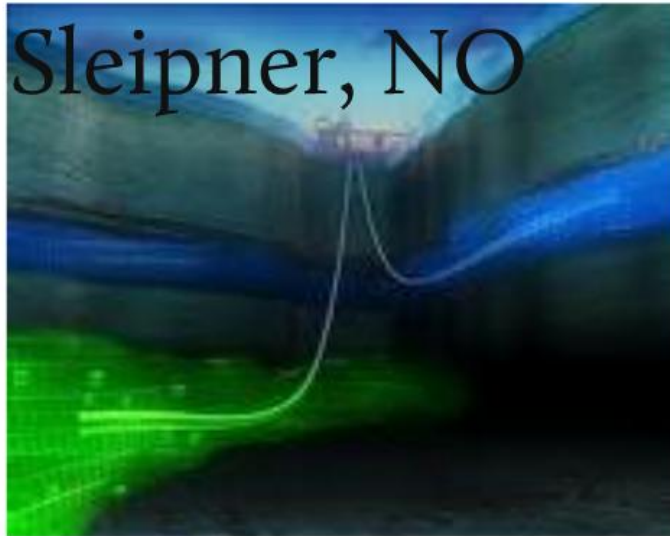
CO₂ capture and storage projects

Mongstad, NO

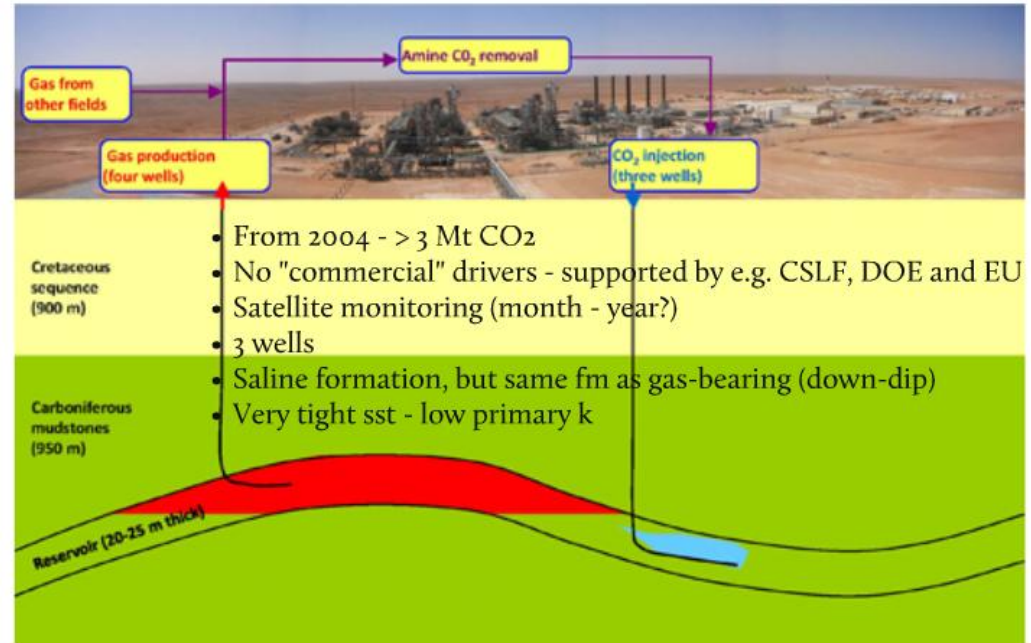


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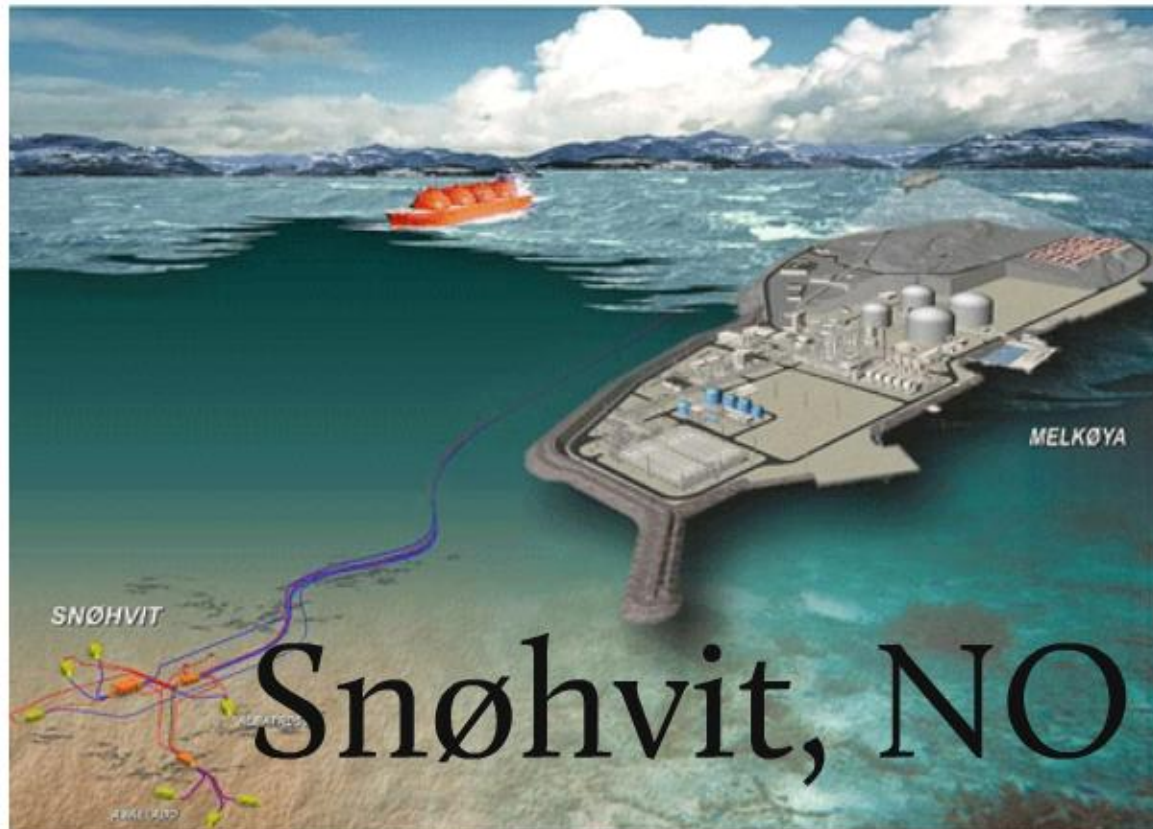
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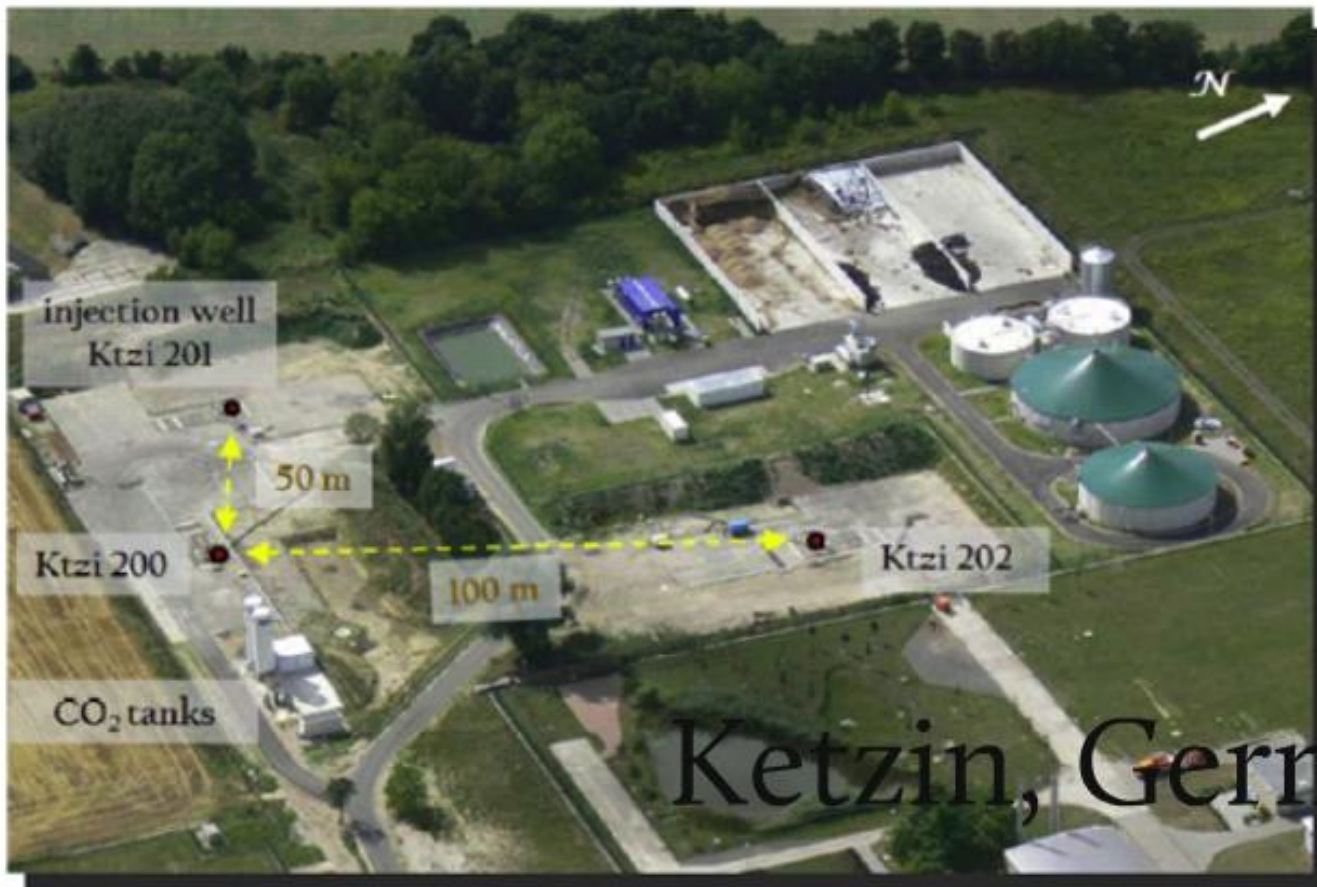


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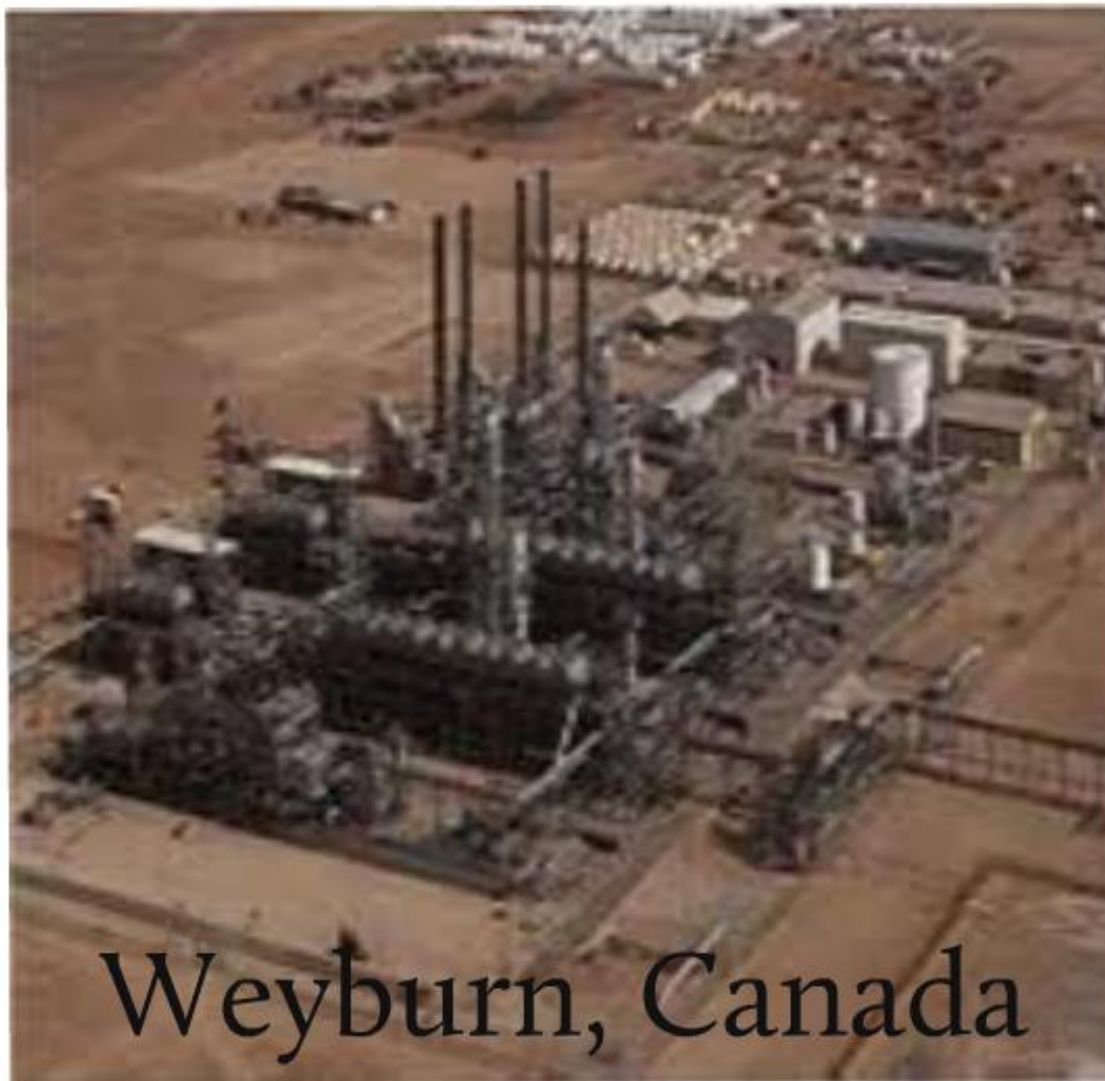
test site Ketzin, September 2008



Ketzin, Germany

GFZ German Research Centre for Geosciences

- Since 2008 - more than 48,500 t of food grade CO₂
- Research project - CO₂ sink
- 2 monitoring wells, seismic and surface CO₂ detectors
- 2 injection wells
- 2,000 t of CO₂ from Schwarze Pumpe on its way (coal power plant)
- Truck transport



Weyburn, Canada

- Since 2000 - > approx. 5000t/d
- Commercial drivers - CO₂ - EOR - extended lifetime
- Soil monitoring (test project until 2005) + seismic
- 171 injection wells (alternating?)

EU

- Member States have put forward to the EIB roughly half of the proposals submitted to them on 9 March
- 13 CCS proposals selected for 2nd stage from 22 received for a 'desired' portfolio of 8 CCS projects
- 250 MW demonstration is lower limit for power plants and 500 ktCO₂ stored per year for industrial emission sources
- 65 RES proposals selected from 131 received for a 'desired' portfolio of 34 projects
- In CCS, competition will be highest for the power post combustion category: 6 proposals for 2 places in the portfolio. In the pre-combustion category there are 3 proposals for 2 places, whereas in oxyfuel and industrial applications there are 2 proposals for 2 places in each category

	CCS projects
France	1
Germany	1
Italy	1
Netherlands	1
Poland	1
Romania	1
United Kingdom	7
Total	13

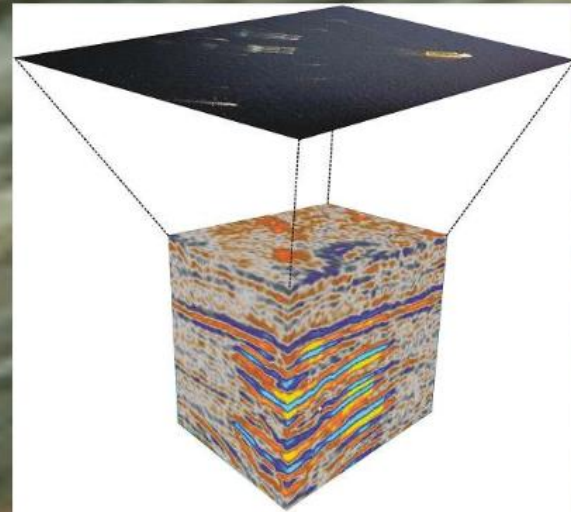
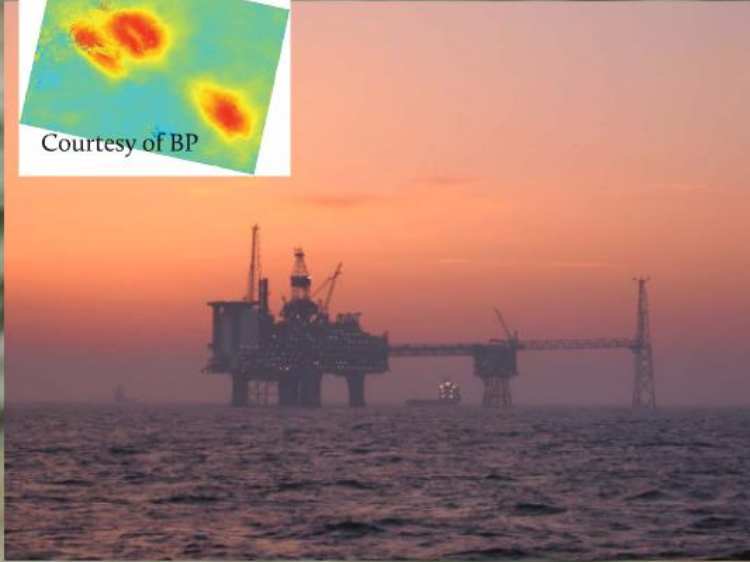
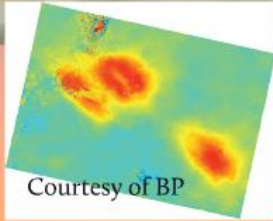
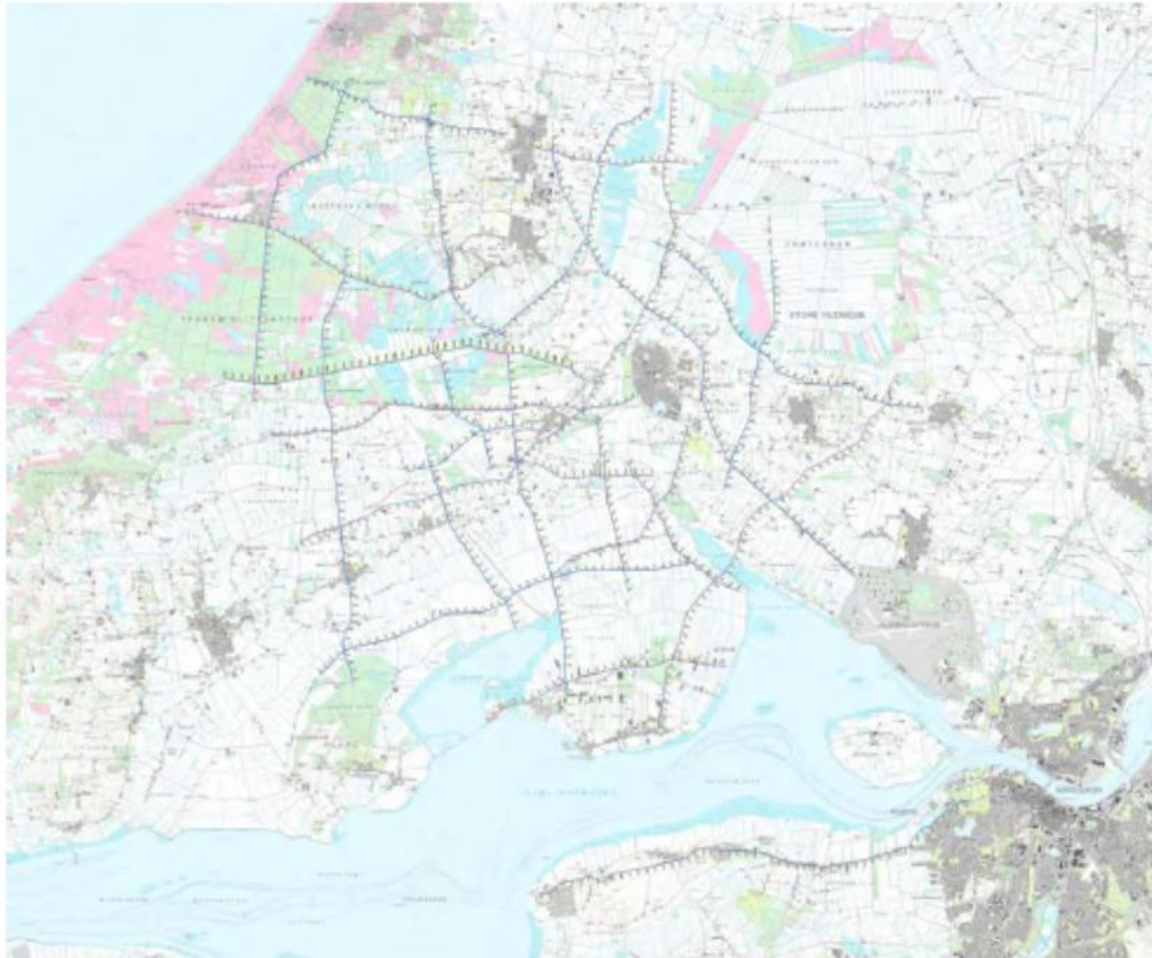


Figure 2: 3D seismic survey, showing acquisition vessel and subsurface 'cube' of data (images courtesy of Statoil, Veritas and BP).

Monitoring



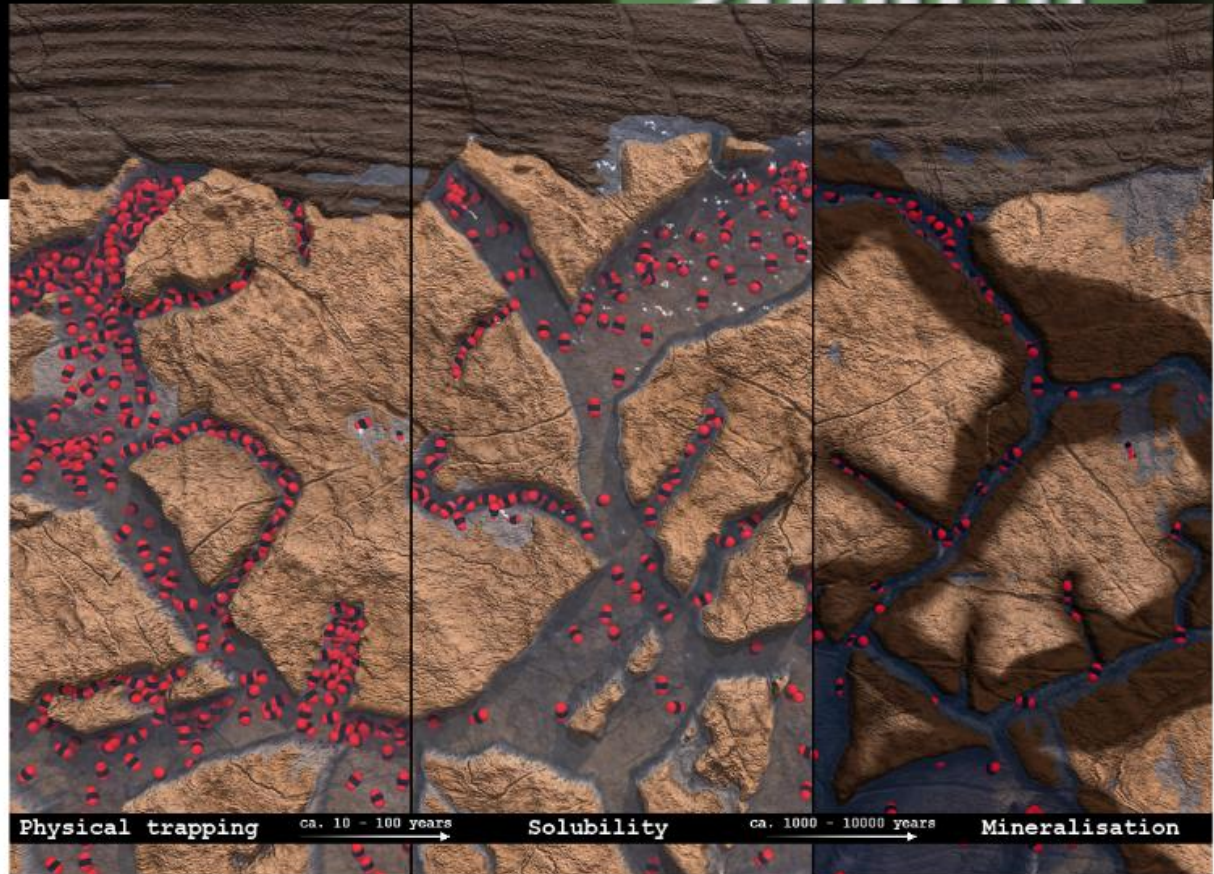
Transportation



Storage

- Enhanced oil/gas recovery
- Deep saline aquifers
- Depleted oil/gas fields
- Enhanced coal-bed methane recovery

>800 m



Physical trapping

ca. 10 - 100 years

Solubility

ca. 1000 - 10000 years

Mineralisation

Immobilising CO₂ in a gaseous or supercritical phase. CO₂ is trapped in structural traps or in pores in the rock

CO₂ is dissolved and immobilised in fluids in the formation (water or hydrocarbon)

The dissolved CO₂ reacts chemically with the minerals in the formation or adsorb on their surface

Main issues

- Currently not economic
- ...or mandatory
- Politics matter
- Industry seek

improvement in:

- energy efficiency (lower energy penalty)
- concentrated flue gases
- costs (capture and monitoring)
- ship transport

CAN be SOLVED!

Solutions...

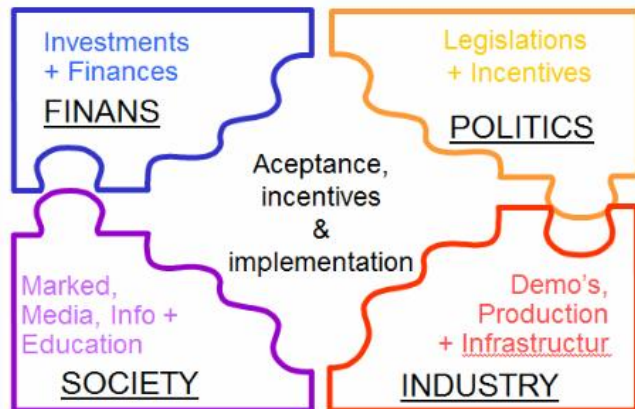
Thousands of solutions!

Here's
what we
should
DO!



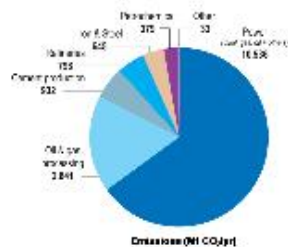
Identify and understand the problem

Find, develop and present solutions

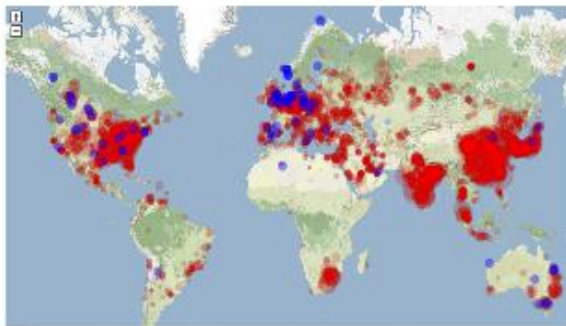


Focus on incentives and implementation

Capture and store CO₂ from large point sources



Coal power plants
Pulp and paper
Gas power plants
Chemicals
Refineries
Cement kilns
Iron/steel factories



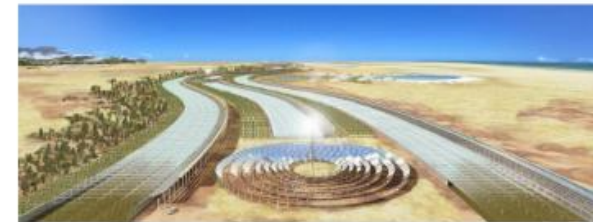
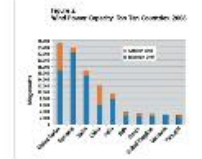
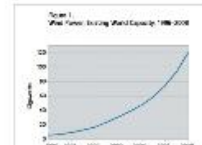
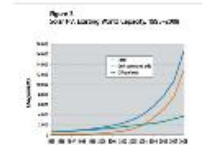
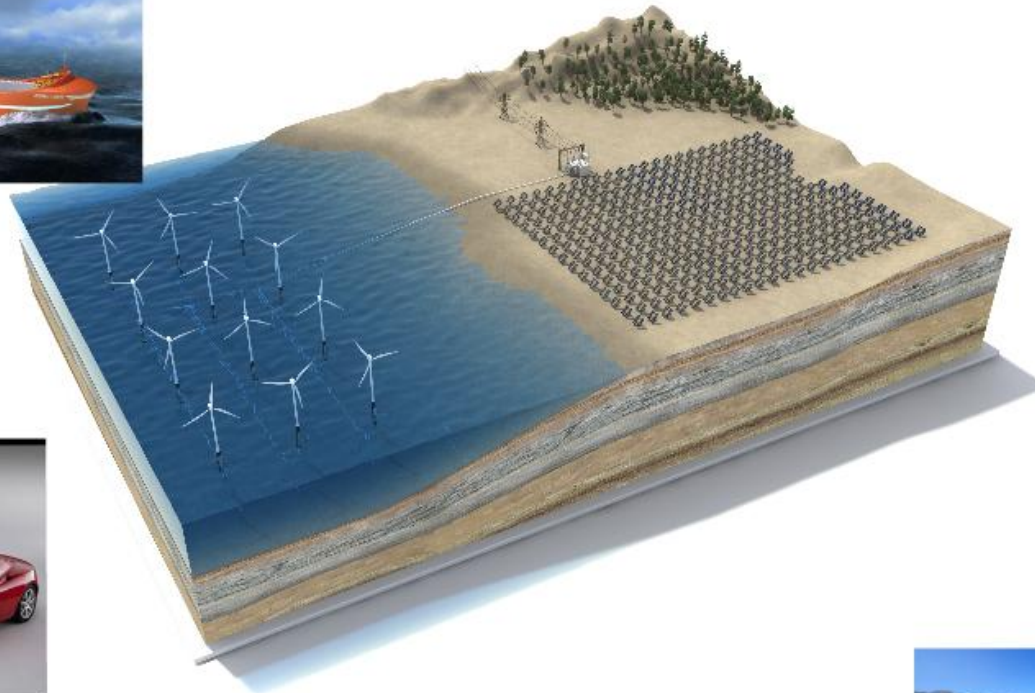
www.bellona.org/ccs

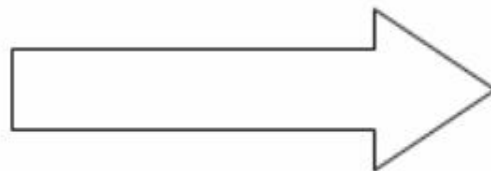
Lifestyle change

What makes us happy?



Smarter energy systems





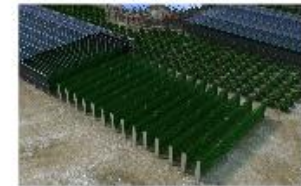
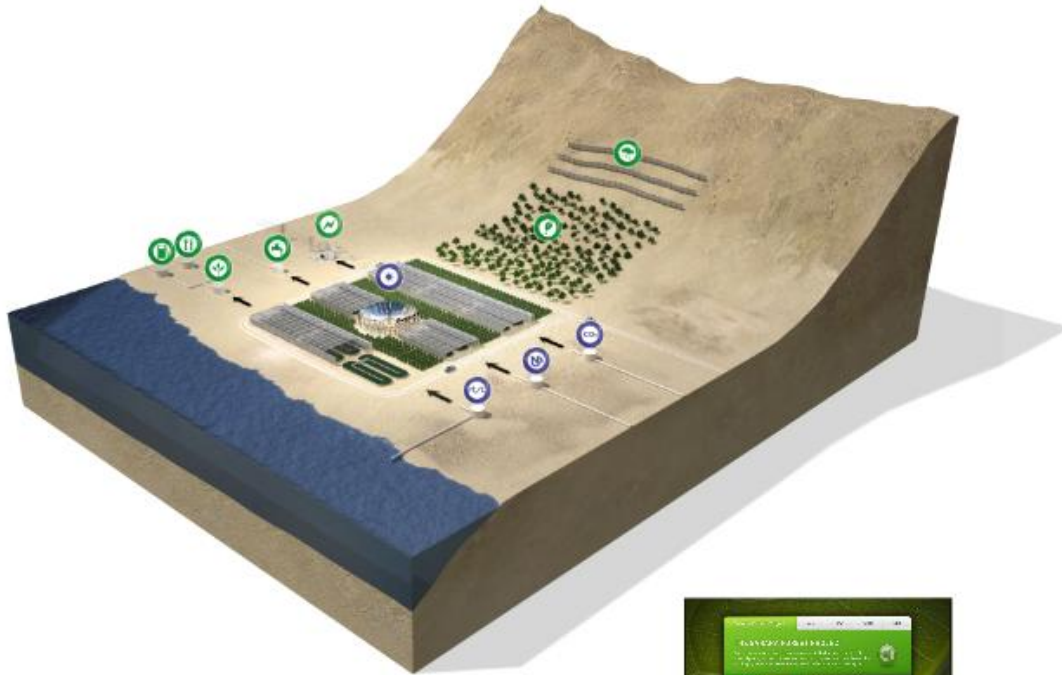
1987:
47.000 kr
7000 g

2006:
500 kr
100g

Protect forests and wetlands

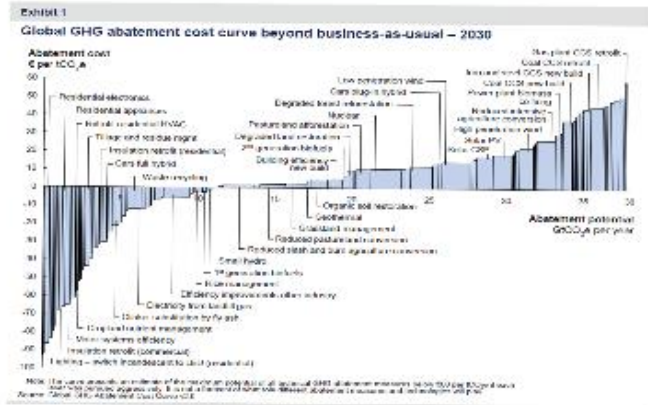


Sustainable bioenergy



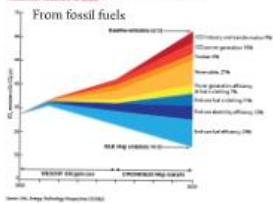
www.saharaforestproject.com

Save energy... and money!

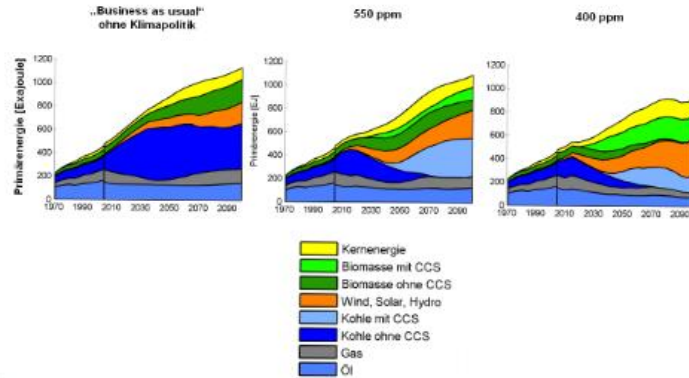


How much CCS is needed?

Figure 3: CCS delivers one-fifth of the lowest cost GHG reduction solution in 2050

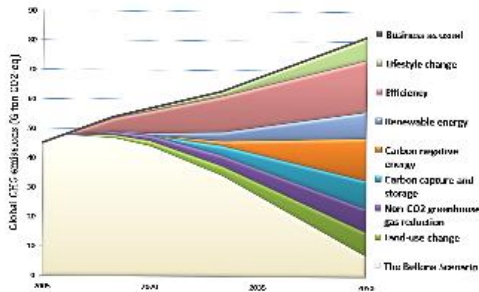
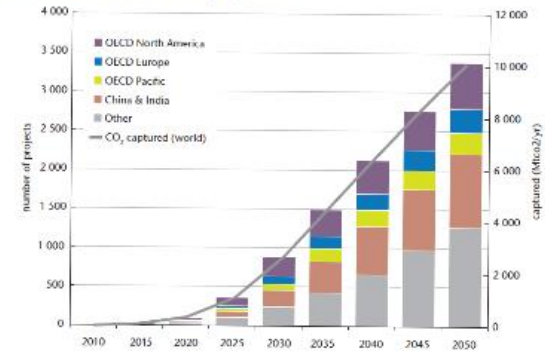


IEA: 50% reduction but possible: CCS accounts for 1/4 of reductions



source: Potsdam Institute for Climate research

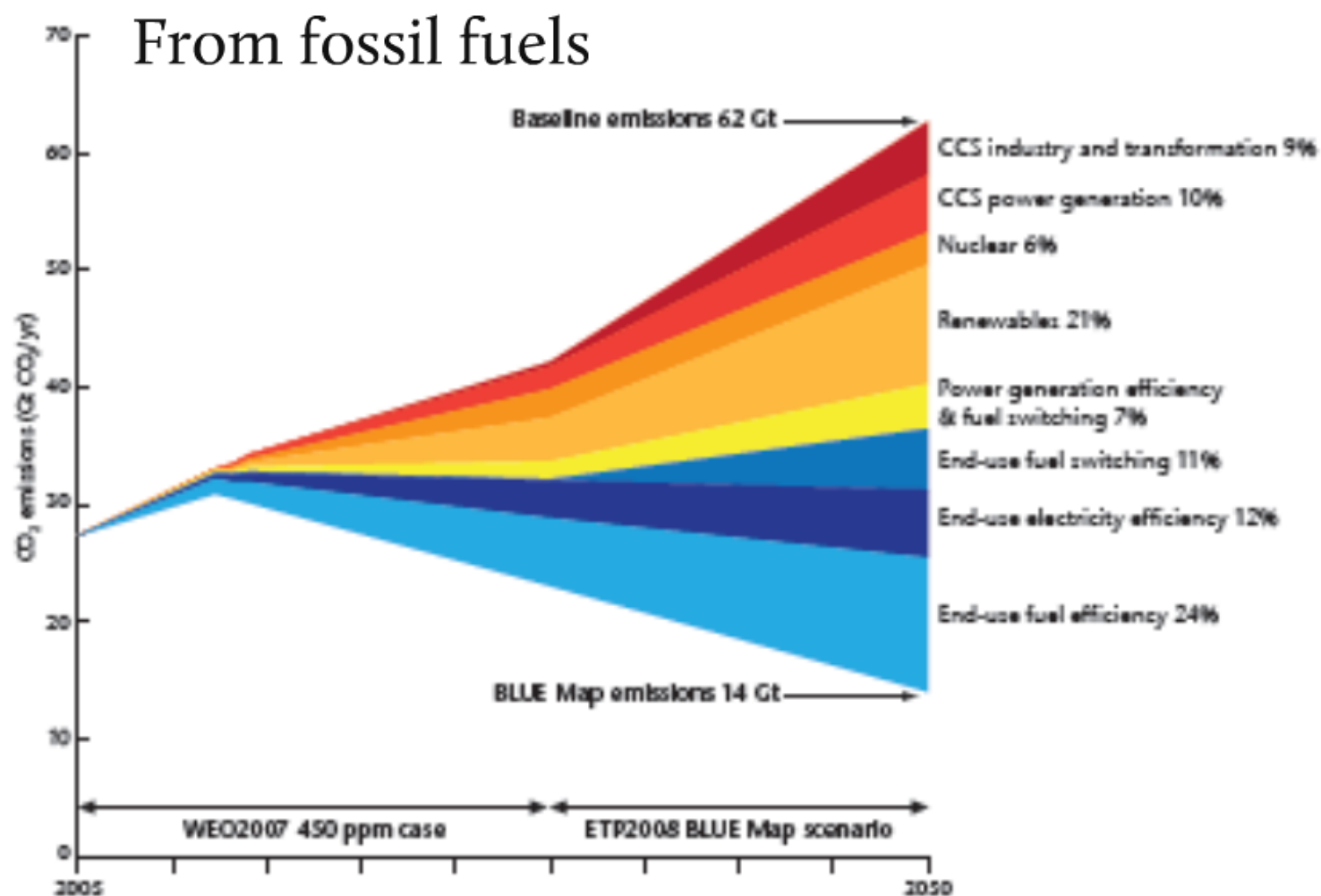
Figure 4: Global deployment of CCS 2010–2050 (CO₂ captured and number of projects)



CCS is only part of the solution



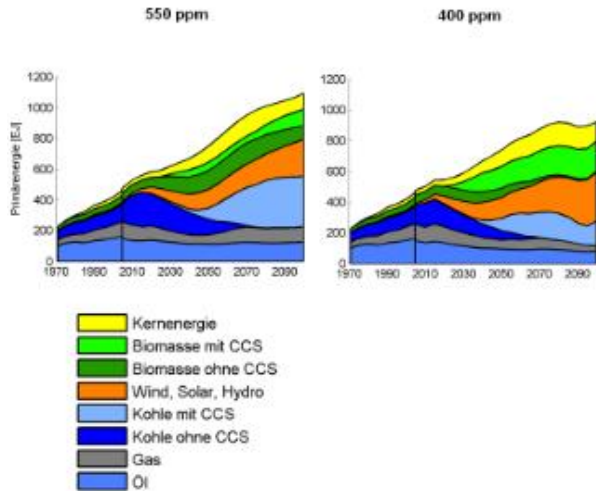
Figure 1: CCS delivers one-fifth of the lowest-cost GHG reduction solution in 2050



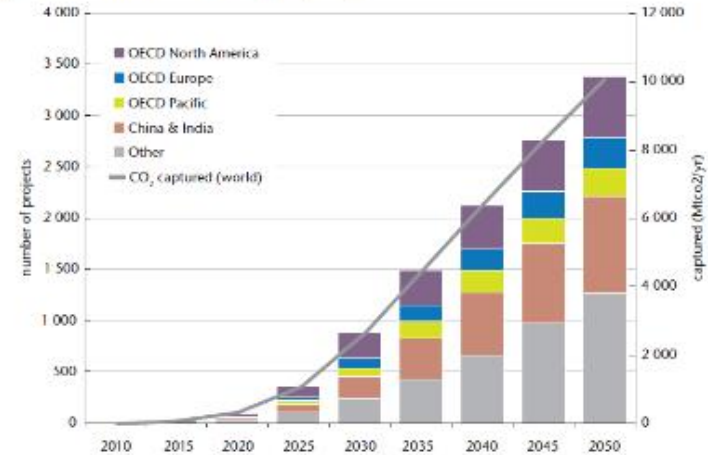
Source: IEA, *Energy Technology Perspectives* (2008a).

CCS is needed?

Figure 4: Global deployment of CCS 2010–2050
(CO₂ captured and number of projects)



source: Potsdam Institute for Climate research



CCS is only part of
the solution



Is public

ENTHUSIASM

for CCS possible?

Go for

proactive
enthusiasm!

Don't aim for
reactive
acceptance...

Don't pretend it's

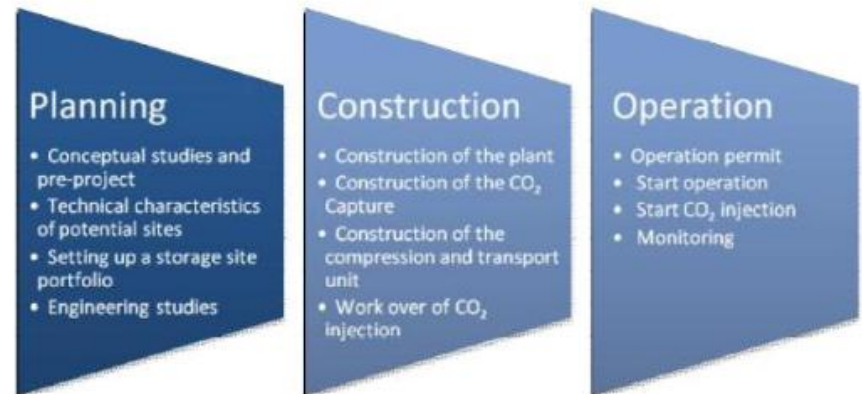
EASY

if it isn't

Social Process



Technical Process



Be prepared!

message
[what you say]

equally
important

messenger
[who you are]

Cooperate!

Institutes

NGOs

Communities



Employment

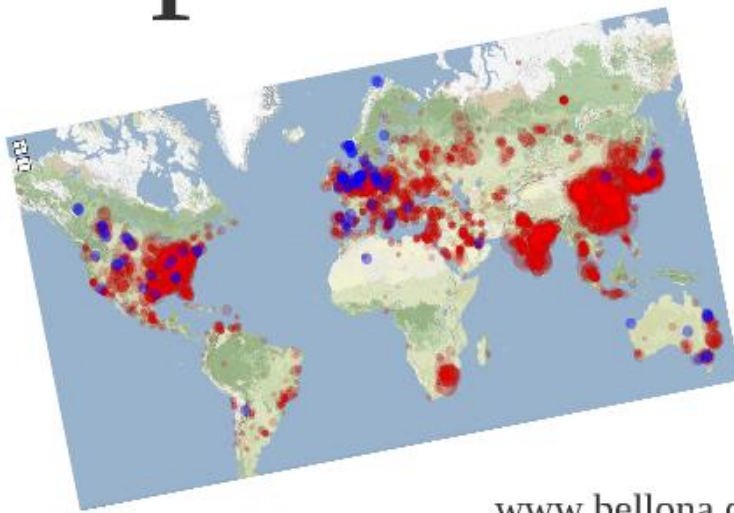
Health & Environment

Competitiveness

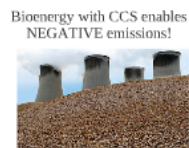
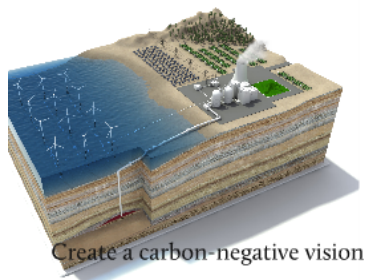
Sweeten the deal!

... but cut the crap!

Make information available
Share knowledge
Explain

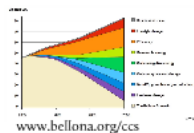


www.bellona.org/ccs

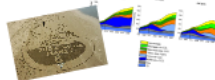


Create a positive VISION!

Part of the solution



More climate protection is possible
WITH CCS than WITHOUT it!



Bioenergy with CCS enables
NEGATIVE emissions!



Building wind turbines, solar panels, biofuels, electric vehicles

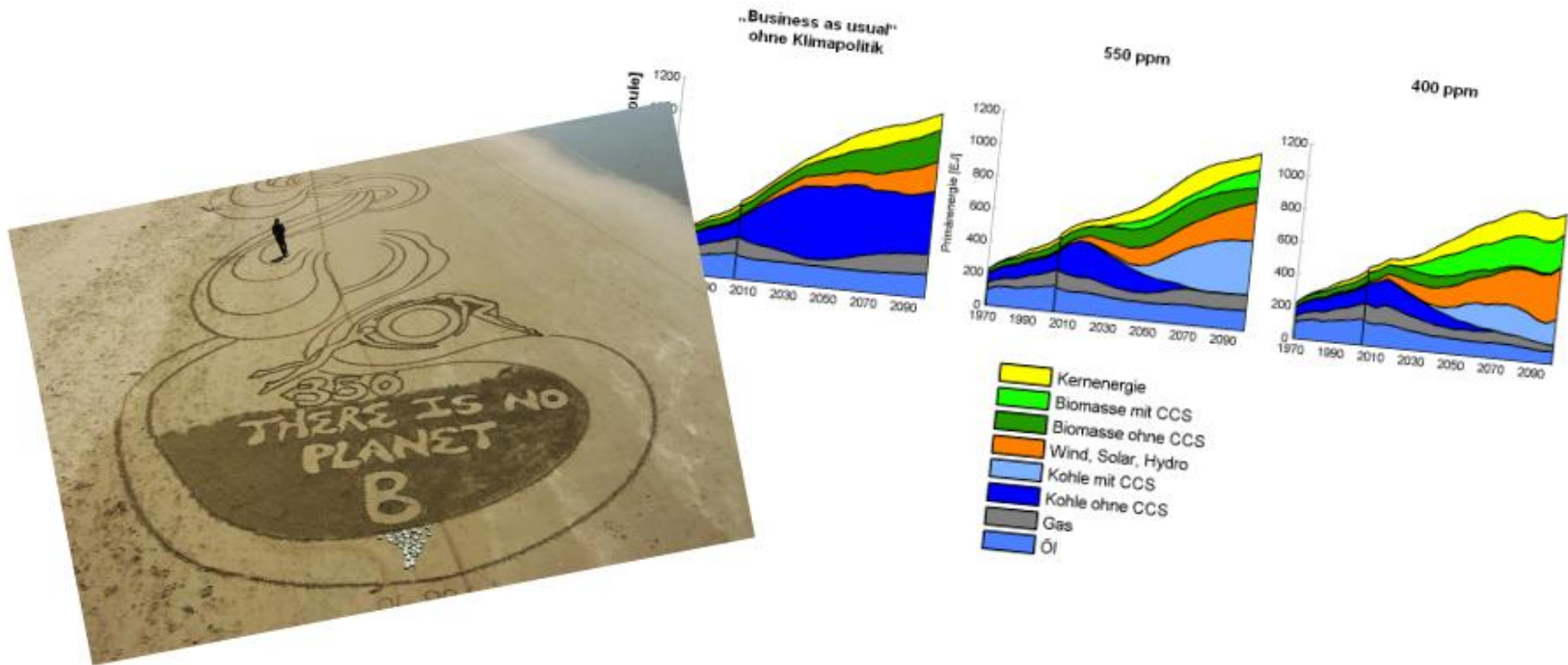
WITHOUT

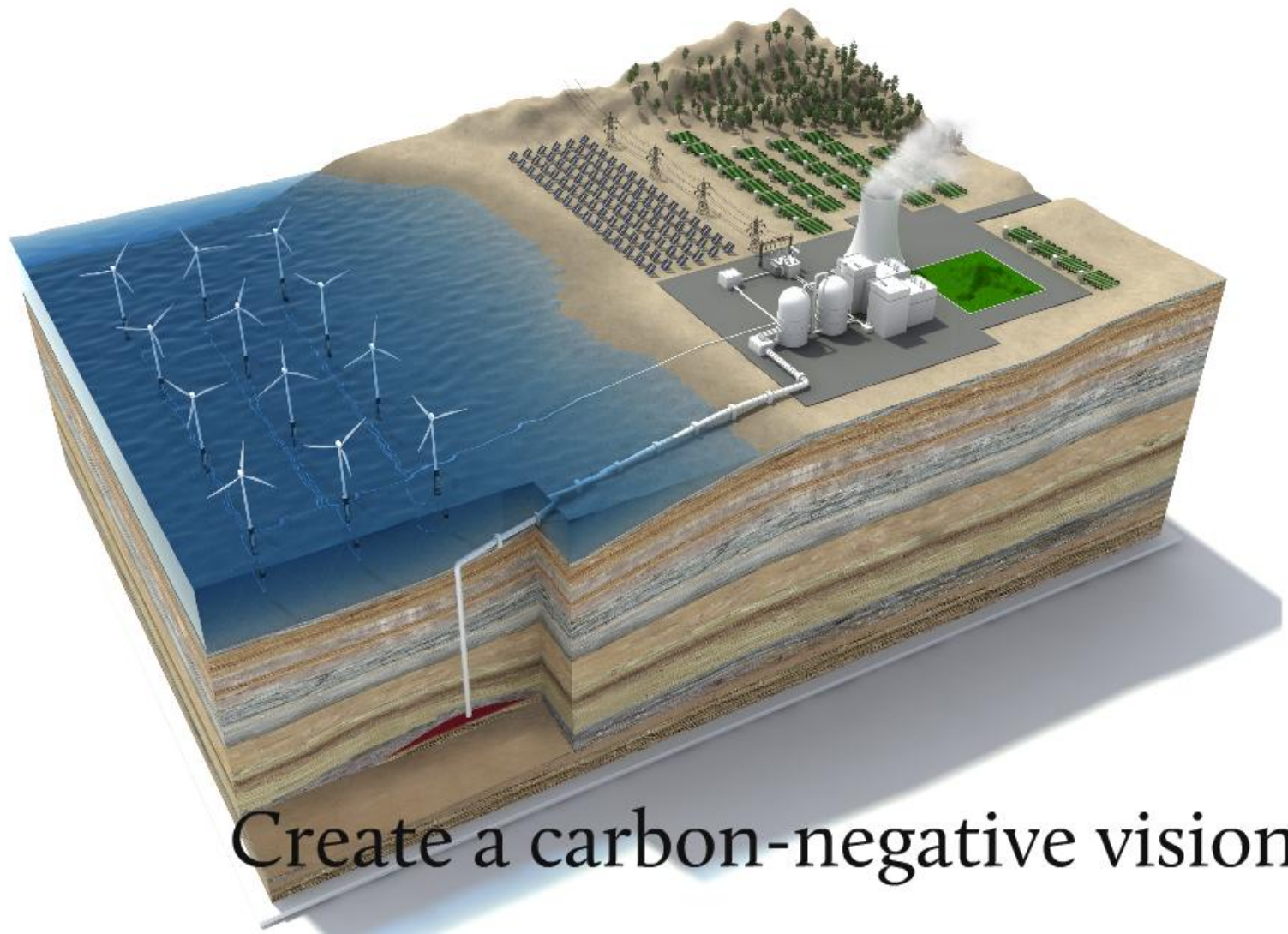
EMISSIONS



CCS is not a goal in itself, it is a bridge to a truly sustainable energy chain.

More climate protection is possible WITH CCS than WITHOUT it!

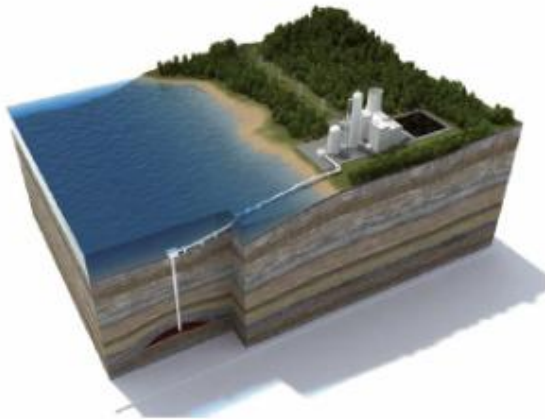




Create a carbon-negative vision

WHY CCS NOW

This publication explains why capture and geological storage of CO₂ is a necessary tool to combat global warming



www.bellona.org/ccs

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Amines Used in CO₂ Capture - Health and Environmental Impacts

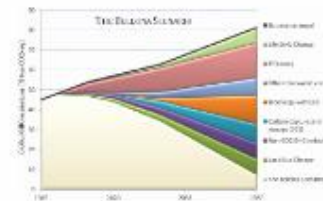
Renjie Shao and Aage Stangeland
The Bellona Foundation



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How to Combat Global Warming

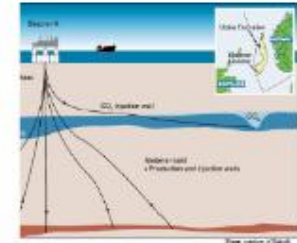
- An ambitious but necessary approach to reduce greenhouse gas emissions



Prepared by the Bellona Foundation for the CCS Conference, Oslo, June 4-6, 2008

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Carbon Dioxide Storage: Geological and Environmental Issues – Case in the Sleipner Gas field in Norway



Semere Solomon

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http://www.bellona.no/portal/bellona.org/files/fil_Why_CCS_COP15_brochure.pdf

or at <http://www.bellona.org/ccs/Artikler/publications>

