European and Global Prospects of Carbon Capture and Storage

Hot Topic Hour
McIlvaine Company
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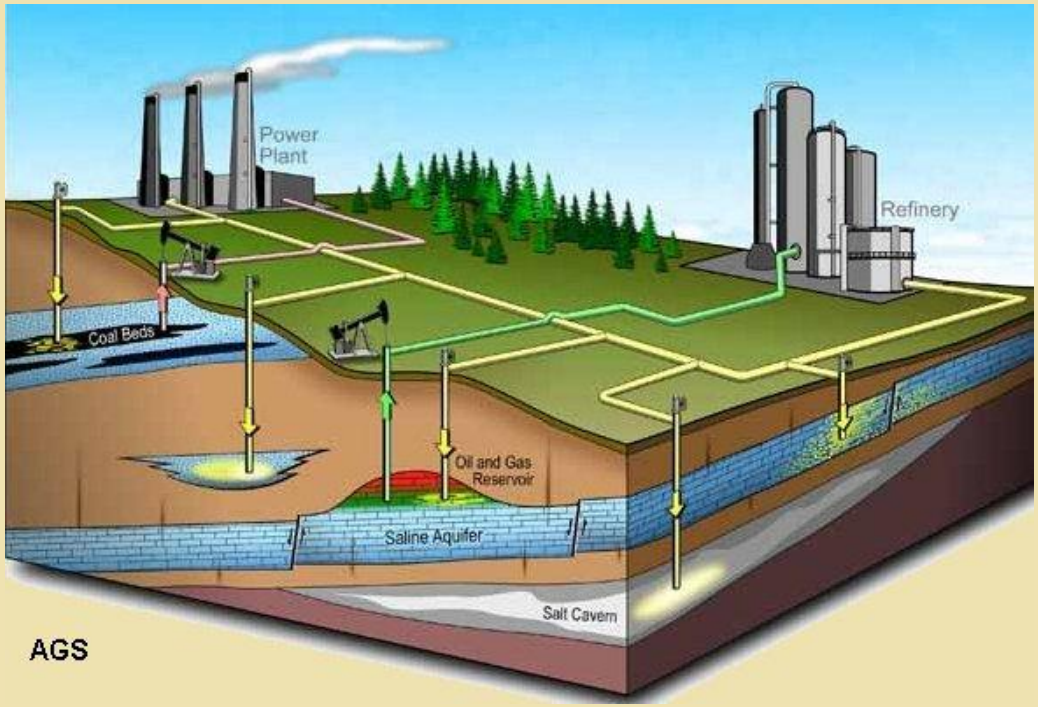
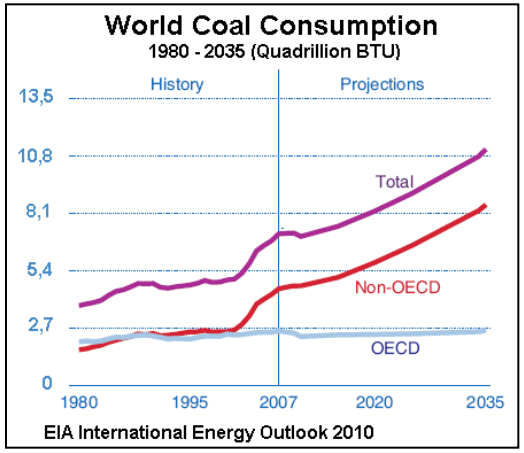
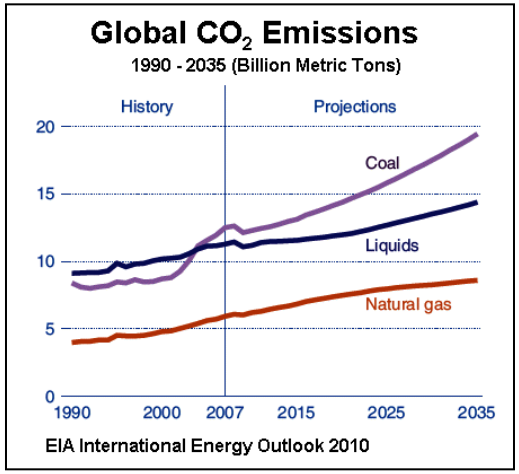


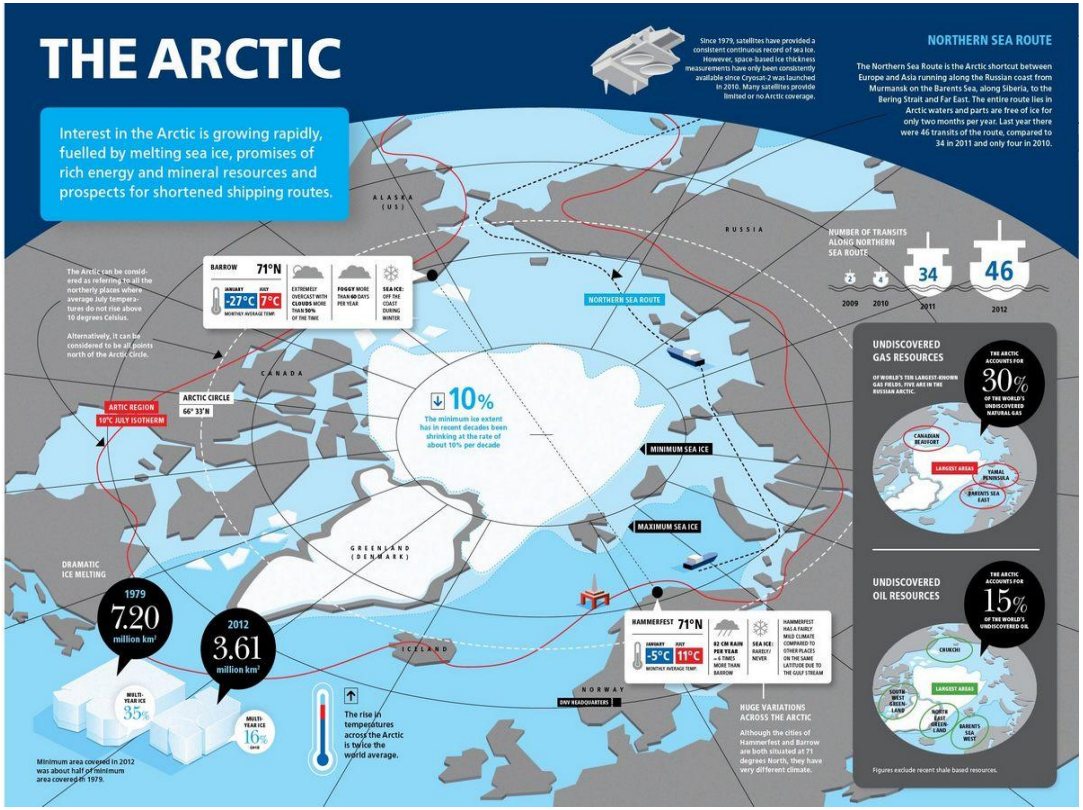
Fossil fuel usage, particularly of coal, is altering carbon balances in the biosphere.

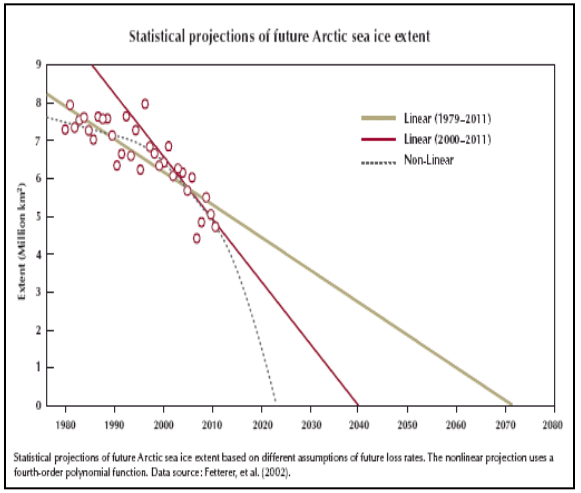
- The combustion of fossil fuels (coal and lignite, oil and natural gas) now emits 32 billion tonnes (Gt) of carbon dioxide per year, increasing to 40 Gt/a by 2030.
- By 2015, CO_2 emissions from coal usage in non-OECD countries will likely be twice the level (8.9 Gt) of all OECD countries (4.2 Gt).
- Rising CO_2 concentrations in the Earth‘s atmosphere are imperiling ecological balances.



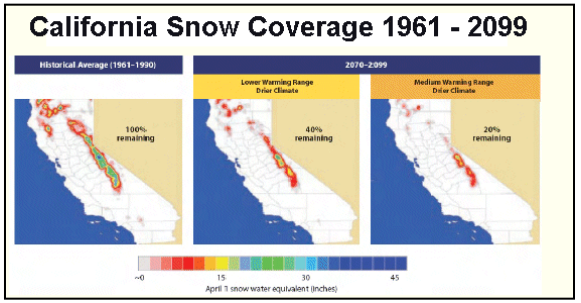


Global warming trends coincide with rising atmospheric CO_2 concentrations.

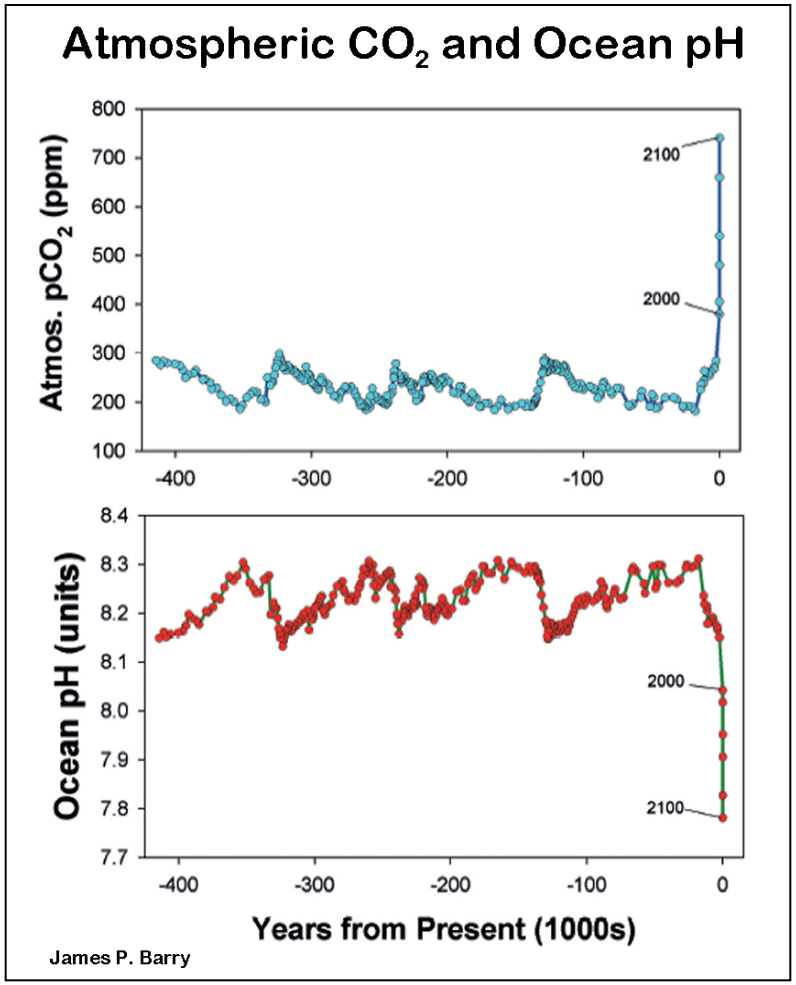




Statistical projections of future Arctic sea ice extent based on different assumptions of future loss rates. The nonlinear projection uses a fourth-order polynomial function. Data source: Fetterer, et al. (2002).



Absorbed atmospheric CO_2 results in acidification (decreasing pH levels) of the world's oceans.



- If atmospheric CO_2 concentrations exceed 450 – 500 ppm (July 2013: 397 ppm, increasing 2 - 3 ppm/a), corals and shellfish become incapable of forming their calcium carbonate skeletons.
- Ocean acidification (decline of alkalinity) is "irreversible on timescales of at least tens of thousands of years". (UN Convention on Biological Diversity)
- The Earth is thus already "well on the way to the next great extinction event". (Ove Hoegh-Guldberg, Global Change Institute, Australia)

Carbon compensation by photosynthesis is an increasingly limited prospect.

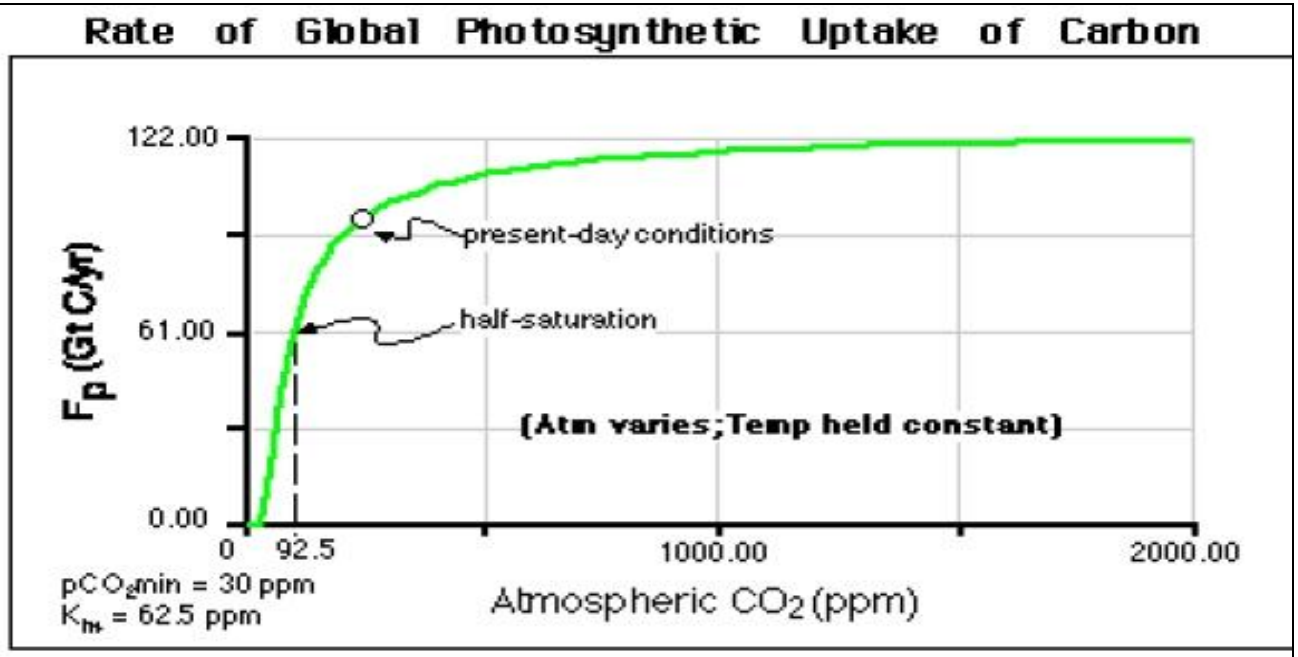


Figure 7.04. Graph of photosynthetic use of carbon at varying levels of atmospheric CO_2 concentration, based on the equation used in our carbon model. Note that the response of photosynthesis to changing atmospheric levels depends on the atmospheric concentration. This type of behavior is typical of processes governed by enzymes and is described by the Michaelis-Menten equation. Our present-day position on this curve is not too heartening — as the atmospheric CO_2 rises, the rate of photosynthesis will increase less and less, and "greening" of the biosphere is less capable of slowing the build-up of atmospheric CO_2.

Europe is prolonging fossil fuel dependency to implement re-industrialization strategies.

EUROPEAN COMMISSION

PRESS RELEASE

Brussels, 10 October 2012

Industrial revolution brings industry back to Europe

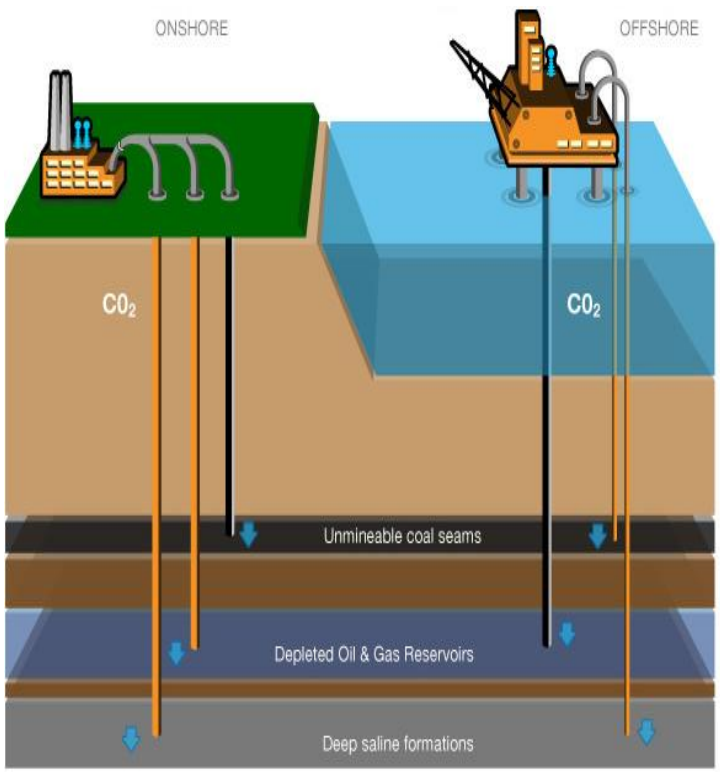
German Coal & Lignite Power Plants 2012 - 2020 (BDEW)				
Operator	**Location**	**Capacity MW**	**Dedication Year**	**Max. CO_2 Mt/a**
RWE Power	BoA 2&3 Neurath	2100	2012	14.2
Vattenfall Europe	Boxberg/Block R	675	2012	4.6
RWE	Hamm	1530	2013	6.9
Eon	Datteln	1055	2013	4.7
EnBW	Karlsruhe	874	2013	3.9
Trianel	Lünen	750	2013	3.4
GDF Suez	Wilhelmshaven	731	2013	3.3
swb AG / EWE	Bremen	45	2013	0.2
STEAG	Duisburg	725	2013	3.3
Vattenfall Europe	Hamburg-Moorburg	1640	2014	7.4
GKM Mannheim	Mannheim	911	2014/15	5
Eon	Staudinger	1100	2016	8.2
SüdWestStrom	Brunsbüttel	1820	2017	4.5
MIBRAG	Profen	660	2020	4.1
Eon	Stade	1100	not announced	5
GETEC	Büttel / Bayer	800	not announced	3.6
RWE Power	BoAplus Niederaußem	1100	not announced	7.4
Total		**17,616**		**89.5**

- On October 10, 2012, the European Commission announced a program for the “Third Industrial Revolution”.
- The contribution of industry to the EU economy is targeted to rise from currently 15.6% to 20% by 2020.
- CO_2 emissions related to industrial energy demand are commensurately increasing.
- Germany plans to build up to 17 new coal and lignite power plants between 2012 – 2020.

Carbon Capture and Storage (CCS) implements CO_2 reduction at stationary emission sources.

- **International Energy Agency (IEA):** In order for CCS to provide 19% of total CO_2 savings, almost 80% of all fossil power plants and approximately half of the iron and steel, cement, pulp and paper, and ammonia plants would need to apply CCS. (*CO_2 Capture and Storage*, 2008, p. 211)
- **EU Directive 2009/31/EG** on the geological storage of carbon dioxide**:** "The CO_2 emissions avoided in 2030 (*by CCS*) could account for some 15 % of the reductions required in the Union."
- **European Commission**: In scenarios without CCS, "the costs for achieving climate stabilisation in 2050 are at least 70% higher than scenarios that include CCS". (*CO_2 Capture and Storage*, 2009, p. 4)
- ***Stern Review on the Economics of Climate Change*****:** "What we do in the next 10 or 20 years can have a profound effect on the climate in the second half of this century and in the next." (UK 2006)

CCS could be essential to CO_2 reductions in the global industrial and power sectors.



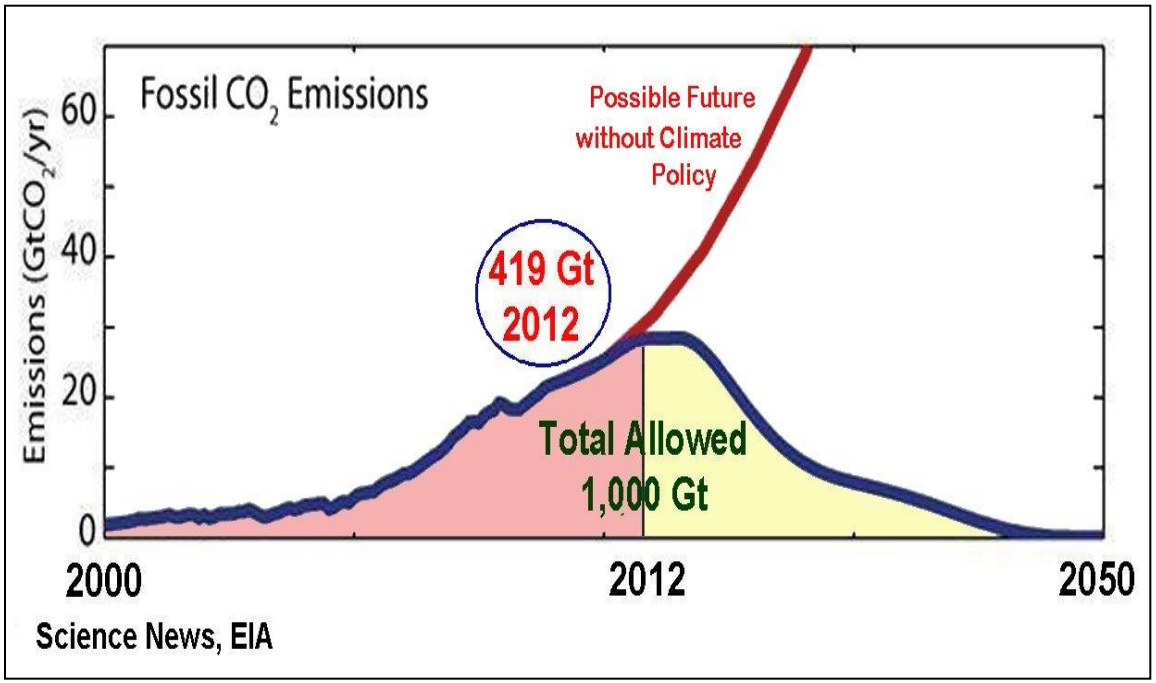
- CCS process chains would store CO_2 underground.
- The IEA strategy translates to over 3,000 CCS installations by 2050 for achieving 19% of the CO_2 avoidance required to limit global warming to +2 ºC.
- Attaining this objective implies commissioning a new CCS installation every four days over the next 37 years.

Over 40 % of CO_2 emissions budgeted for 2 ºC global warming have already been expended.

Potsdam Institute for Climate Impact Research / Oxford University / Eidgenössische Technische Hochschule:

From 2000 to 2050, total CO_2 emissions may not exceed 1,000 Gt.

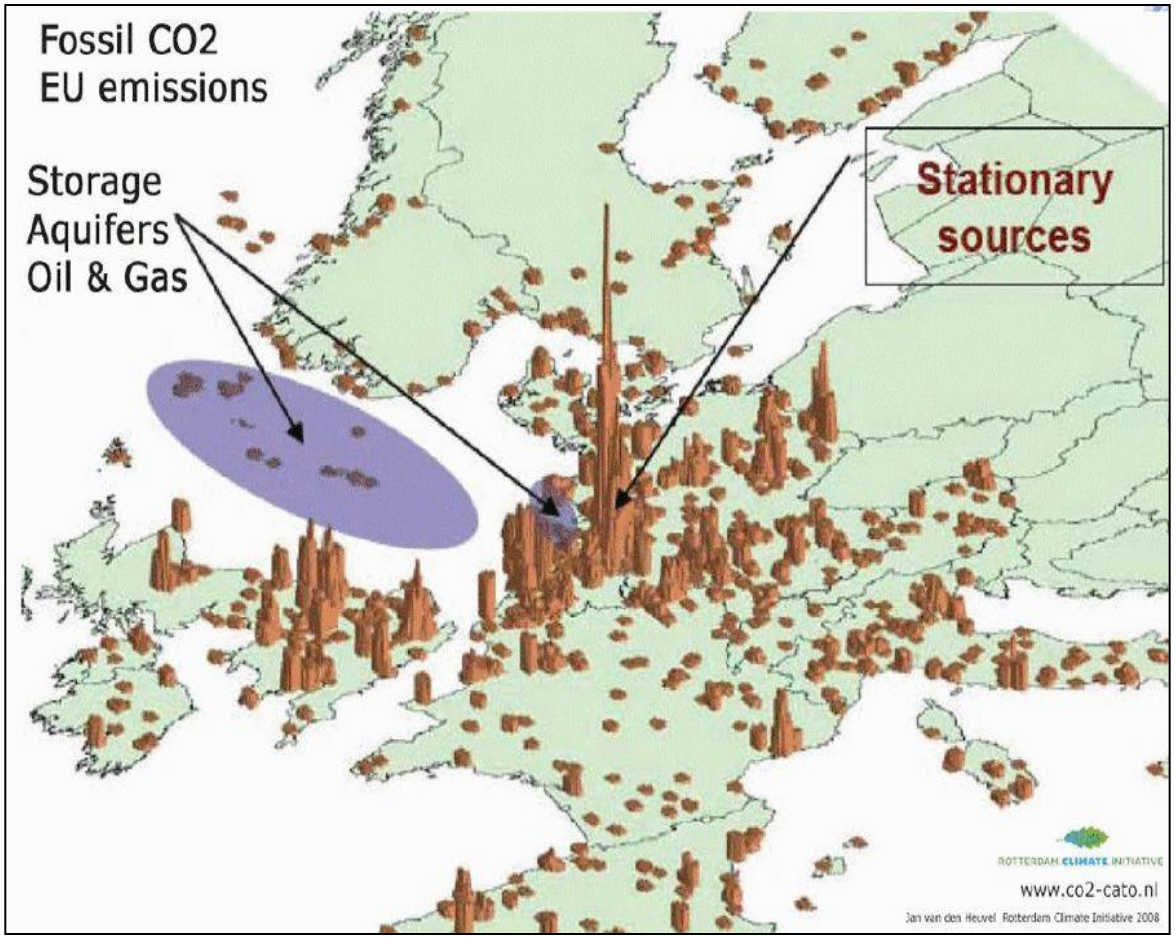
"Climate Change: Halving Carbon Dioxide Emissions By 2050 Could Stabilize Global Warming". Science News, May 4, 2009.



Under present trends, CO_2 emissions must be avoided entirely after 2030 to prevent global warming from exceeding +2 ºC.

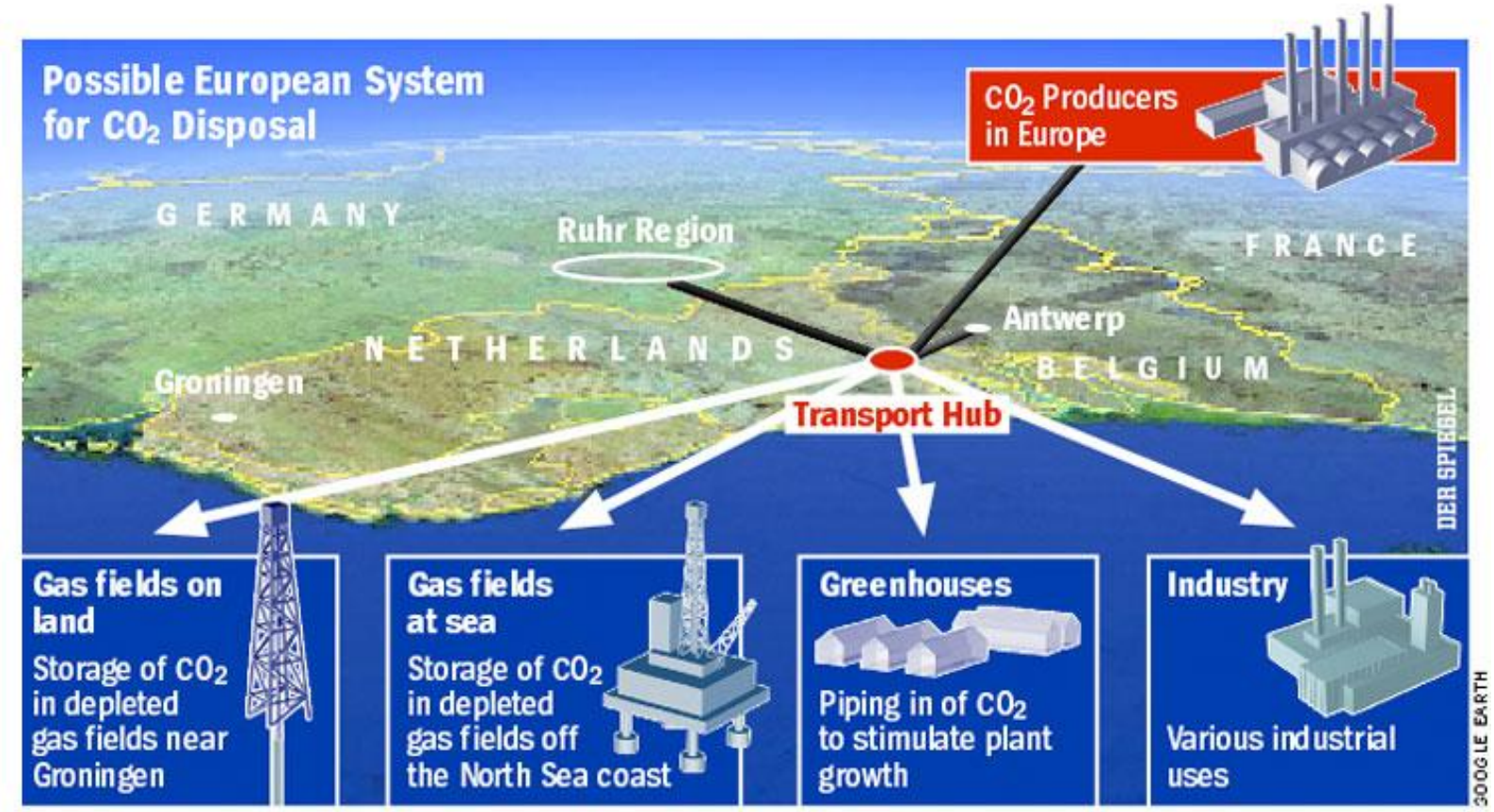
A new IEA CCS plant would therefore be required every two days before 2030.

Candidate CO_2 storage locations in Europe are distant from most fossil fuel power stations.



According to the Scottish “Centre for Carbon Storage“, the North Sea is only suitable as a regional repository for CO_2 emissions from large point sources in the United Kingdom and Norway.

The most extensive CO_2 storage capacities in the Netherlands will be usable only after mid-century.



8.9 Gt only after 2030 - 50	1.6 Gt - high incident pipeline expenses	not permanent	limited

A European CO_2 pipeline network would require considerable trans-national financial transfers.

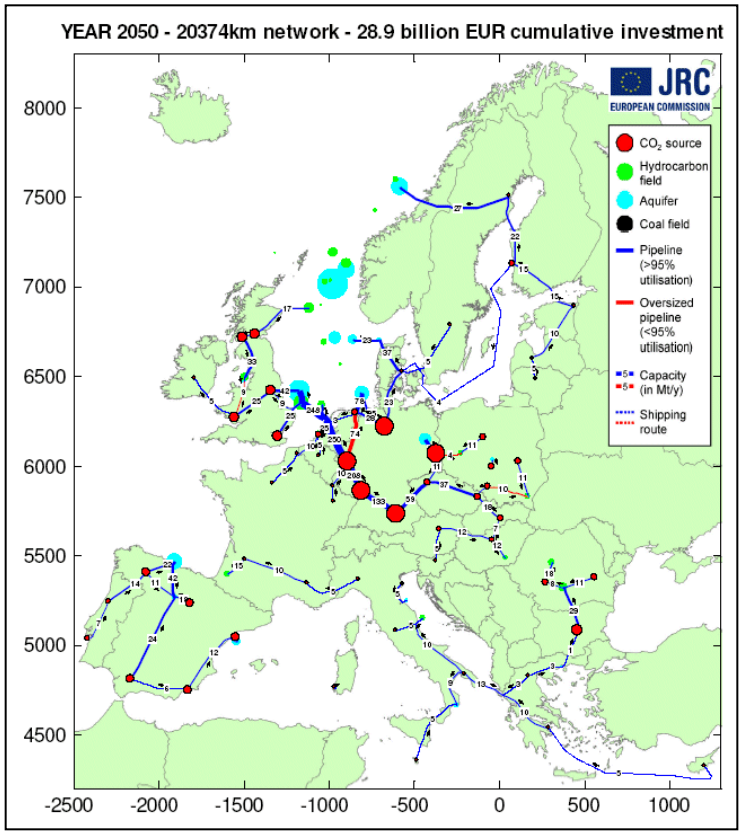
Required Contributions to CO_2 Pipeline Investment Costs by EU Member States

	Amount € billions	Percentage		Amount € billions	Percentage
Austria	0.6	2	Netherlands	0.5 – 1.2	2 – 4
Belgium	2.1 – 2.2	8	Norway	-11.7 – -16.6	-42 – -59
Bulgaria	2.1 – 2.2	7 – 8	Poland	10.8 – 13.8	38 – 49
Czech Republic	4.8 – 6,3	17 – 22	Portugal	1.5 – 1.6	6
Denmark	-3.7 – 0.5	-13 – 2	Romania	-1.9 – 2.1	-7 – -8
France	0.5 – 1.2	2 – 4	Slovakia	1.3 – 1.5	5
Germany	16.3 – 18.5	58 – 66	Slovenia	0.3 – 0.5	1 – 2
Hungary	1 – 3	0.2 – 0.8	Spain	-0.1	0
Italy	12	3.2 – 3.3	United Kingdom	-2.4 – -3.8	-9 – -14

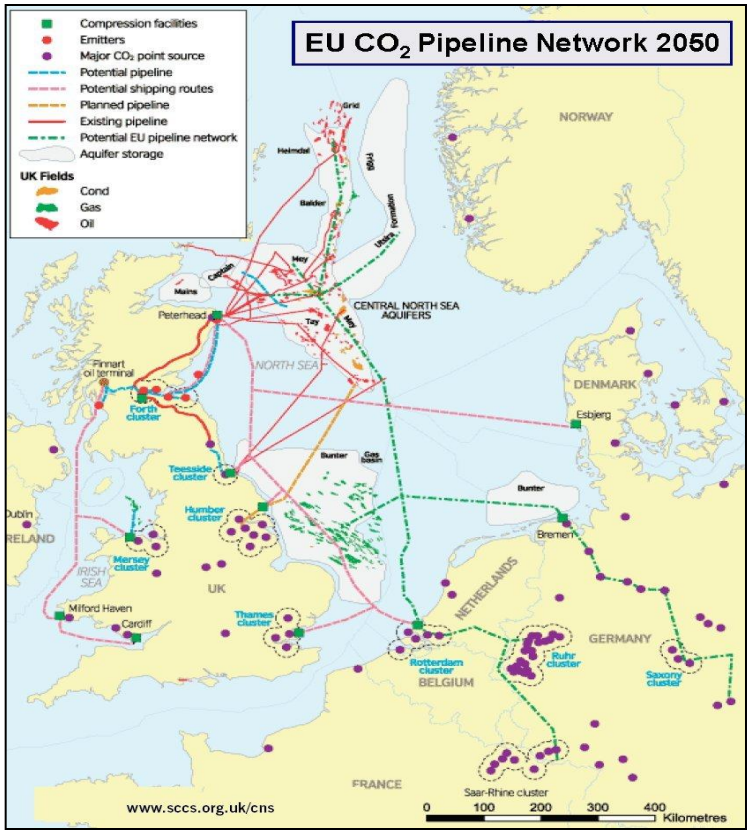
Although Germany would contribute only 30% of all captured CO_2 emissions to the transport pipeline, it could be required to cover up to 66% of the investment costs.

Morbee, Joris (6. – 8.07.2011): "International transport of captured CO_2: Who can gain and how much?". International Energy Workshop, Stanford: Palo Alto. http://ie.jrc.ec.europa.eu

Initial North Sea CO_2 pipeline proposals have been downscaled to link only industrial centers.

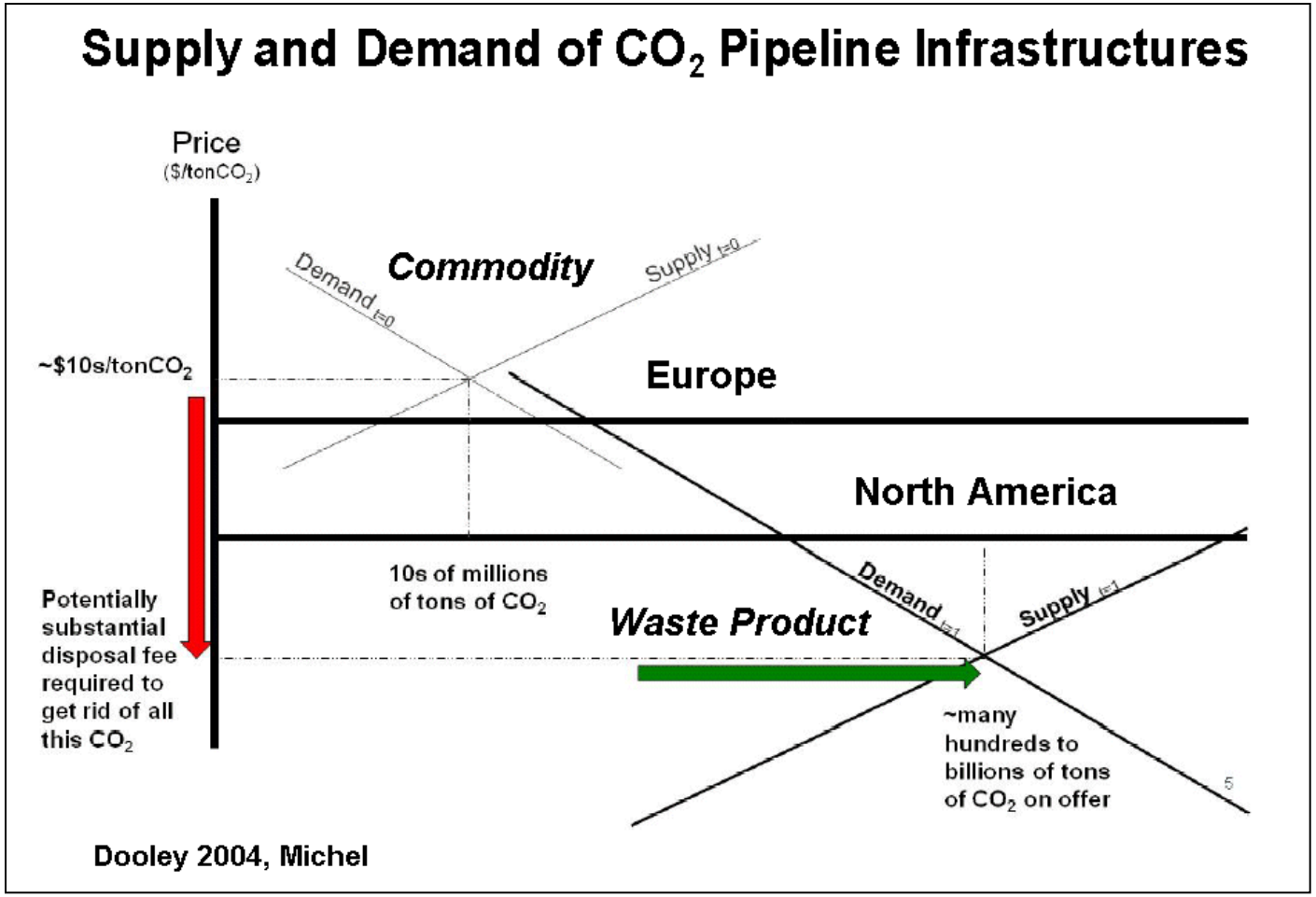


Original CO2Europipe proposal:
20,374 km, 1.2 Gt/a by 2050

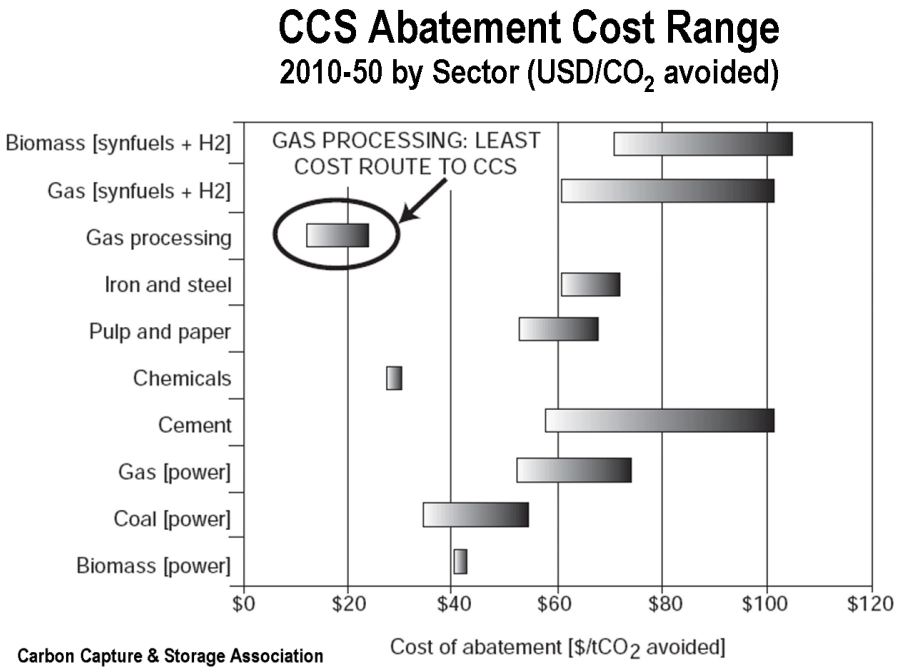


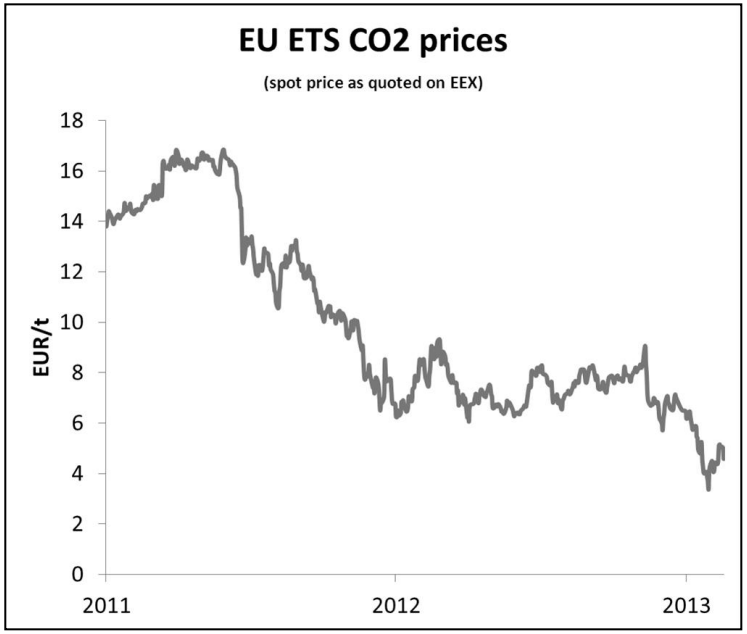
Feasible realization: > 100 Mt/a for EOR & industrial applications

Without commercial demand, CO_2 becomes a waste product with high CCS disposal costs.



CCS abatement costs far exceed EU prices for CO_2 Emission Trading Scheme (ETS) allowances.





ETS CO_2 prices have fallen to a fraction of CCS abatement costs.

CCS development remains underfunded, inhibiting future commercial deployment.

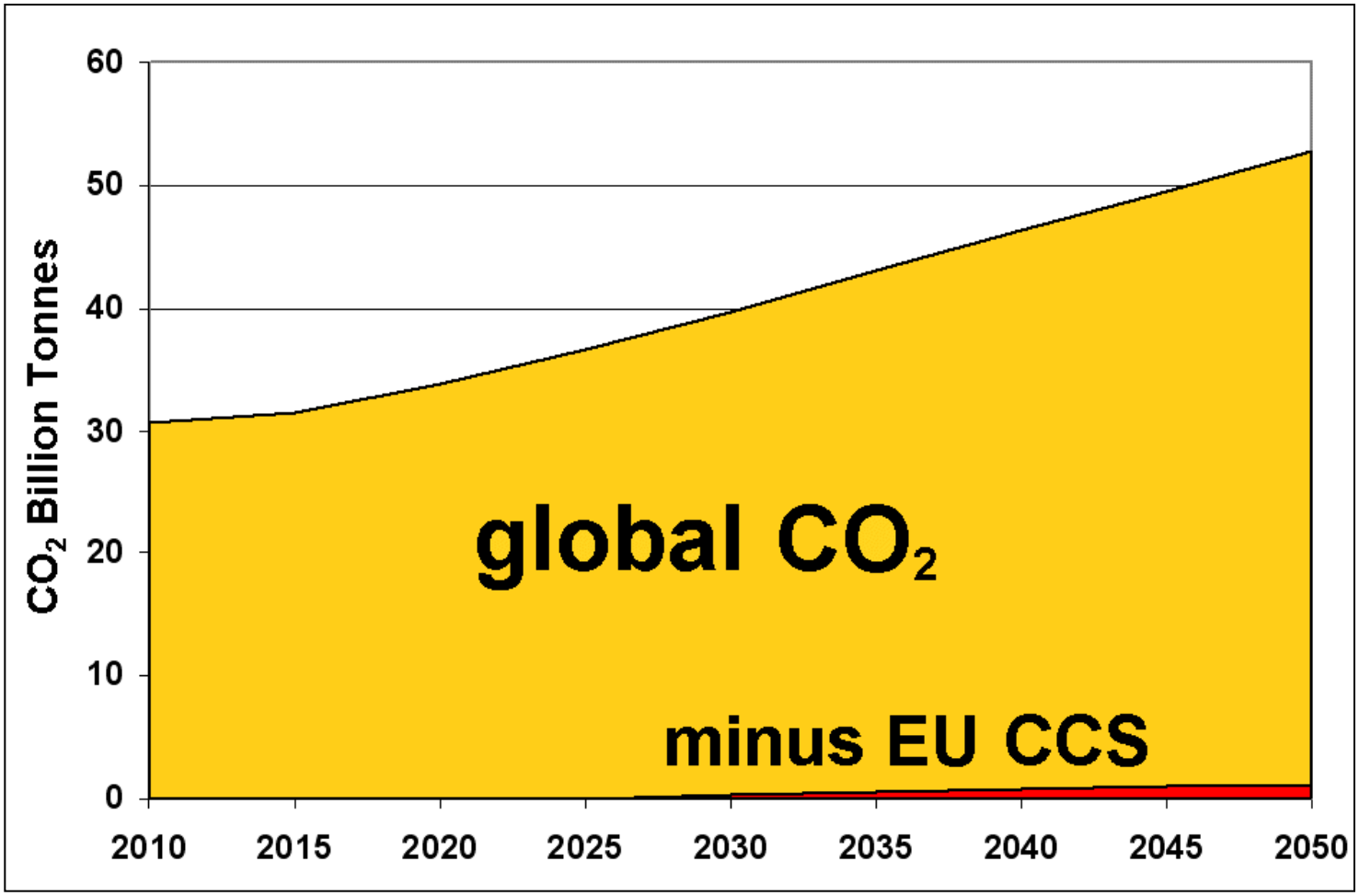
- After two years of consideration, the United Kingdom Energy Research Council (UKERC) determined in 2012 that a regulatory approach for making CCS compulsory in all fossil plants would only be practical if the technology were more advanced.
- **Dr Jim Watson,** director of the energy research group at Sussex University and lead author of the UKERC report, has noted:
  - **Commercial CCS operations do not yet exist.**
  - **No perception prevails of when they will be technically proven at full scale, and whether costs will be competitive with other low-carbon options.**
  - **The government's commitment must lead to several full-scale CCS projects as soon as possible to determine whether it is a serious option for the future.**

(Carbon Capture Journal, September 2, 2012)

CCS coal power plants could not efficiently supersede nuclear generation in Germany.

- Conventional German grid power was generated in 2012 from 19.1% hard coal (118 TWh), 25.7% lignite (159 TWh), and 16.1% nuclear (99.5 TWh).
- If nuclear power – scheduled for phase-out in 2022 – was replaced by fossil fuel generation, and all coal and lignite power stations were equipped with CO_2 capture, the energy demands of CCS process chains would require over 150 TWh of additional generated electricity.
- The electrical power dedicated to CO_2 capture and transport would be equivalent to more than 75,000 new wind turbines (three times current German wind power capacity), or to doubling present lignite generation.

Maximum EU CCS implementation would remain an inadequate response to rising CO_2 emissions.



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