# European Assessments of Carbon Capture and Storage

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**Hot Topic Hour**
**McIlvaine Company**

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# Lower generation costs are sustaining coal usage despite rising $CO_2$ emission levels.

- **Per MBTU, the fuel procurement costs for electrical power generation from hard coal ($3) and mine-mouth lignite ($2) lie far below petroleum ($14) and natural gas ($5).**

- **Coal and lignite power plants emit up to three times the $CO_2$ of natural gas per generated kWh, diminishing their cost advantages under the EU Greenhouse Gas Emission Trading System (ETS).**

- **The United Kingdom is considering a Emission Performance Standard to help offset the cost of low-carbon power plant designs. According to Climate change secretary Chris Huhne: "It would be impossible for any new coal power station to be built without being equipped with carbon capture and storage (CCS)."**

- **The rapid increase of coal usage in Asian countries is greatly outdistancing the rate of CCS deployment.**

# EU targets for greenhouse gas emissions and renewables promote carbon reduction.

## 20 20 by 2020

## Europe's climate change opportunity

**Commission of the European Communities, January 23, 2008**

- "A reduction of at least 20% in greenhouse gases (GHG) by 2020 – rising to 30% if there is an international agreement committing other developed countries to 'comparable emission reductions'…"
- "A 20% share of renewable energies in EU energy consumption by 2020." (Current level 8.5 %)

**Reducing GHG emissions by 30 % in the EU is contingent on comparable resolve by the United States.**

# The EU SET-Plan for energy technologies includes subsidies for CCS demonstration projects.

| *European Strategic Energy Technology Plan (SET-Plan)* | |
|---|---|
| **European Industrial Initiatives** | **Billion euros (2010 - 2020)** |
| Wind Energy | 6 |
| Solar Energy (PV & CSP) | 16 |
| Bioenergy | 9 |
| Carbon Capture and Storage (CCS) | 10.5 - 16.5 |
| Electricity grid | 2 |
| Sustainable Nuclear Energy | 5 – 10 |
| Smart Cities | 10 – 12 |
| **Total** | **58.5 – 71.5** |

**10 to 12 CCS demonstration projects (Zero Emission Plants ZEP) above 250 MW being subsidized by the EU include Jänschwalde (Germany), Maasvlakte (Netherlands), Belchatow (Poland), Hatfield (United Kingdom), Compostilla (Spain), and Porte Tolle (Italy).**

# Impediments to CCS realization may be compounded by conceptual fallacies.

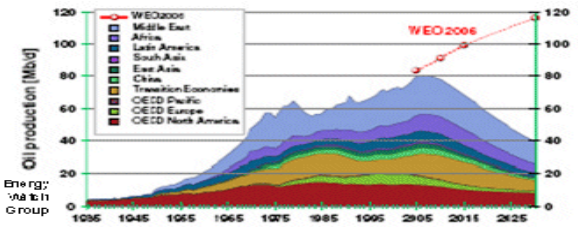
| Impediment | Cause | Consequence |
|---|---|---|
| Postponement of a CCS power station at RWE until at least 2030 | Denial of EU funding due to uncertainties of $CO_2$ pipeline and storage | Negative signal for other CCS projects |
| Municipal and peaking gas power stations unsuited for CCS | Costly $CO_2$ removal and pipelines at intermittent-duty plants | Preference for non-CCS plants under prevailing low $CO_2$ trading prices |
| Economic perspectives for CCS undefinable | Implementation time frame not predictable | Growing investments in nuclear power plants |
| CCS adoption difficult in emerging economies | Limited energy supplies unable to bear CCS efficiency losses | $CO_2$ emissions rise in step with population and living standards |
| Declining high-quality fossil fuel availabilities | Accessible fuel reserves rapidly exploited | Questionable long-term usage of CCS sites and infrastructure |

# Carbon capture and storage (CCS) requires greater fuel and water resources.

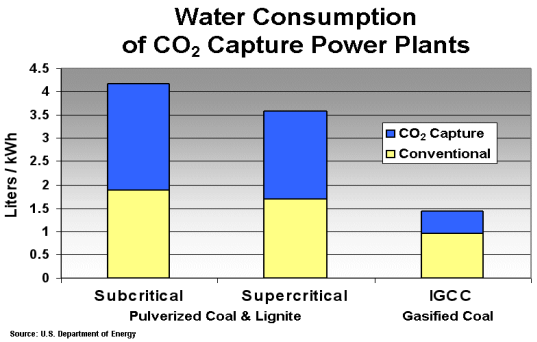
## Deploying CCS to avoid $CO_2$ emissions would mean:

**Up to 40% added mined energy demand to offset efficiency losses inherent to capturing, compressing, transporting, and injecting $CO_2$, as well as for fuel procurement.**

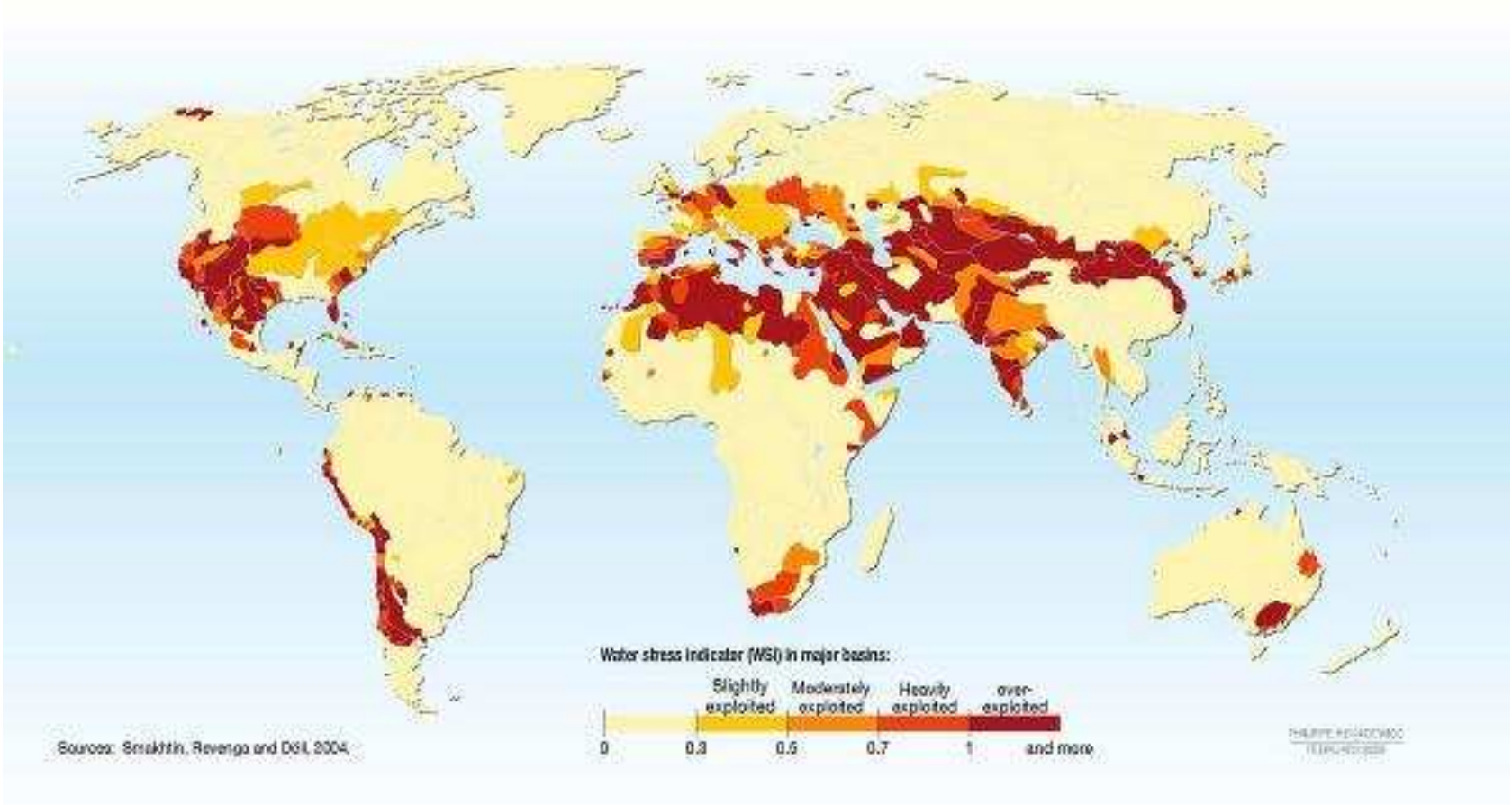

**Accelerated depletion of fossil fuel reserves within a century, in India and most of Europe by mid-century.**




**Increased power plant cooling water requirements because of added energy consumption, greater groundwater withdrawal due to power plant and mining demands.**



# Worldwide water stress makes global CCS implemention increasingly questionable.



# CCS in Europe is confronted with legal questions on pipeline routes and groundwater imperilment.

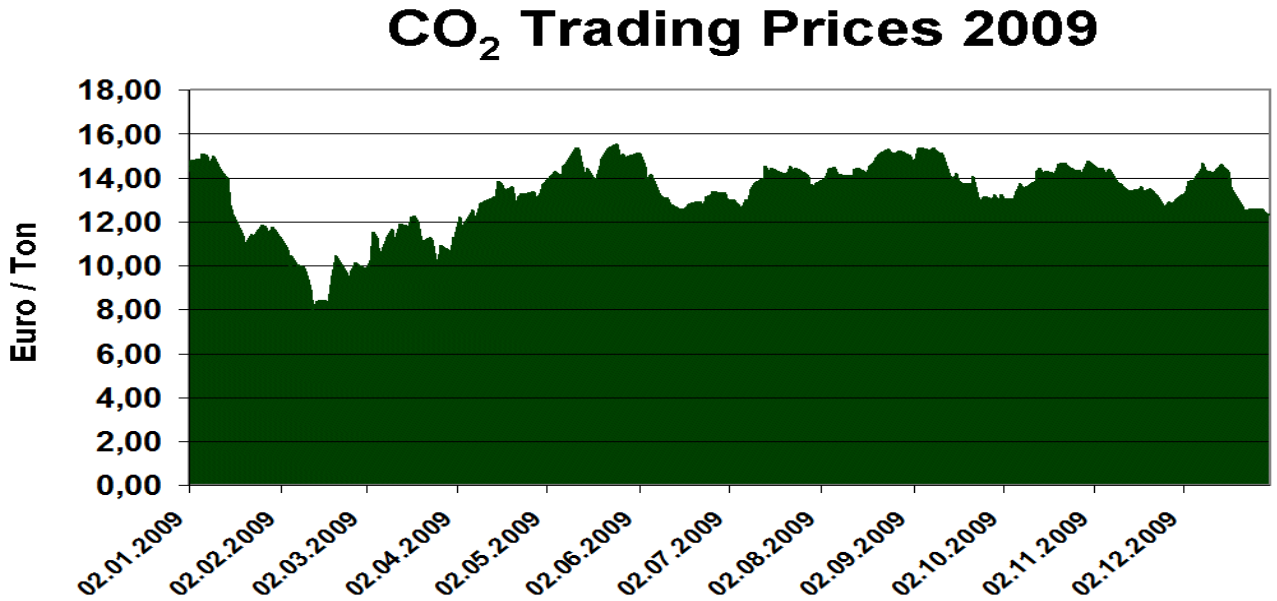
**The European Commission has refused to subsidize a 500 km $CO_2$ pipeline proposed by RWE in northwestern Germany due to issues of immanent domain and geological storage integrity.**

**The Jänschwalde CCS project planned by Vattenfall near Berlin requires licensing to be completed before the EU funding deadline at the end of 2015 despite local opposition to $CO_2$ storage and to expanded lignite surface mining.**

**DONG Energy in Denmark has already abandoned coal plant projects due to CCS uncertainties and the profitability of renewable power generation.**

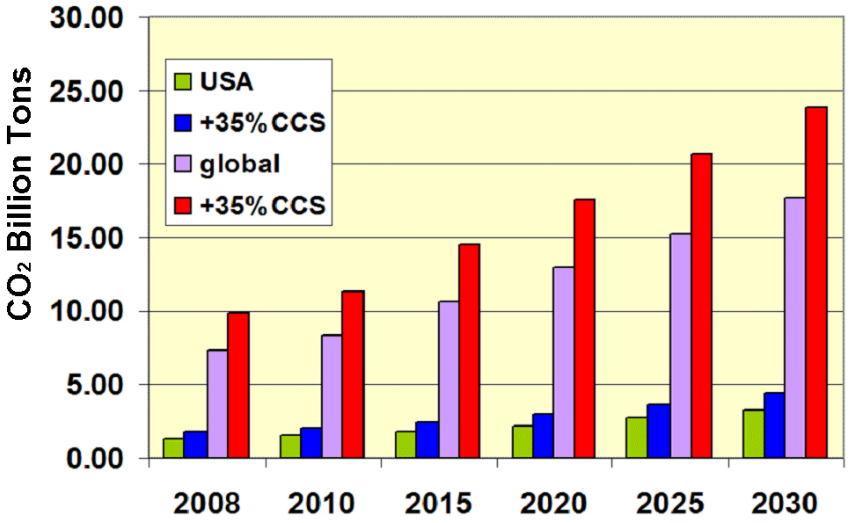

# Current $CO_2$ trading prices are not sufficient to support commercial implementation of CCS.

**Initial CCS implementation costs in the United States have been estimated at \$125/t $CO_2$ or \$96/t with subsidies provided by the American Clean Energy & Security Act.**
**By contrast, $CO_2$ emission trading levels in Europe have fallen below 15 € (\$19) per ton.**



# CCS energy losses necessitate $CO_2$ mitigation capacities far in excess of emission targets.

**Prospective $CO_2$ Avoidance Requirement for Kyoto Compliance**
(= 95% of 1990 levels in industrial countries)




Xie & Economiedes 2009

**Cumulative $CO_2$ Storage by 2015**

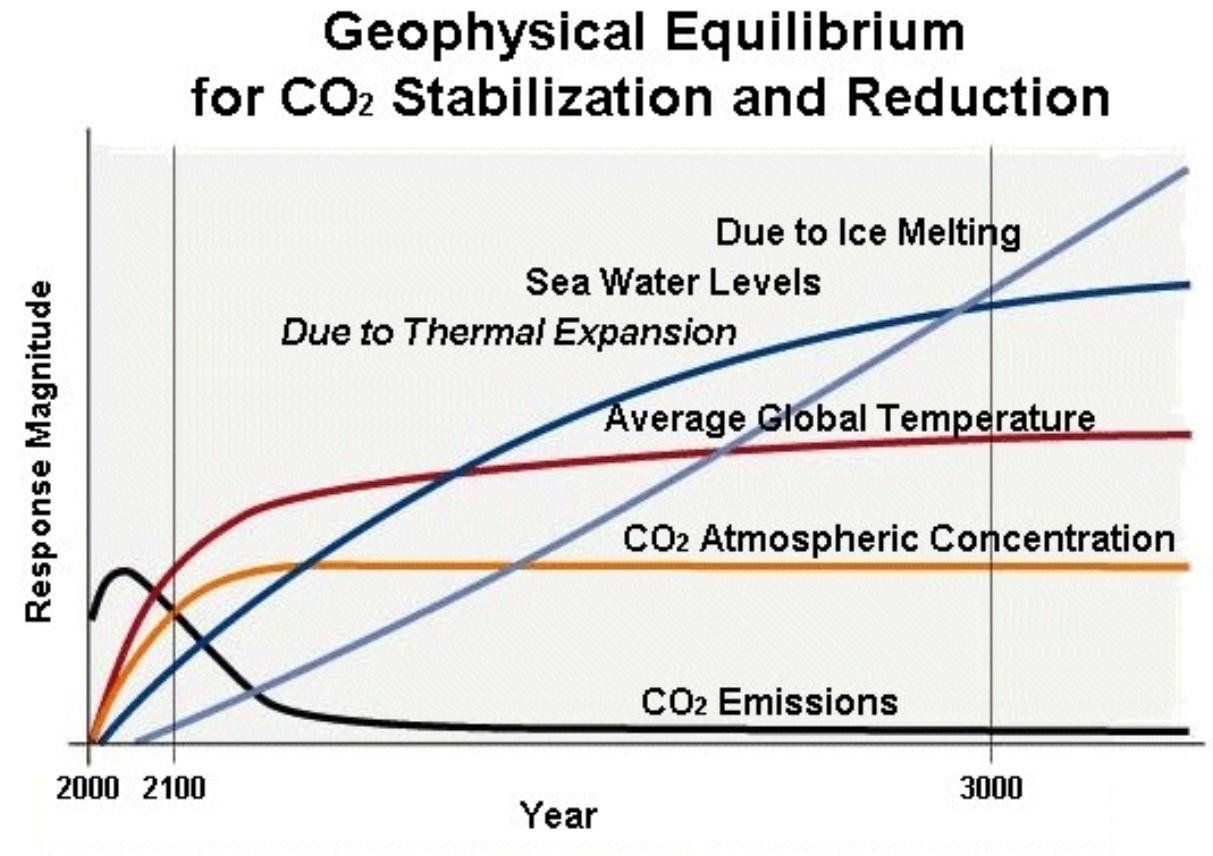
Table 6-2 Select existing and planned $CO_2$ storage projects as of early 2009

| Project | $CO_2$ source | Country | Start of injection | Amount injected by | | |
|---|---|---|---|---|---|---|
| | | | | 2006 | 2010 | 2015 |
| Rangely | GP | USA | 1986 | 22 Mt | 25 Mt | 29 Mt |
| Sleipner | GP | Norway | 1996 | 9 Mt | 12 Mt | 17 Mt |
| Weyburn | Coal | Canada | 2000 | 5 Mt | 15 Mt | 26 Mt |
| In Salah | GP | Algeria | 2004 | 2 Mt | 7 Mt | 12 Mt |
| Midale | Coal | Canada | 2005 | 1 Mt | 3 Mt | 5 Mt |
| Ketzin | NA | Germany | 2007 | 0 | 50 kt | 50 kt |
| Otway | Natural | Australia | 2007 | 0 | 100 kt | 100 kt |
| Snøhvit | GP | Norway | 2008 | 0 | 2 Mt | 5 Mt |
| Gorgon | GP | Australia | 2010 | 0 | 0 | 12 Mt |
| **TOTALS** | | | | **39 Mt** | **64 Mt** | **106 Mt** |

Global CCS Institute: *Strategic Analysis of the Global Status of Carbon Capture and Storage* (2009)

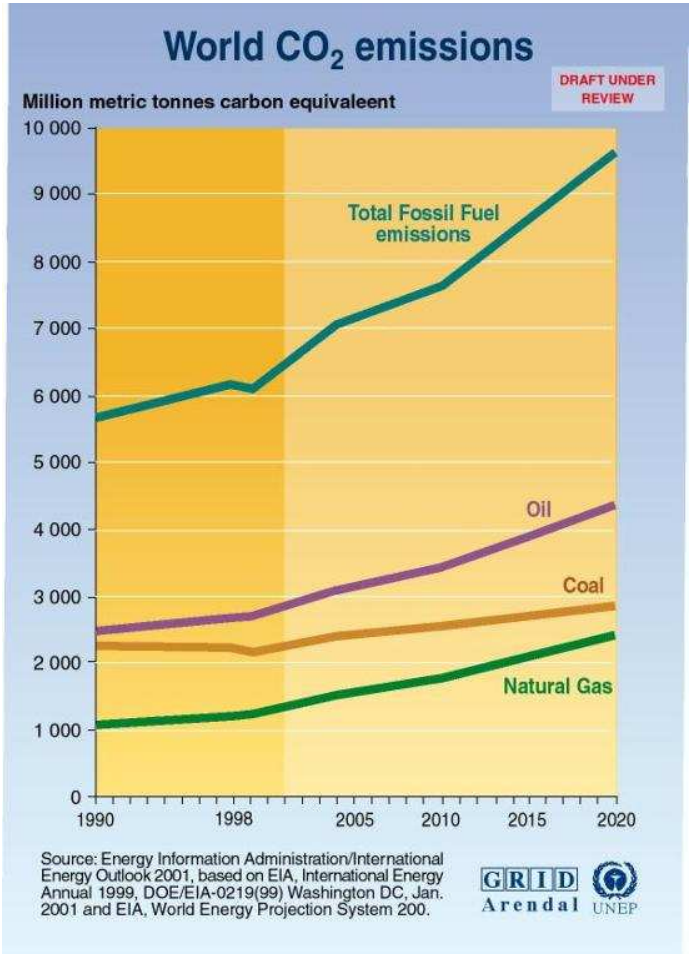
**The amounts of $CO_2$ stored by CCS projects now being implemented or planned are miniscule compared with ongoing accumulations of greenhouse gases.**

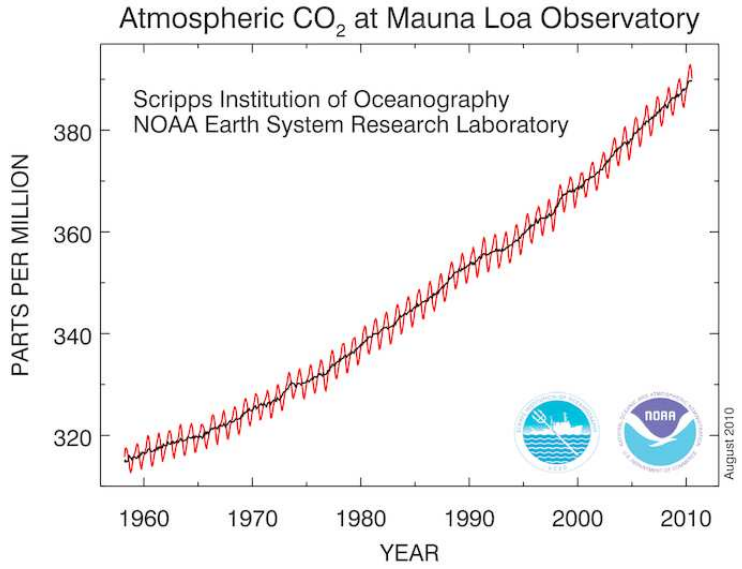
# The prospect of altering the consequences of cumulative $CO_2$ emissions is at best marginal.




Source: Intergovernmental Panel on Climate Change

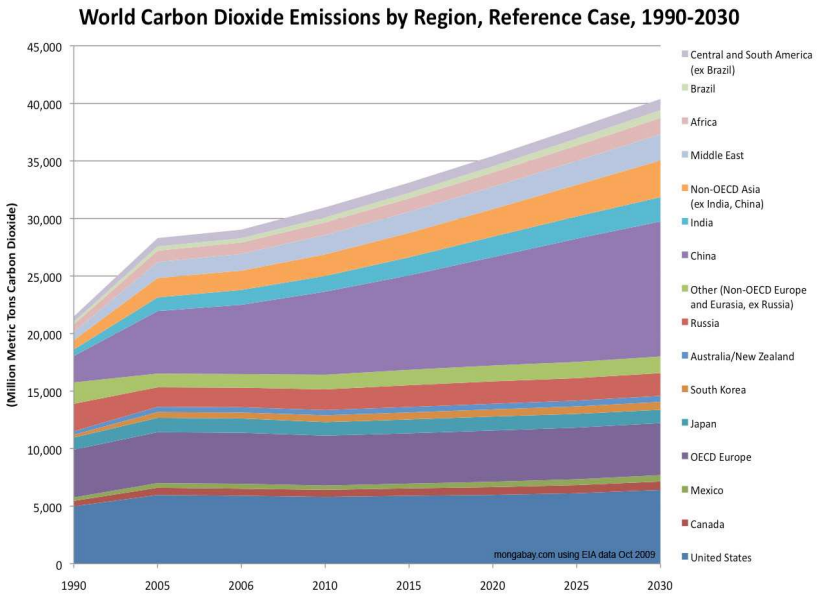
# Even large-scale CCS remedies would not significantly reduce global carbon emissions.

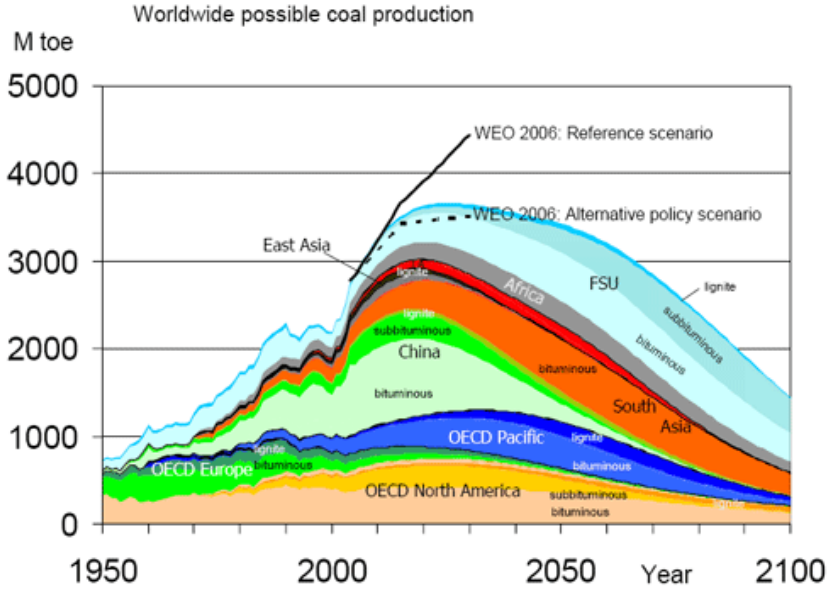



**Coal produces less than a third of total greenhouse gas emissions, and only large or clustered plants are viable for CCS implementation.**

# CCS promotes coal usage, accelerating the depletion of global fuel reserves.




(Source: Energy Watch Group)

**Global $CO_2$ emissions will rise in the first half of this century irrespective of CCS deployment.**

**After 2050, CCS will be constrained by the decline of coal reserves that it has helped to deplete.**

# Many arguments for CCS implementation are incongruent with physical reality.

- The application of CCS is restricted to a narrow segment of fossil fuel usage under considerable geological constraints.
- By the time CCS can be routinely integrated into coal power plants worldwide, diminished fossil fuel reserves will have restricted the extent and duration of their operation.
- Limited water resources at many plant sites preclude the added cooling demands of capturing and compressing $CO_2$.
- CCS cannot deliver competitive carbon-free power at current emissions trading levels, while a five-fold higher price must be guaranteed for the life of the generating equipment to insure its commercial justification.
- CCS may enrich certain business enterprises, but it is beyond the financial means of global climate change strategies.

# The conditions of future CCS deployment remain to be quantified.

- **The assumption of unlimited fuel availability for CCS should be superseded by data on long-term coal availabilities that fulfill the fuel quality requirements of advanced plant designs.**
- **Siting projections must include the certified availability of cooling water supplies adequate for supporting the added thermal requirements of capturing and compressing carbon emissions.**
- **Geological investigations must confirm the suitability of underground formations for $CO_2$ storage without leaking or leeching.**
- **A global referendum is necessary to determine whether the diversion of fuel resources for burying carbon emissions underground may be justified to coming generations.**