Internalization of Externalities and Carbon Abatement Costs

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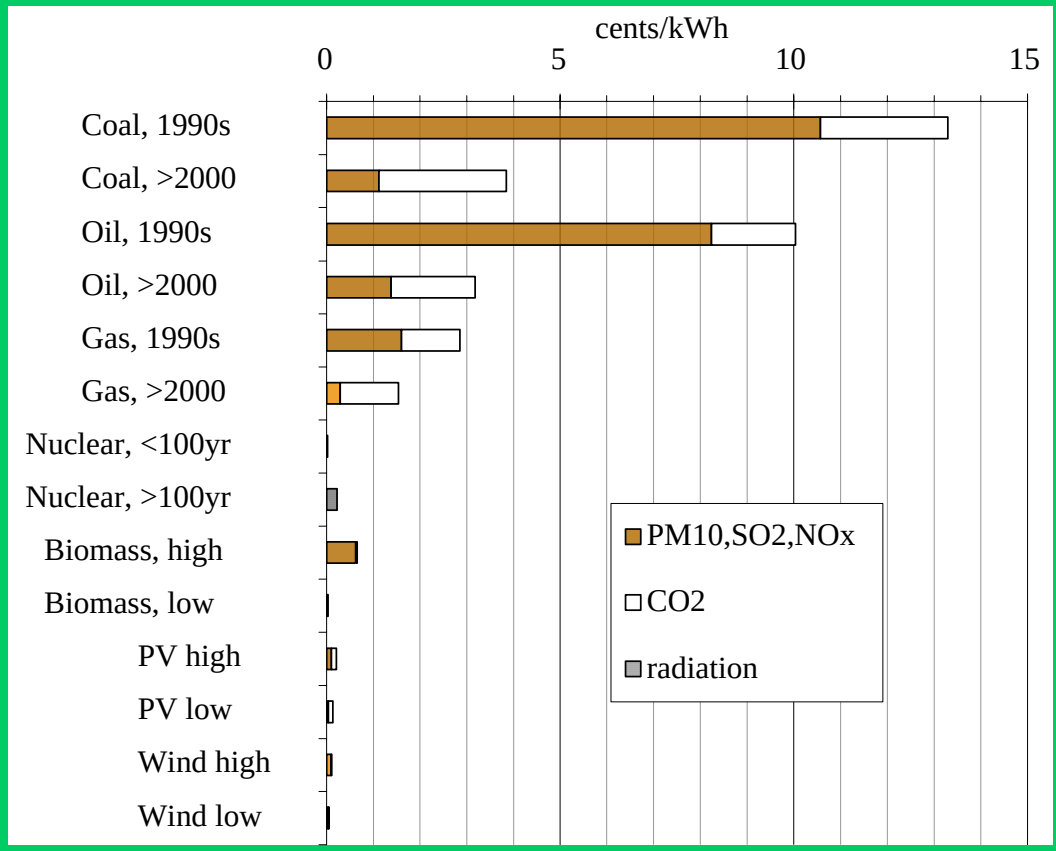
MAXIMA Workshop
"Estimating External Costs of Electricity Production"

Ecole des Mines, Paris, France
10-11 May 2005

Outline

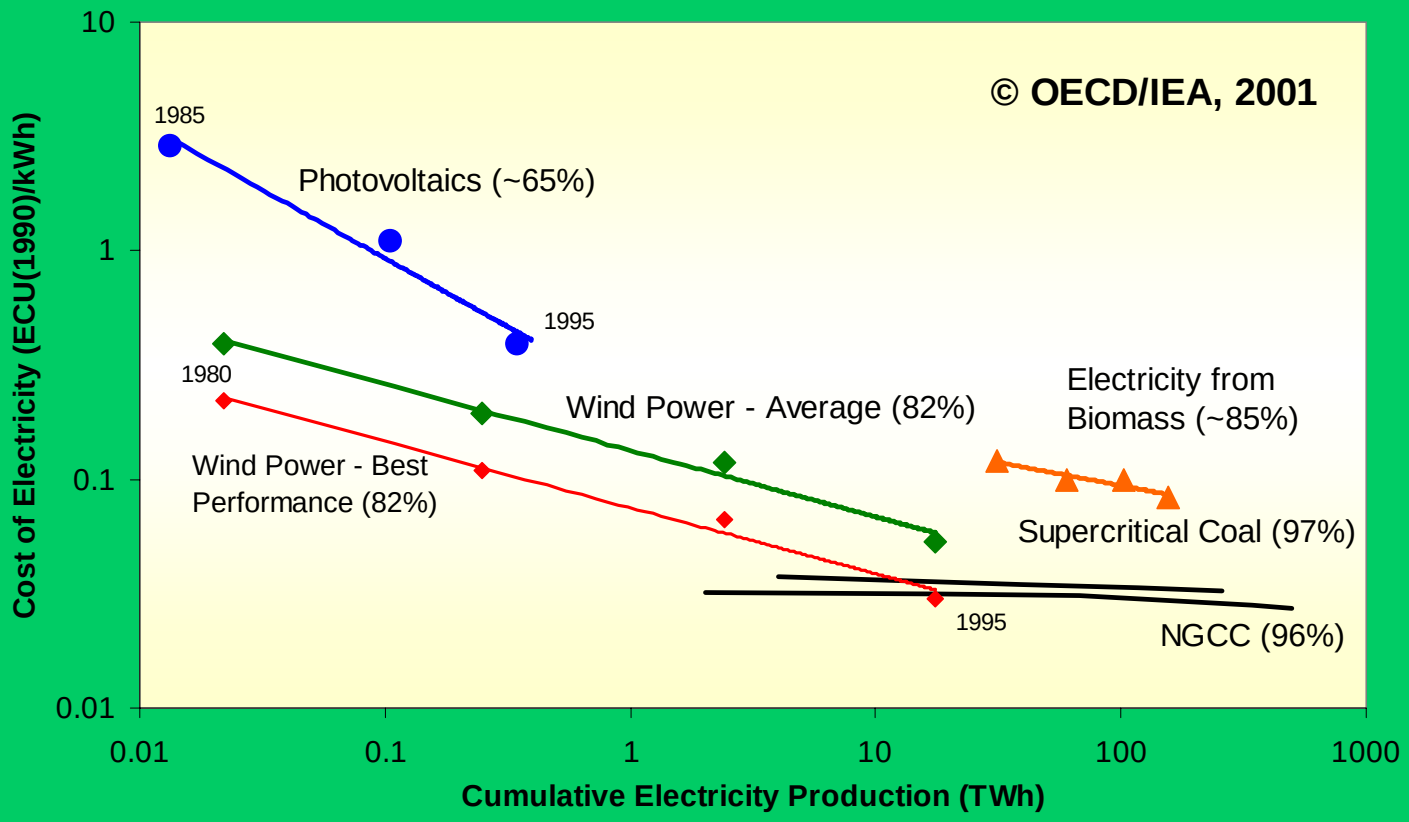
- I. Externalities: introduction
- II. Learning-by-doing
- III. Carbon Capture and Storage (CCS)
- IV. CCS – Abatement costs
- V. Environmental externalities of CCS
- VI. Conclusions

I. Damage costs



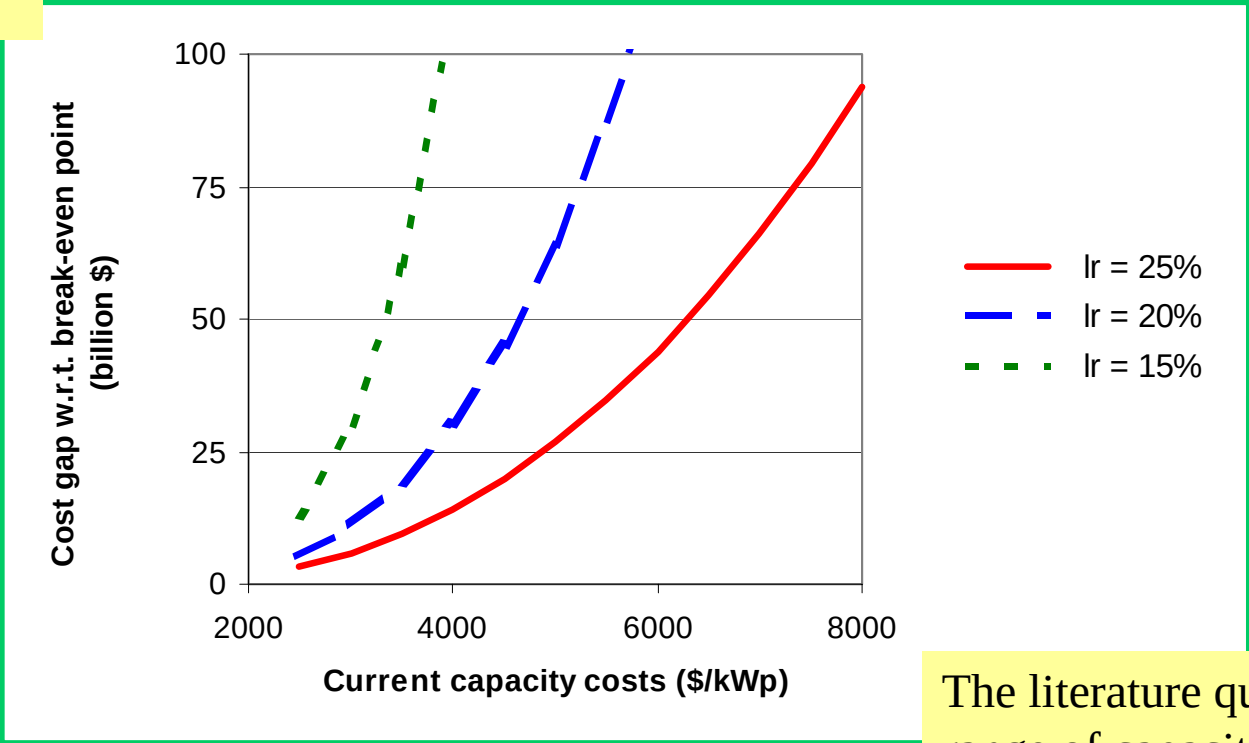
Comparison of damage costs for EU fuel chains. *Source: ExternE, 1998.*

II. Energy learning curves



II. PV cost gap

lr: learning rate



The literature quotes a wide range of capacity costs.

PV cost gap as a function of current costs.

II. Avoided damage by PV

Progress ratio (%)	**75%**	**80%**	**85%**
Cost gap ($ billion)	27	64	288
Avoided damage ($ billion)	12	37	239
Avoided damage (% of cost-gap)	44%	58%	83%

Effort required for reaching break-even / bridging cost gap.

- Avoided damage depends entirely on assumptions one makes regarding the external costs of the energy option PV replaces.
- This is one example of why it is relevant to analyse uncertainties of external costs, as well as the consequences of these uncertainties.

III. CO_2 capture

Two major options:

Centralised:

- Post-combustion: flue gas from nat. gas (NGCC) and coal (PC) power plants contains ~4% and ~14% CO_2, respectively.
- Combustion with concentrated oxygen: ~80% CO_2 in flue gas.

Decentralised:

- Pre-combustion: separate fuel into CO_2 and H_2.
- Carbon dioxide collectors.

III. CO_2 storage

Carbon storage can be categorised by:

- Mechanism: through physical, chemical or biological processes;
- Location: in the ocean, on the terrestrial surface, or in the subsurface (underground);
- Time scale: relative permanence of storage, over decades, centuries or millennia.

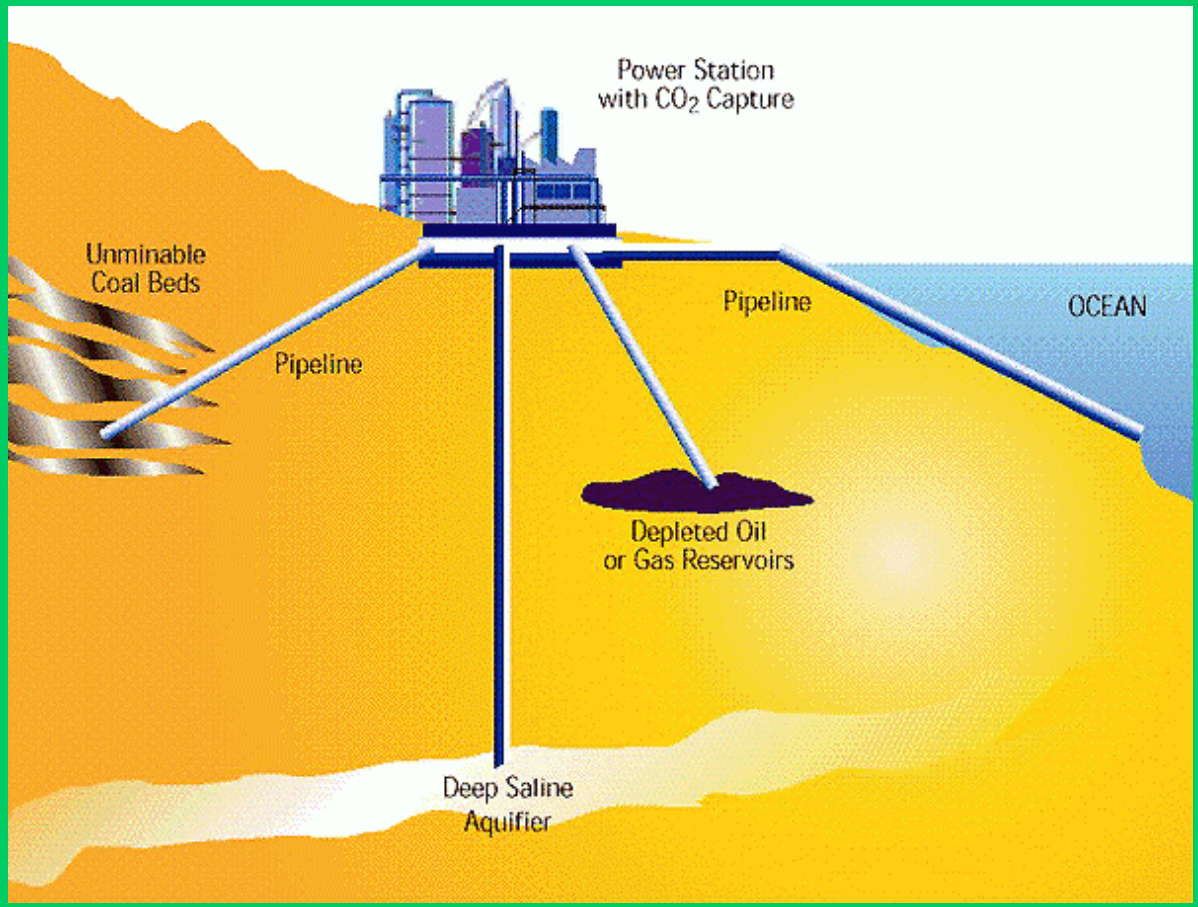
III. Physical approaches

Either (A) underground (geological) or (B) ocean storage of carbon dioxide. In particular:

- Depleted oil or gas fields (enhanced oil recovery, EOR);
- Unminable coals beds (enhanced coal bed methane, ECBM);
- Deep saline aquifers;
- Injection into deep oceans.

- Proximity of storage sites to power plants will be an issue, in order to limit costs related to transportation;
- Largest share of total costs are in capturing, rather than in transportation and storage.

III. 4 physical options



Unlike coal, oil and gas fields: aquifers have no history of containment.

Source: IEA Greenhouse Gas R&D Programme.

III. Sleipner

Source: Nooner et al.

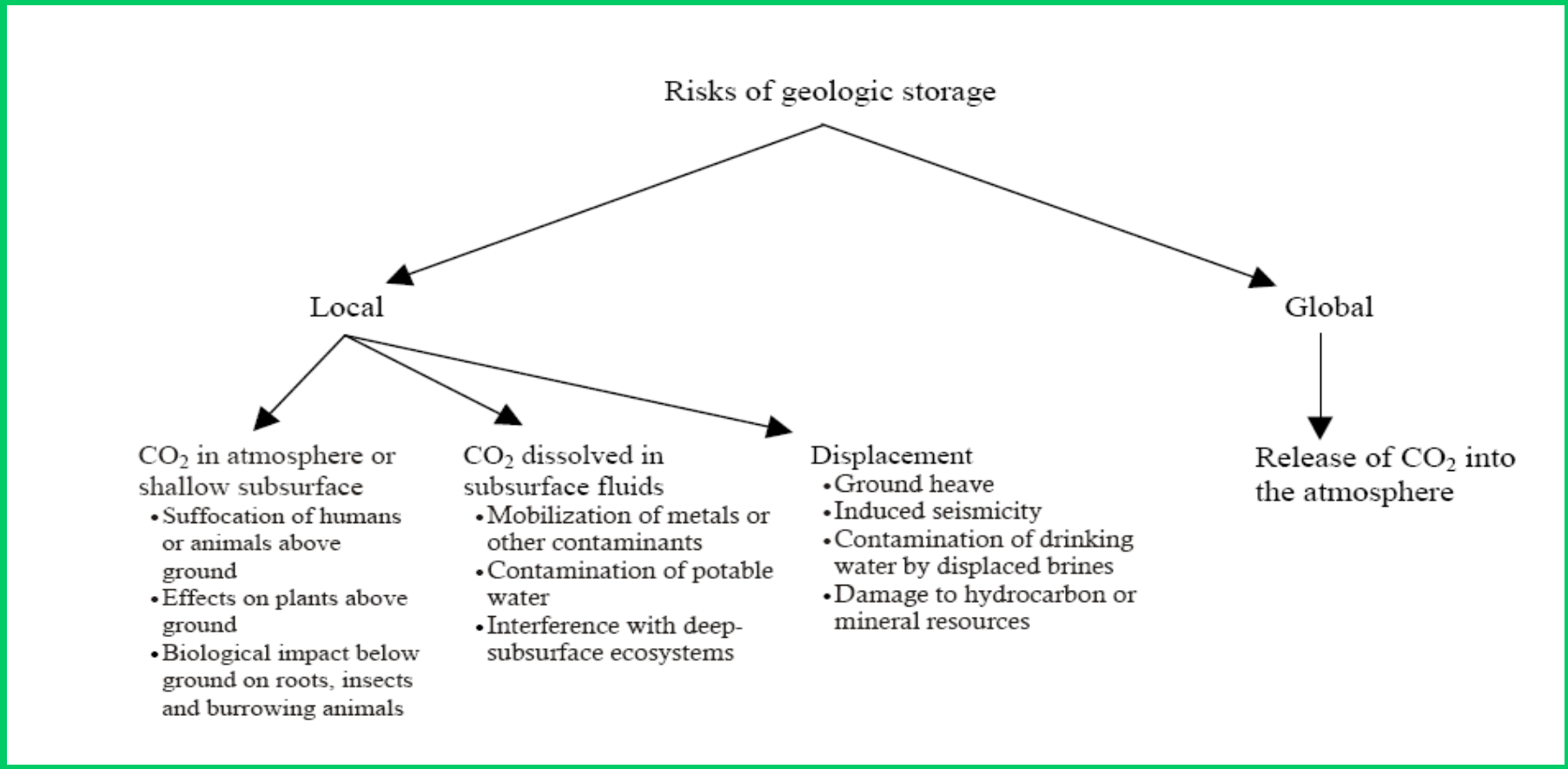
IV. CCS abatement costs

	CCS costs ($/tC avoided)		
Reference plant	**New PC, CCS**	**New NGCC, CSS**	**New IGCC, CCS**
New PC	229	47	162
New NGCC	741	224	542
New IGCC	208	18	138

Sensitivity of CCS costs to reference plant. *Source: Anderson and Newell, 2004.*

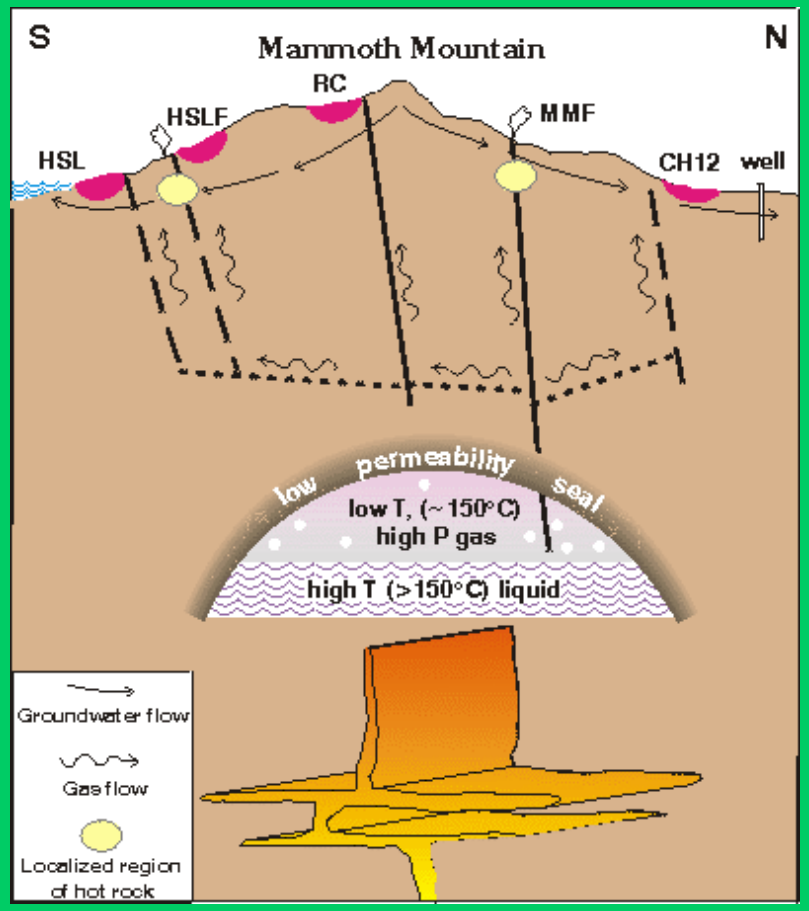
- Numbers obtained with $3MBtu gas price.
- Transport and storage costs are assumed to be $37/tC stored.

V. Risks and externalities



Risks of geological storage. *Source: Keith and Wilson, 2002.*

V. Gradual leakage



CO_2 Leakage at Mammoth Mountain, California.
Source: Jennie Stephens, 2004 / USGS, 1999.

V. CO_2 hazards

Source: David Hawkins, 2004.

VI. Conclusions

- Internalization of externalities is in principle the right way to proceed to create a level playing field for all (carbon an non-carbon) energy technologies.
- For CCS, environmental externalities and risks should not be underestimated (storage heterogeneity).
- While a promising technology in principle, one needs to be wary for undue optimism.
- Much more (externalities-)R&D is needed before large-scale deployment can be realised.