

# Recent advances in CCS economics and sociology

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## **Views on CCS risks acceptability**

Minh Ha-Duong

CIREN



# Risk analysis approaches

Singleton (2009), citing Renn (1992)

- Social Constructivist methods
  - Economic: expected utility...
  - Sociological: surveys, corpus...
  - Psychometric approaches
- Realist methods
  - Probabilistic Risk Analysis: event, fault tree...
  - Toxicology/Epidemiology: experiments, pop. Studies.
  - Actuarial approach: extrapolation-based.

# Outline

1. Acceptable leakage rate for economists
2. Unacceptability of leakage for real people
3. Objectively, leakage is not the largest risk

## References:

Minh Ha-Duong and Rodica Loisel (2009) Zero is the only acceptable leakage rate for geologically stored CO<sub>2</sub> : an editorial comment. *Climatic Change* (2009) 93:311–317

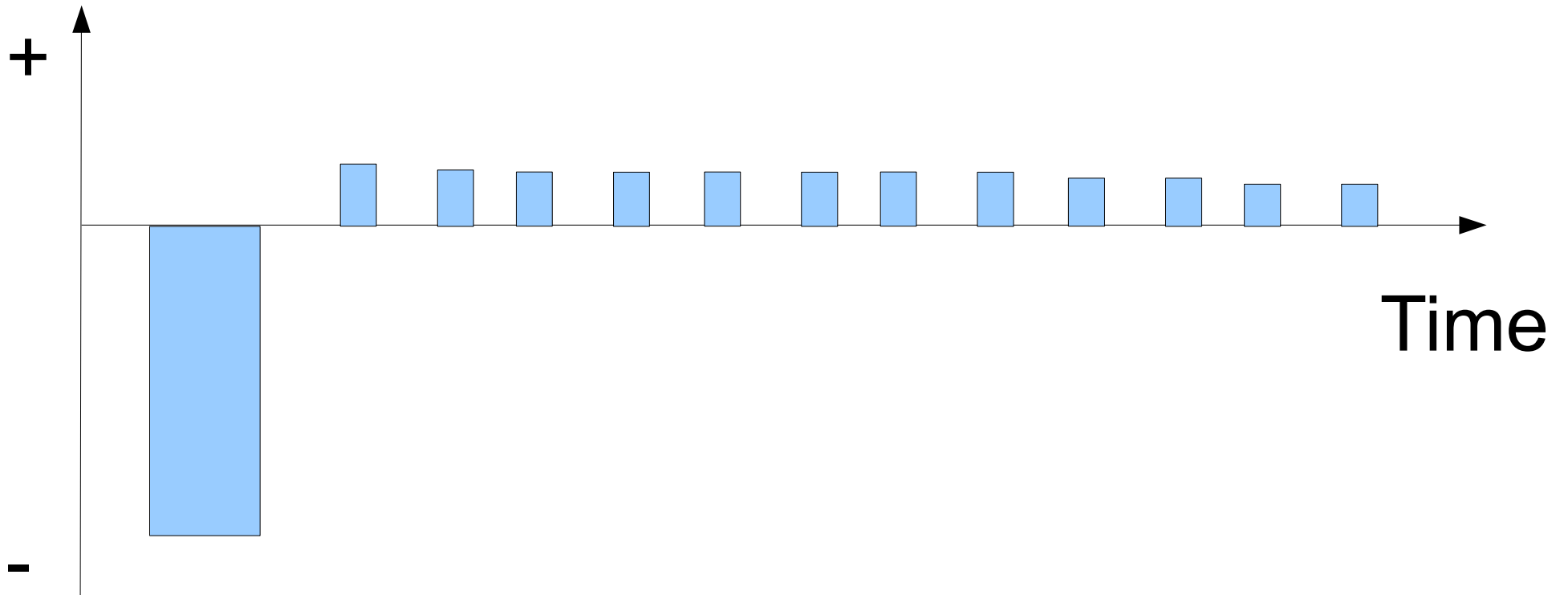
Minh Ha-Duong and Rodica Loisel (2009) Expected fatalities for one wedge of CCS mitigation. Actuarial risk assessment of carbon capture & storage at the global scale in 2050. Poster presented to the *IARU Climate Change Meeting*, Copenhagen.

# 1. Economists

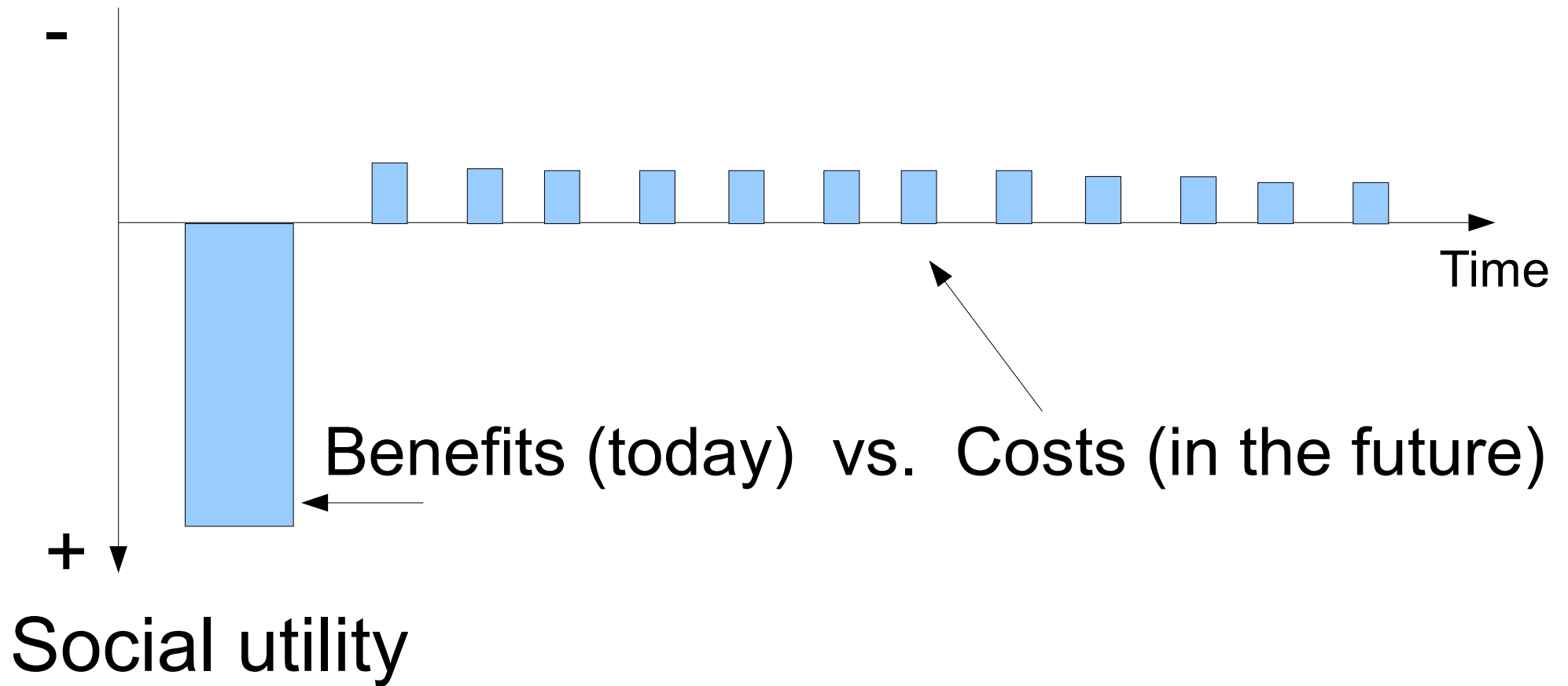
«Some leakage is acceptable »

# Carbon capture in a leaky reservoir

CO<sub>2</sub> flow  
to the atmosphere



# The question is intertemporal valuation



It is like borrowing ...

# Four key parameters

- Energy **penalty**: CO<sub>2</sub> avoided < stored
- **Leakage** rate
- The future is **discounted**...
  - Pure time preference
  - Wealth of future generations
- ... but the value of **avoided CO<sub>2</sub>** increases

# Will CO2 harm us more in 2100 ?

**NO** (discount rate  $>$  CO2 value growth rate)

 there is an acceptable leakage rate

**YES** (Hotelling's rule, France's CAS example)

 storing in leaky systems is not sustainable



## 2. Social actors

«No leakage is acceptable »

A paradox ?

## 2. Social actors

«No leakage is acceptable »

# Environmental NGOs

Anderson et Chiavara (2008)

- Variety: Greenpeace, Friends of Earth, Bellona
- CCS at best a bridging technology:
  - In the long run only renewables and conservation are sustainable
  - No new coal without CCS
  - Massive increase in renewables investment

# Industry's point of view

- Engineers state that zero leakage is their goal, and that leaks will be dealt with.
- No leakage is a project design specification, not a system-wide statistic (cf. airlines)

# Regulator's point of view

- Policymakers set no leakage as a social norm
- At the same time deal with a non-ideal reality (liability for leakage...)
- Miss real-world experience to base policy on, but can adapt

# Finally: people's point of view

- Sound ignorance (pseudo opinion)
- Long term effectiveness and leakage risks are perceived as key variables
- Indirect judgements can be made
  - Experts' reliability, independence
  - Processes' fairness, transparency

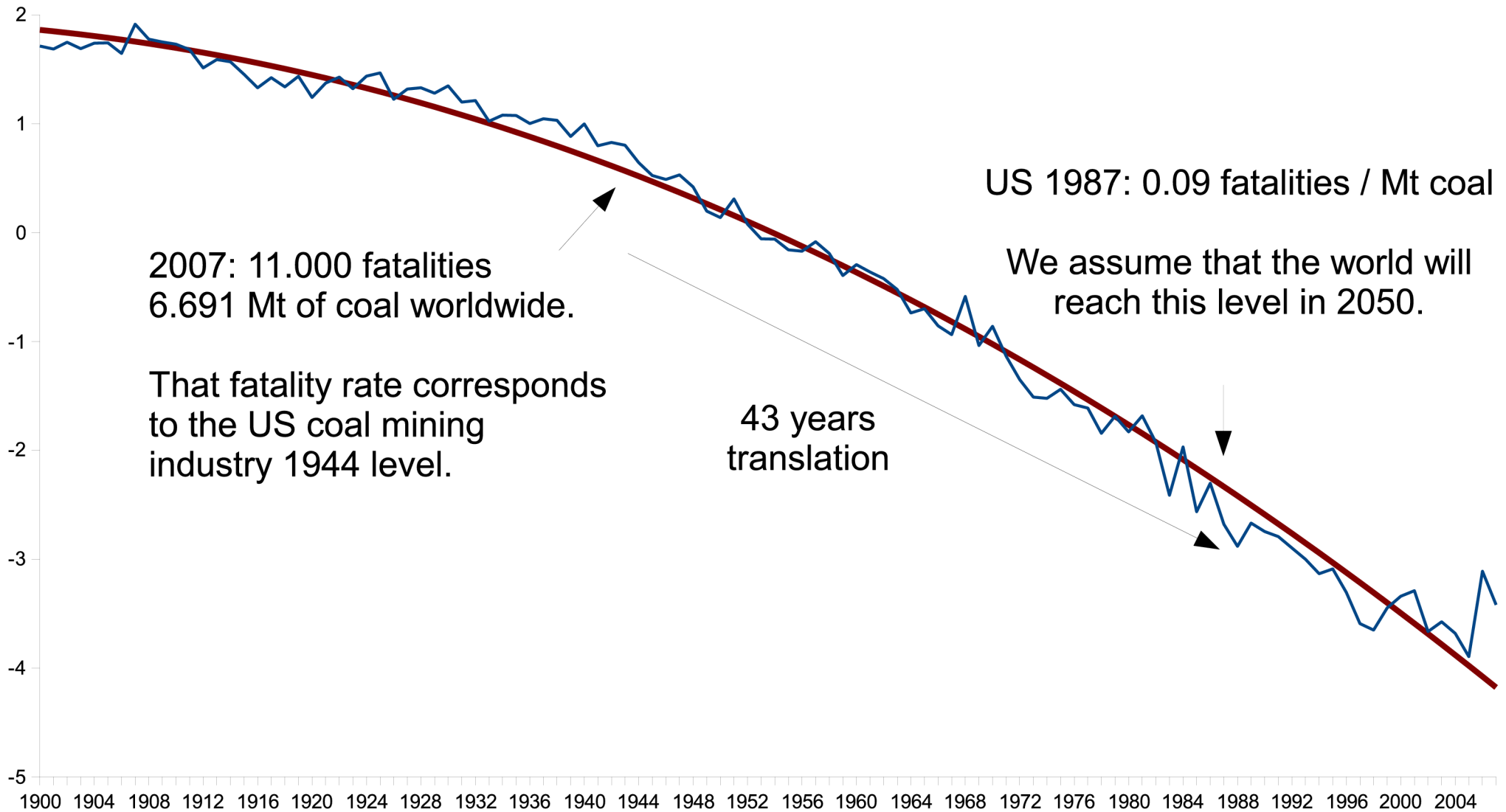
# 3. Actuarial risk analysis

What would be the expected consequences of using CSC to abate  $1\text{GtC yr}^{-1}$  in 2050 ?

- ✓ 1 « wedge »
- ✓ Fatalities = deaths
- ✓ From Mining to Storage

# Mining 5 Gt of coal: 250-500 fatalities

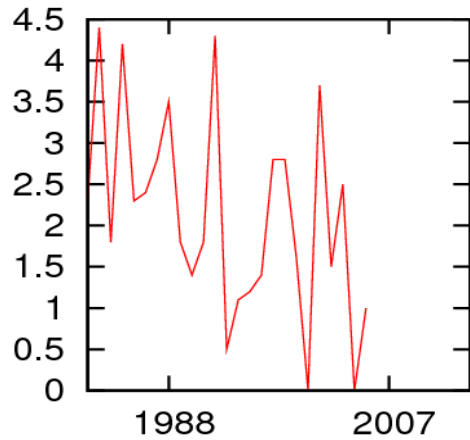
log (Fatalities / Production) in the US coal industry



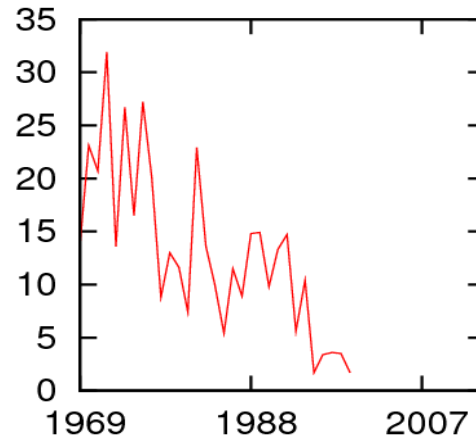


# Capture at 1.500 sites: 1 to 8 fatalities

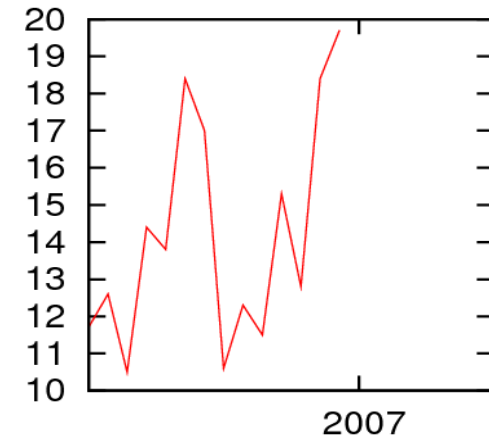
UK



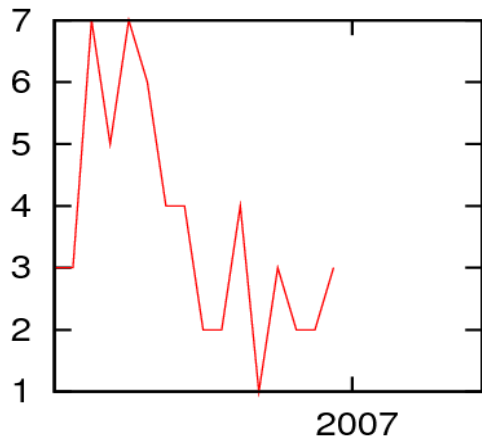
France



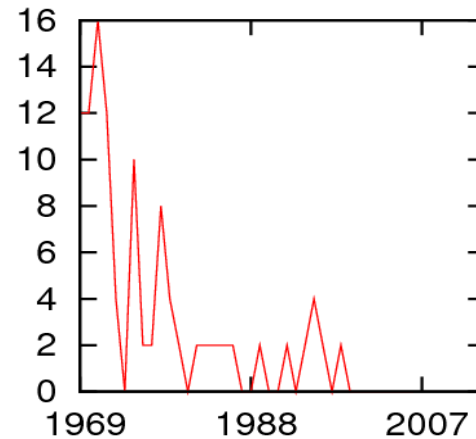
Canada



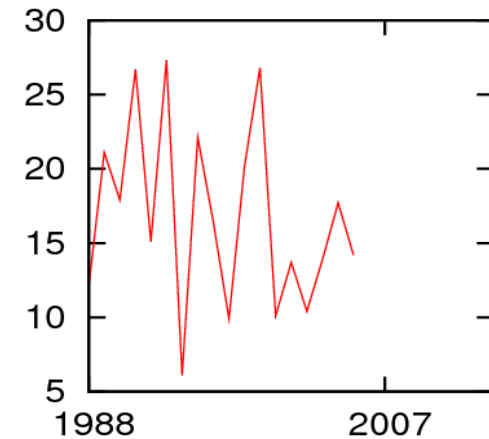
Italy



Japan



China



# Shipping 2.000 Gt miles: 23-57 fatalities

- 400 Mt CO<sub>2</sub> (10%) \* 5.000 miles = 2 Tt miles
- Statistical fatality rates
  - ✓ 11.4 Tt<sup>-1</sup> mile<sup>-1</sup> yr<sup>-1</sup> in oil tanking (1978-2001)
  - ✓ 28.6 Tt<sup>-1</sup> mile<sup>-1</sup> yr<sup>-1</sup> in all goods trade (1989-2004)

# 150.000 km of pipelines: 1 to 15 fatalities

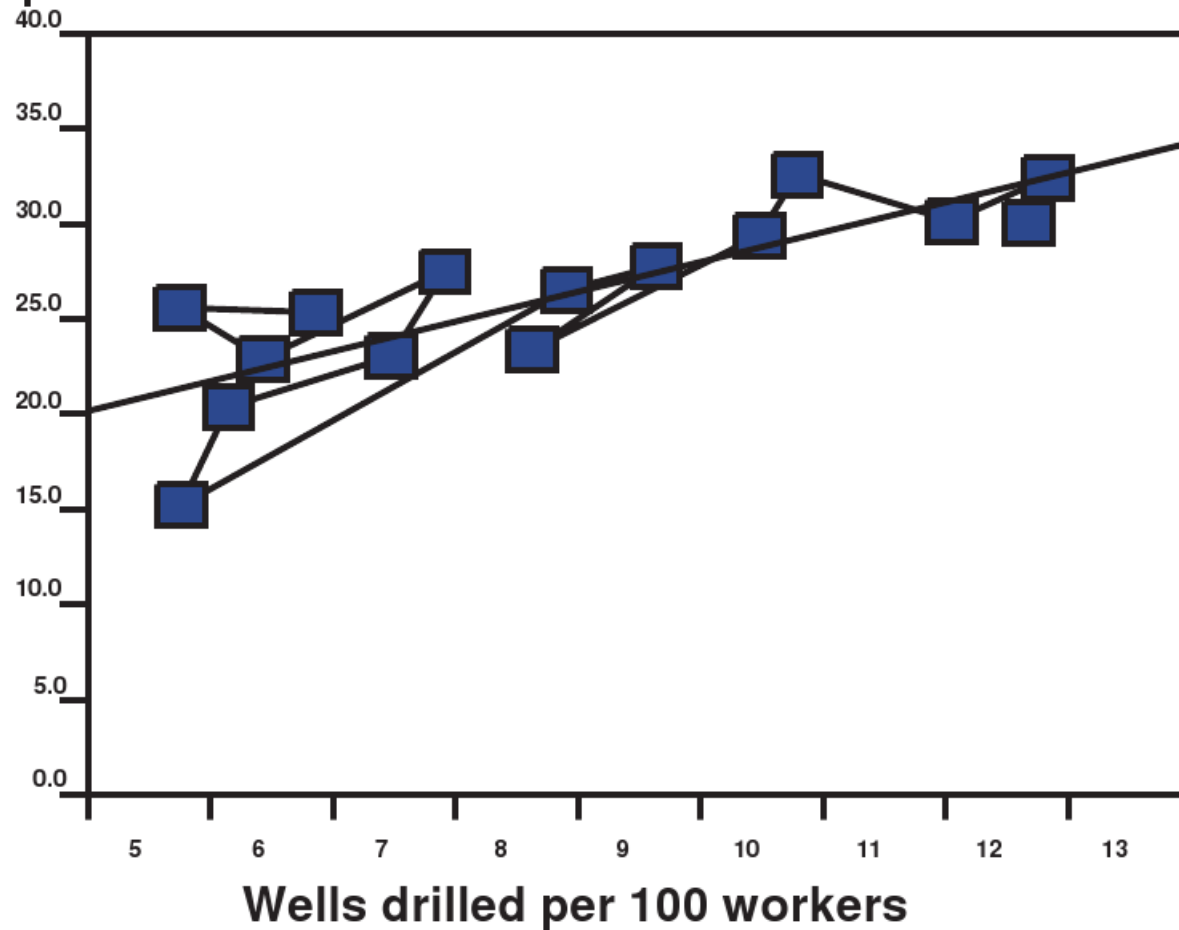
	Natural	Hasardous	
US statistics	Gas Trans	Liquids	CO2
	1986-2008	1986-2008	1990-2008
Fatalities	65	50	0
Network size 1000 km	522	255	6.2
Fat/Mkm/yr	5.4	8.5	0

- 0 fatalities on 0.1178 Mkm yr CO2 → rate < 25.4
- Europe: 11.1 fat/Mkm/yr (oil pipelines, 1971-2006)
- But other societies may tolerate  $10^{-4}$  fat/km/yr

# Injection: drilling 100 wells < 1 expected fatality

## Oil and gas industry occupational risk

FAR per 100.000 workers



# Storage at 1.500 sites <1 expected fatality

- Steam injection analogue:  
1 fatality (1991-2005) for 4.053 wells
- As Low As Reasonably Practical (ALARP)  
economic principle.
- Accepted risks for analogue projects:  
 $10^{-6}$  to  $10^{-4}$  fatality per year.

# The CCS wedge in 2050: a few hundred expected fatalities

- Mostly from mining, then shipping
- Mostly knowable, occupational, tolerated
- Much lower than climate impacts
- Only energy saving has no risk

# Summary

- Distant future costs are generally discounted.
- Non-zero leakage in projects is not acceptable.
- Leakage risks  $\ll$  coal mining or shipping risks