5th Trondheim Conference on CO2 Capture, Transport and Storage, June 16th-17th, Norway

Zero is the only CCS acceptable leakage rate

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CIRED

Outline

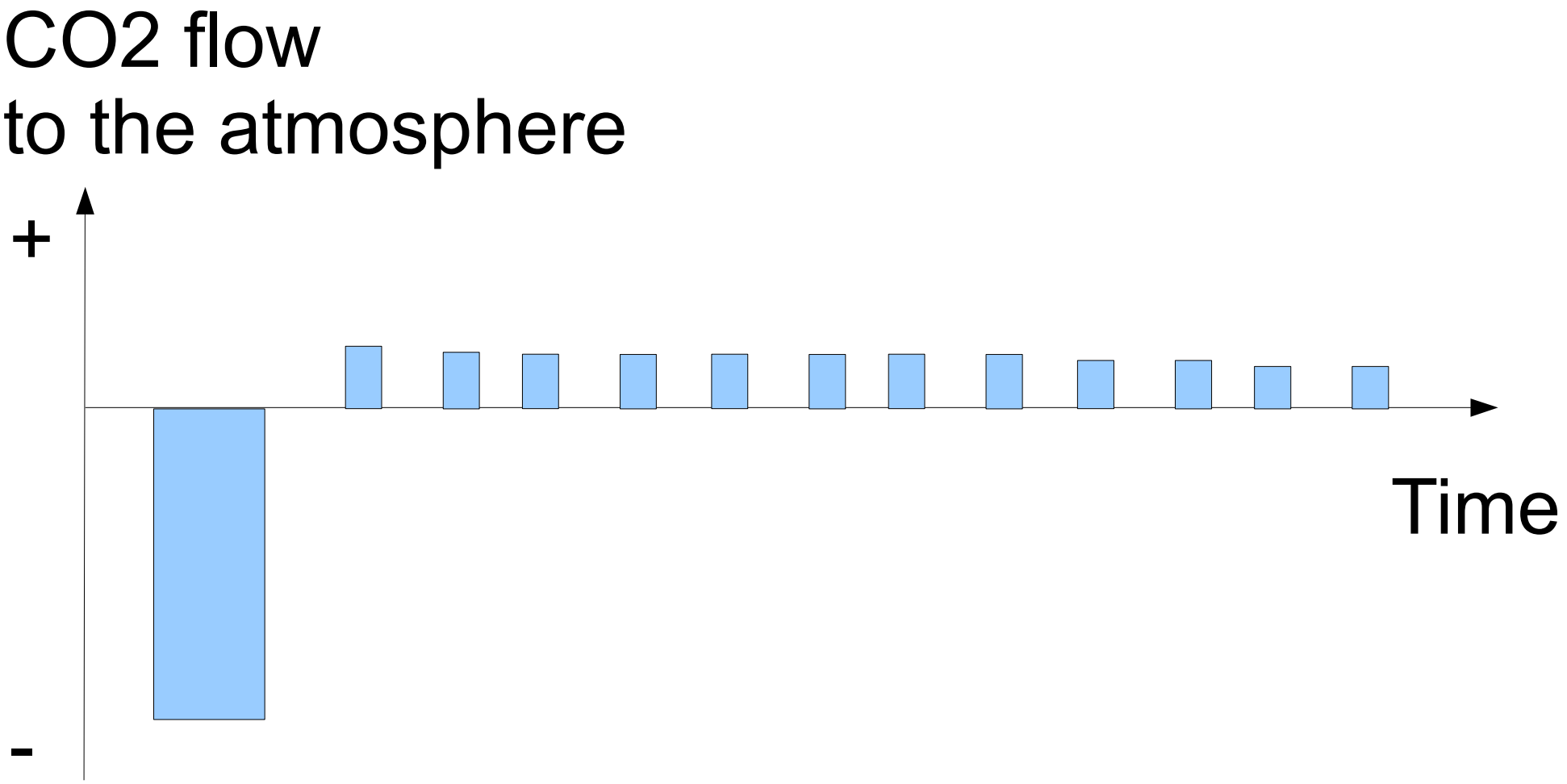
1. Acceptable leakage rate for economists
2. Unacceptability of leakage for real people

1. Economists

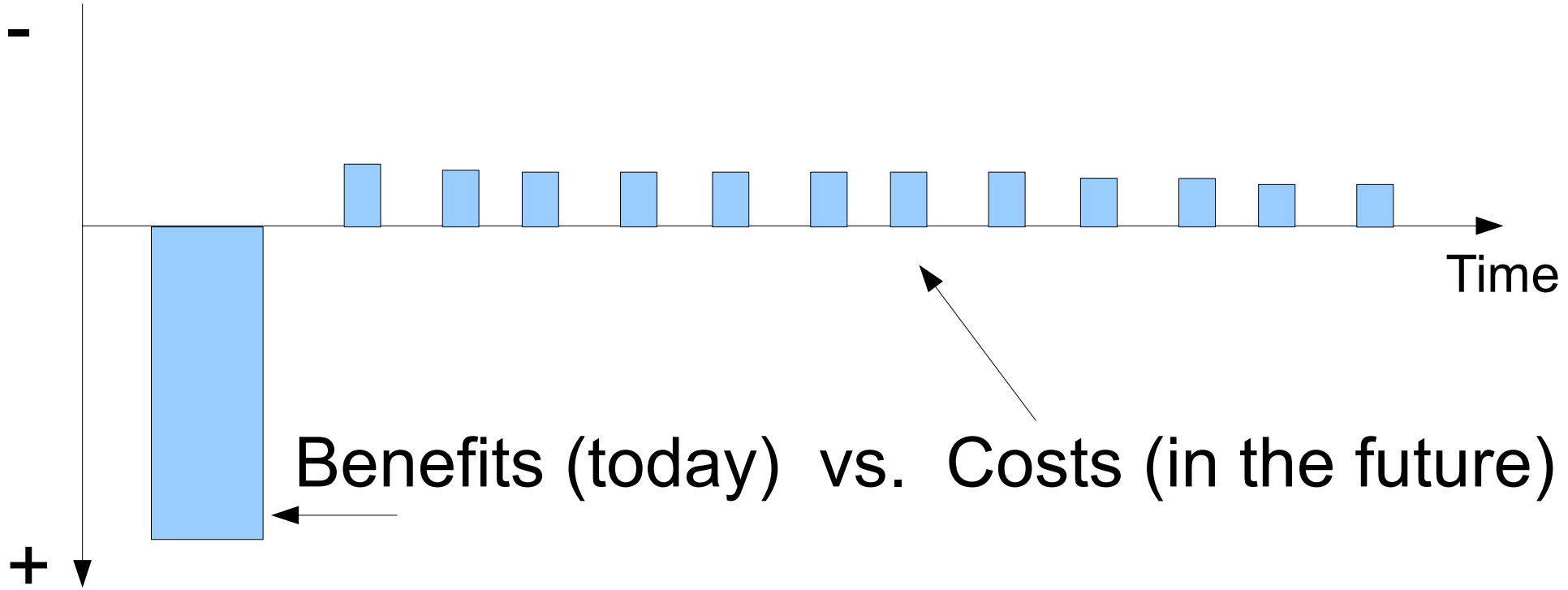
«Some leakage may be acceptable »

Minh Ha-Duong and David W. Keith (2003) Carbon storage: the economic efficiency of storing CO2 in leaky reservoirs. *Clean Technology and Environmental Policy*, 5 (2/3):181-189

Carbon capture in a leaky reservoir



The question is intertemporal valuation



Social utility

It is like borrowing ...

Four key parameters

- Energy **penalty**: CO2 avoided < stored
- **Leakage** rate
- The future is **discount**ed...
  - Pure time preference
  - Wealth of future generations
- ... but the value of **avoided CO2** 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 ? Or different views on leakage ?

Minh Ha-Duong and Rodica Loisel (2009) Zero is the only acceptable leakage rate for geologically stored CO2 : an editorial comment. *Climatic Change* 93:311–317

Environmental NGOs

- Leakage will occur
  - But implications vary: Greenpeace ↔ Bellona
- CCS at best a bridging technology:
  - In the long run only renewables and conservation are sustainable

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 will learn from accepted leakage rates

Finally: people's point of view

- Leakage influence perception
  - Long term effectiveness
  - Local environmental and health risks
- Sound ignorance
  - Pseudo opinion
  - Limited analogies
- Acceptability factors not technical
  - Experts' reliability, independence
  - Processes' fairness, transparency, local history

Conclusion

Storing CO2 in leaky systems is like borrowing.

Non-zero leakage in projects is not acceptable.

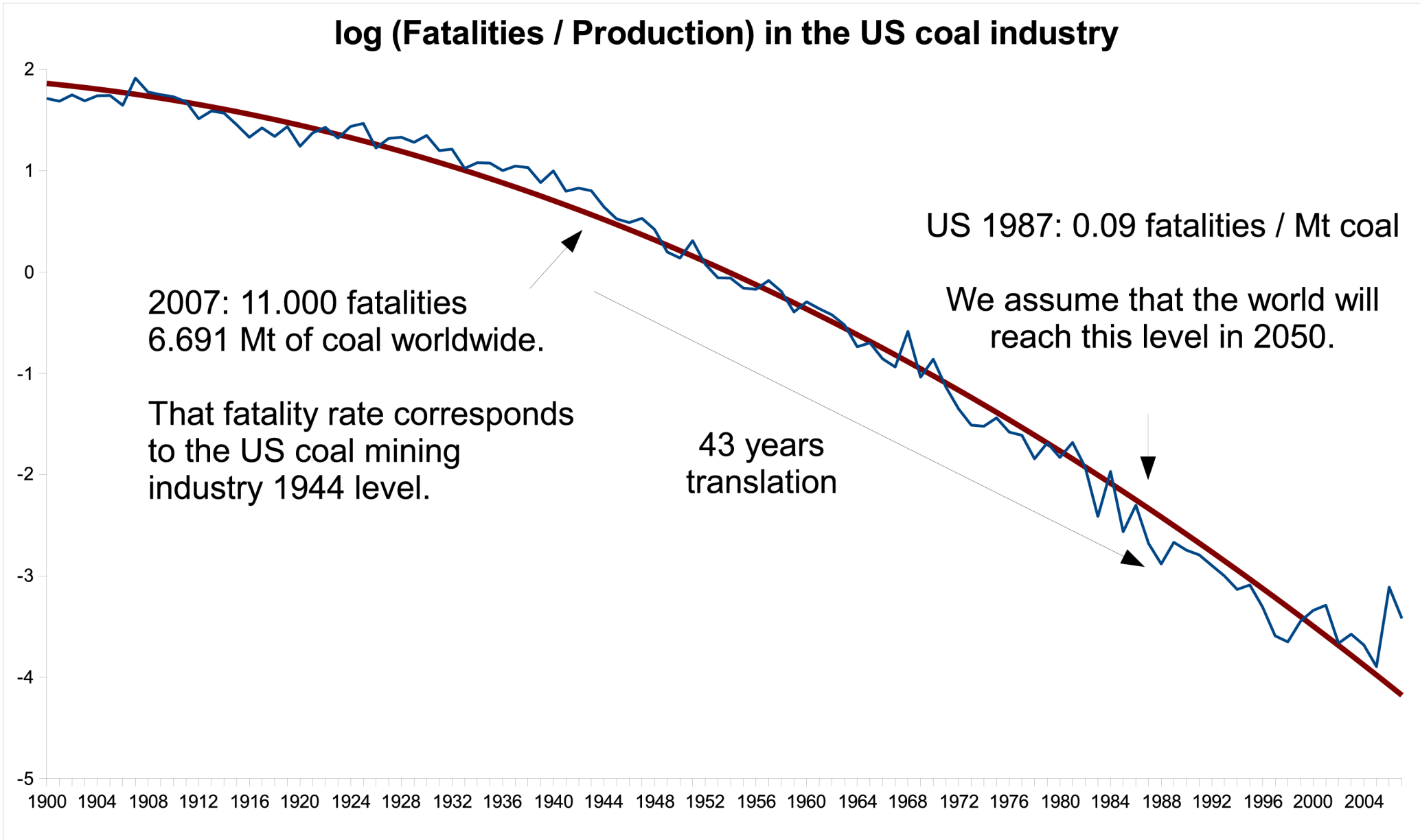
But objectively, are leakage risks greater than those of coal mining or CO2 shipping ?

3. Actuarial risk analysis

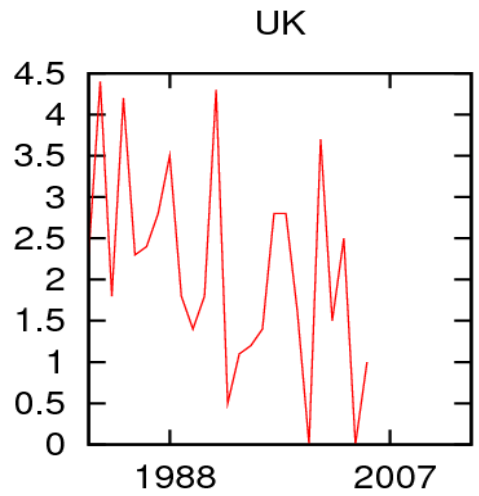
What would be the expected consequences of using CSC to abate 1GtC yr^{-1} in 2050 ?

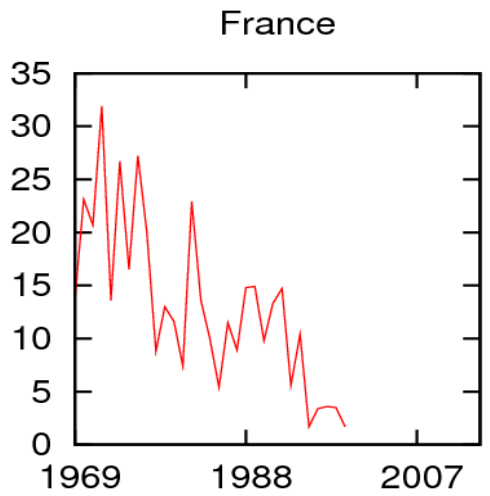
- 1 « wedge »
- Fatalities = deaths
- From Mining to Storage

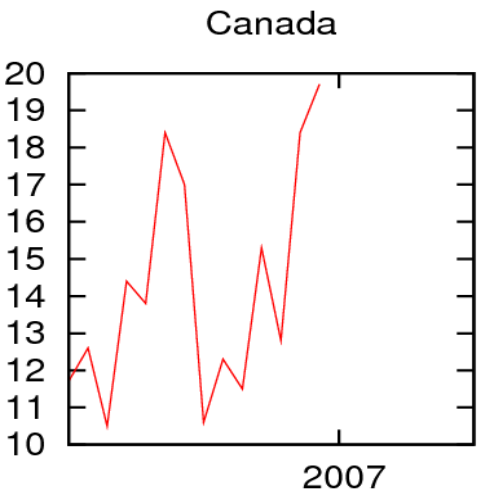
Mining 5 Gt of coal: 250-500 fatalities

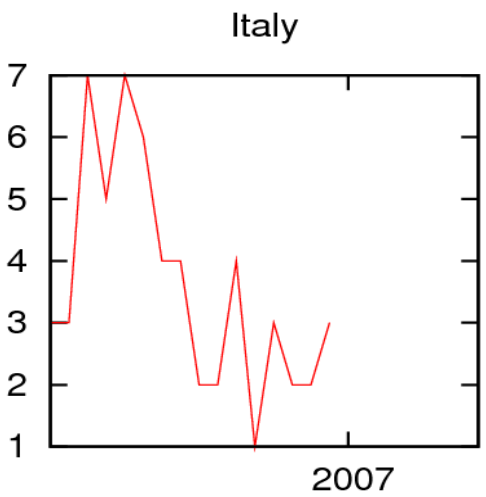


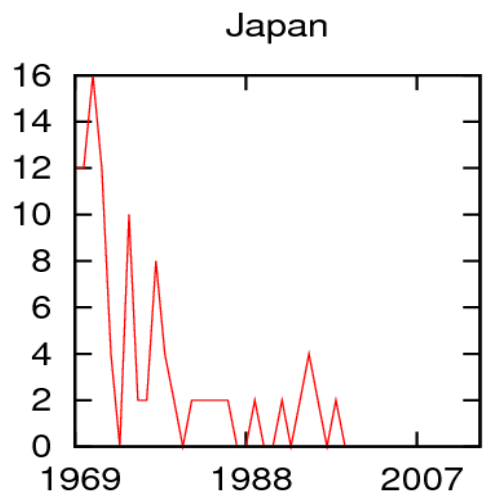
Capture at 1.500 sites: 1 to 8 fatalities

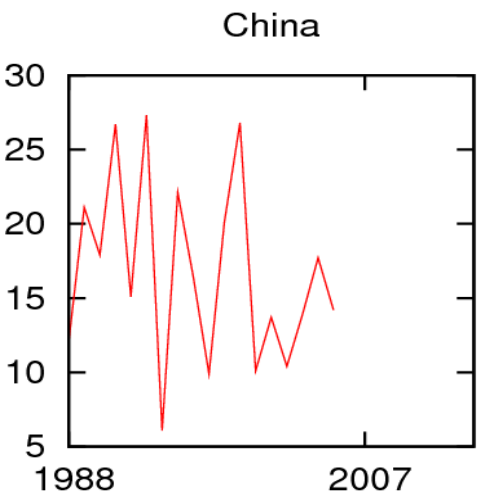












Shipping 2.000 Gt miles: 23-57 fatalities

- 400 Mt CO2 (10%) * 5.000 miles = 2 Tt miles

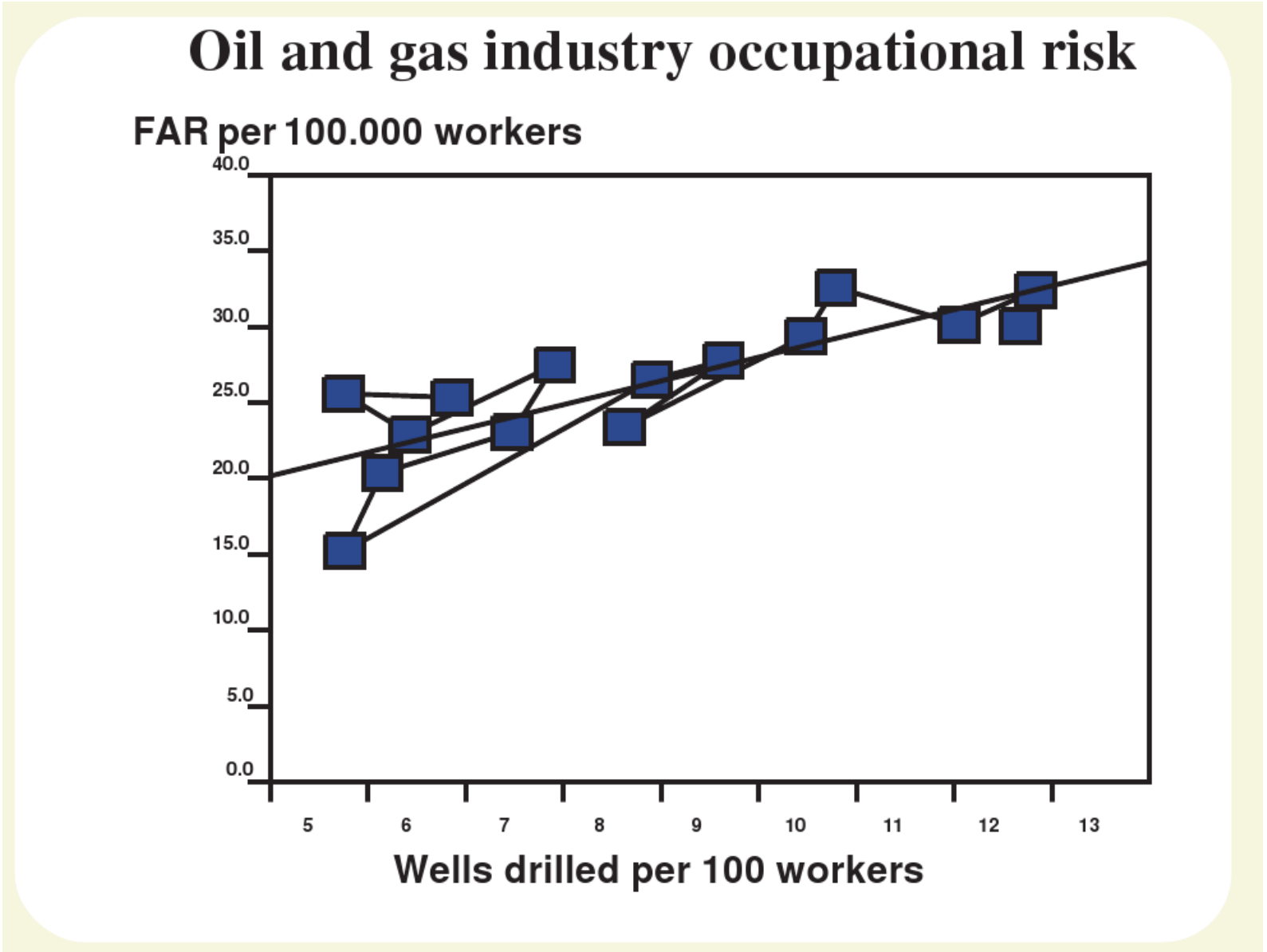
- Statistical fatality rates
  - 11.4 Tt^{-1} $mile^{-1}$ yr^{-1} in oil tanking (1978-2001)
  - 28.6 Tt^{-1} $mile^{-1}$ yr^{-1} in all goods trade (1989-2004)

150.000 km of pipelines: 1 to 15 fatalities

US statistics	Natural Gas Trans	Hasardous 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 CO_2 → 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 exptected fatality



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