Carbon Capture and Storage (CCS)

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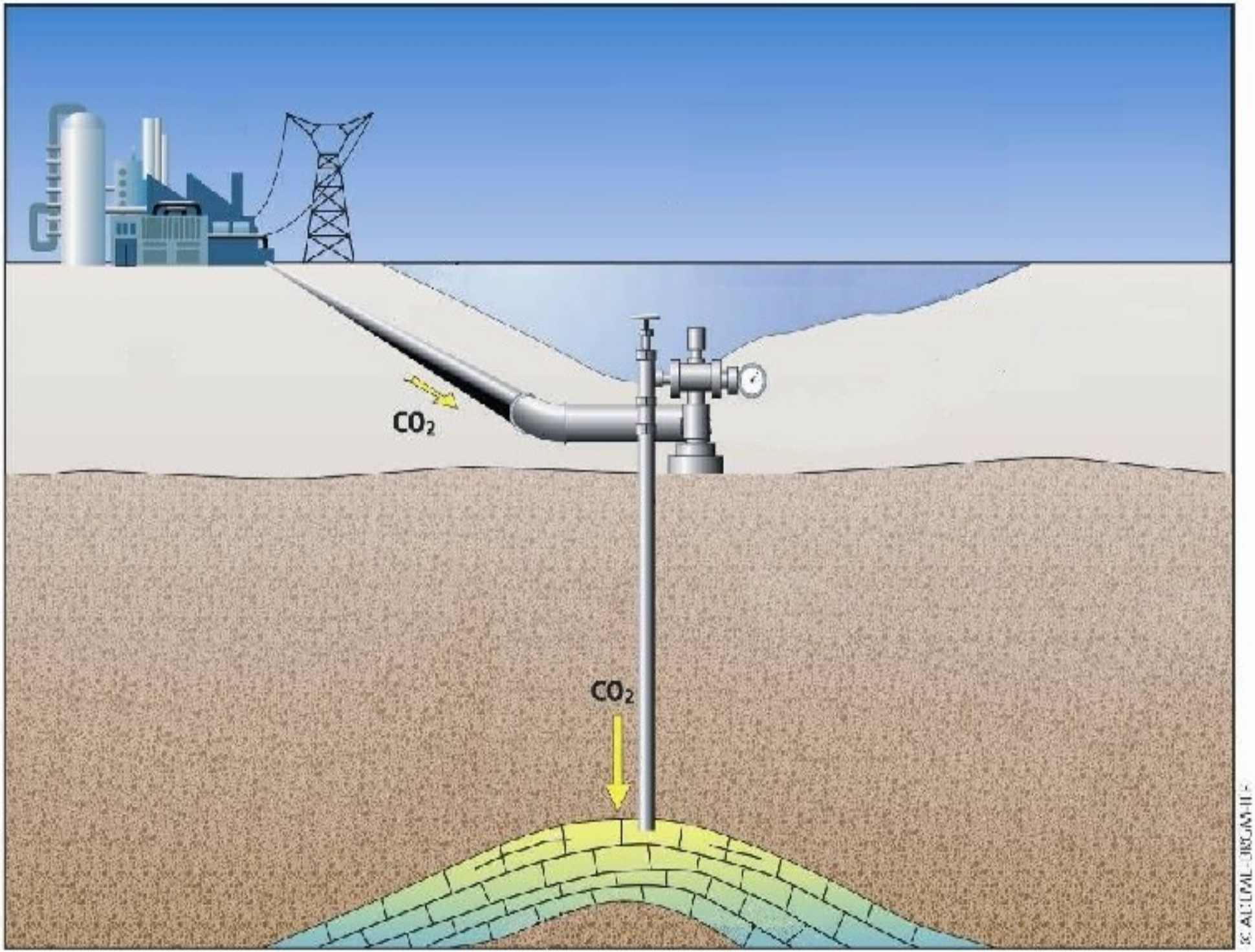
What is it ?

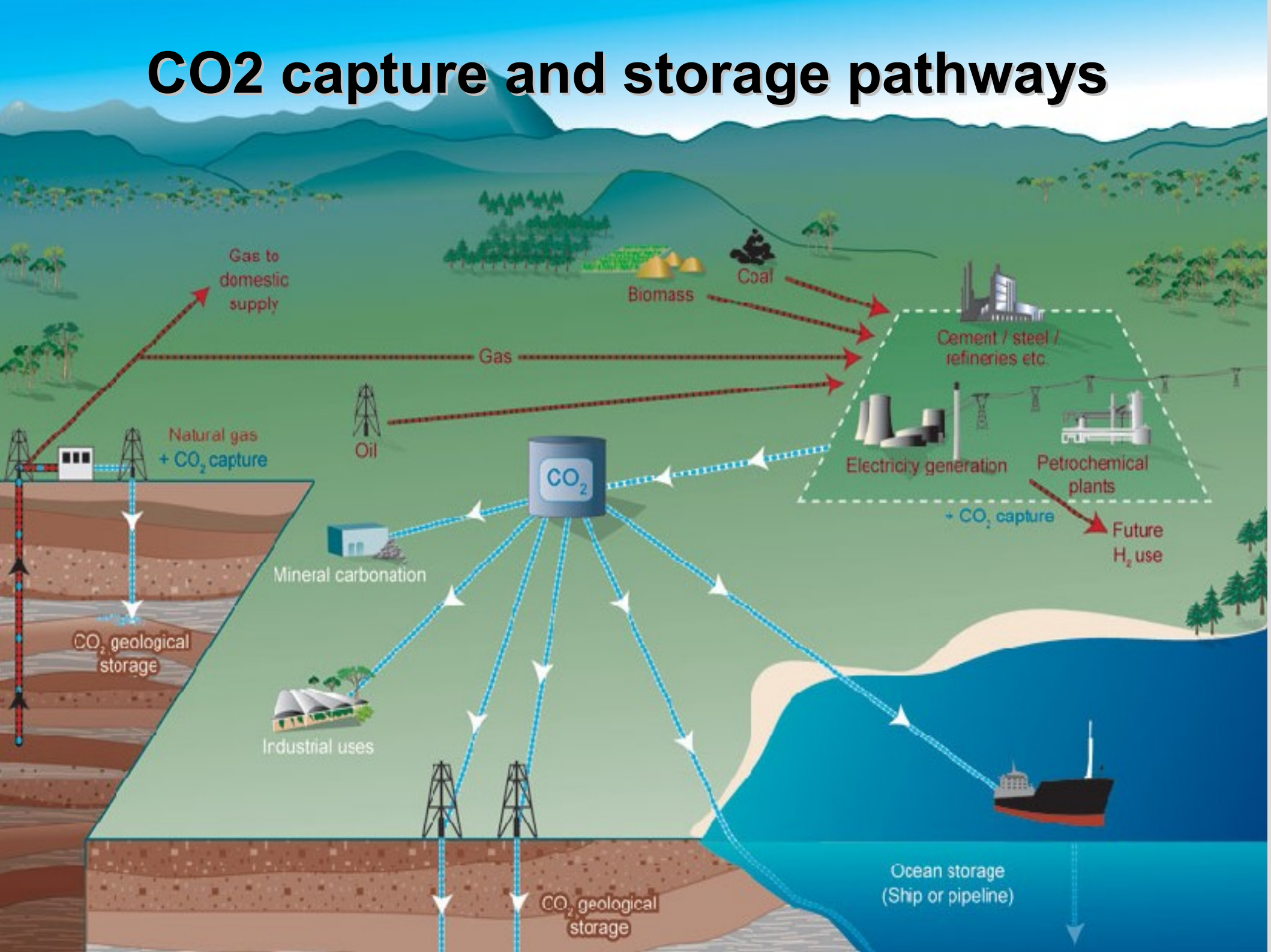
CCS is:

- New technology, new market
- A climate policy option
- Projects in communities


CO_2
CO_2

Example: Sleipner natural gas field, Norway

CO2 capture and storage pathways



Outline

I. Economics : CO_2 markets and CCS

II. CCS risks

III. A case study in France

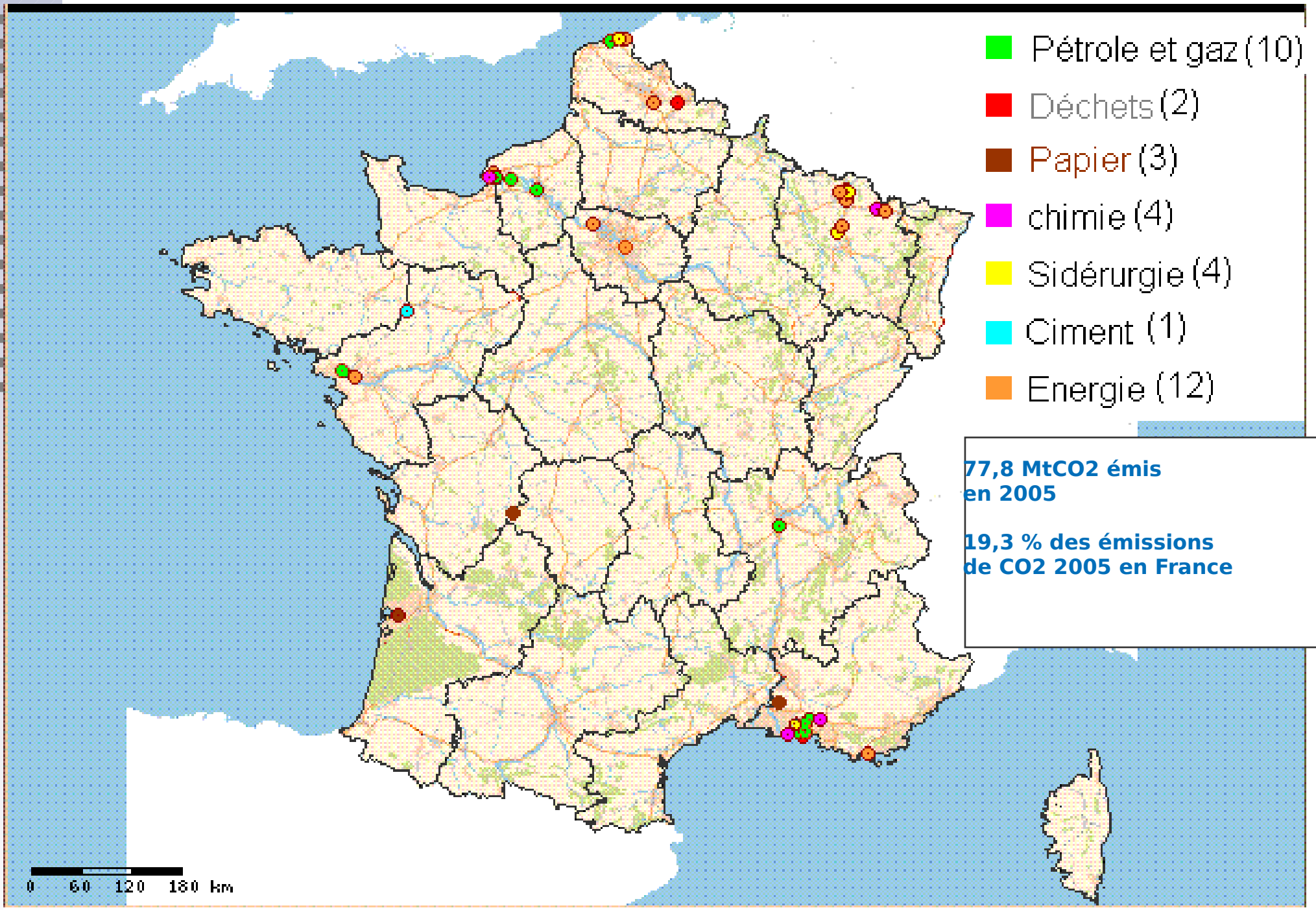
IV. The case for CCS in Vietnam

I. Economics of CO2 and CCS

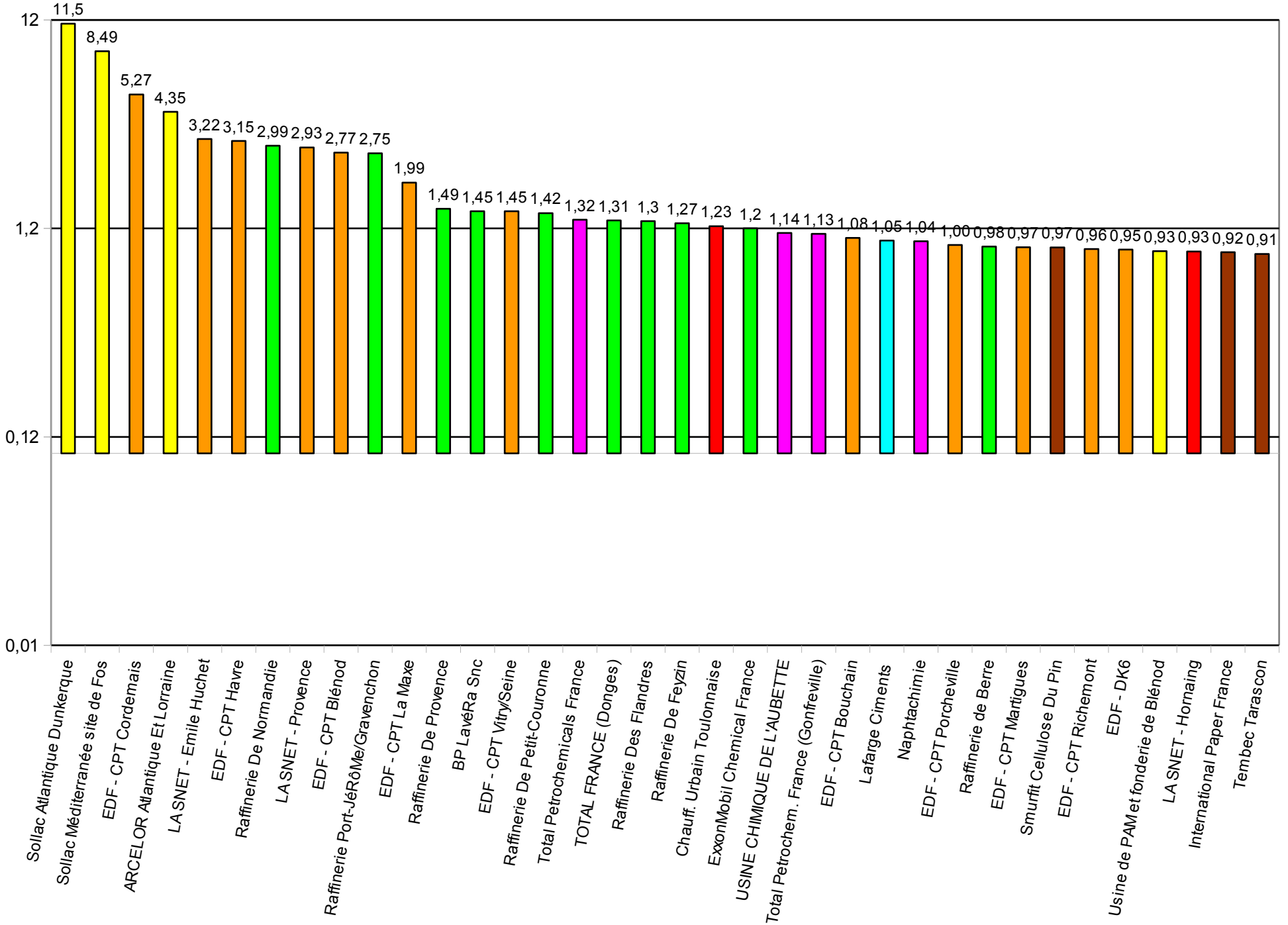
1. The CO_2 emission permits market

- There is a wide variety of industries
- It is more efficient to rule them using one market instrument : the emissions trading system

36 largest CO_2 emitters industry & energy



36 largest (MtCO2, 2005)



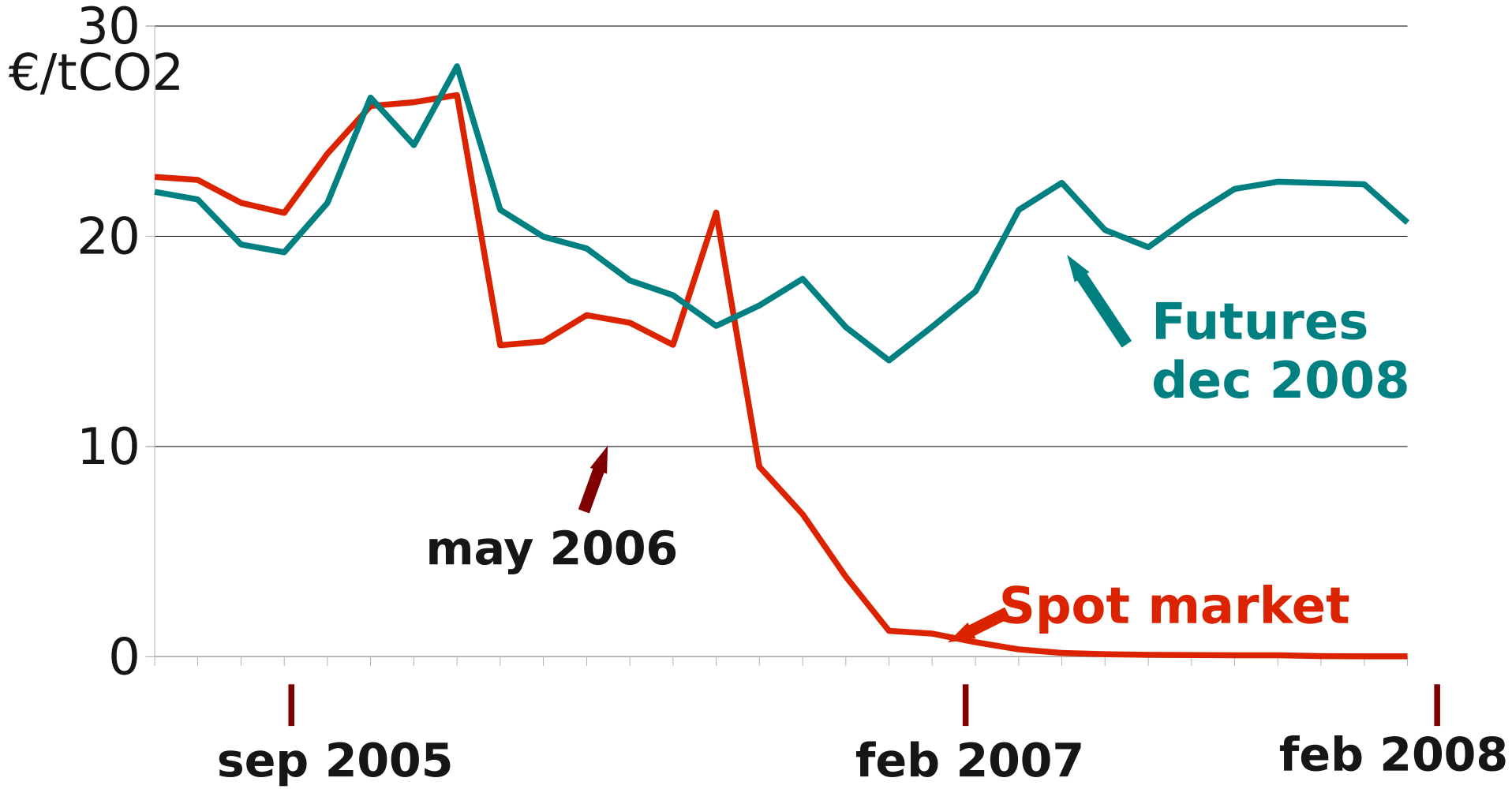
ETS: Emission Trading System

- To emit CO2 european firms must have *allowances*

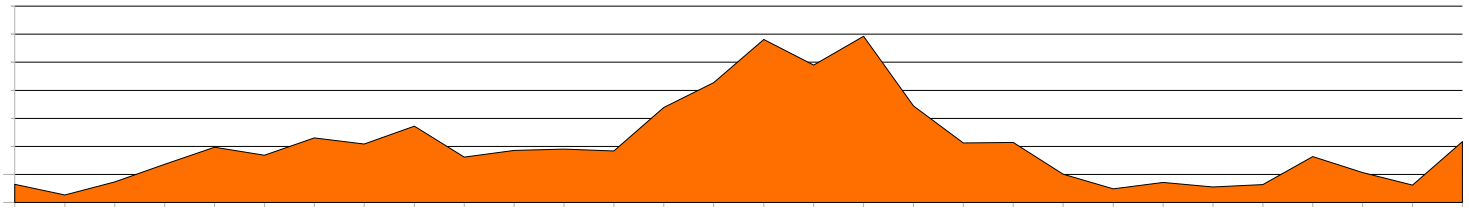
- Allowances can be sold or bought

- Initial quantity given free in 2005, Auctions to be used in later periods

ETS CO_2 allowances: Price history



Volume (Mt/month)



ETS allowance is 15-25 €/tCO_2

Is that enough to justify CCS ?

2. Costs along the CCS chain

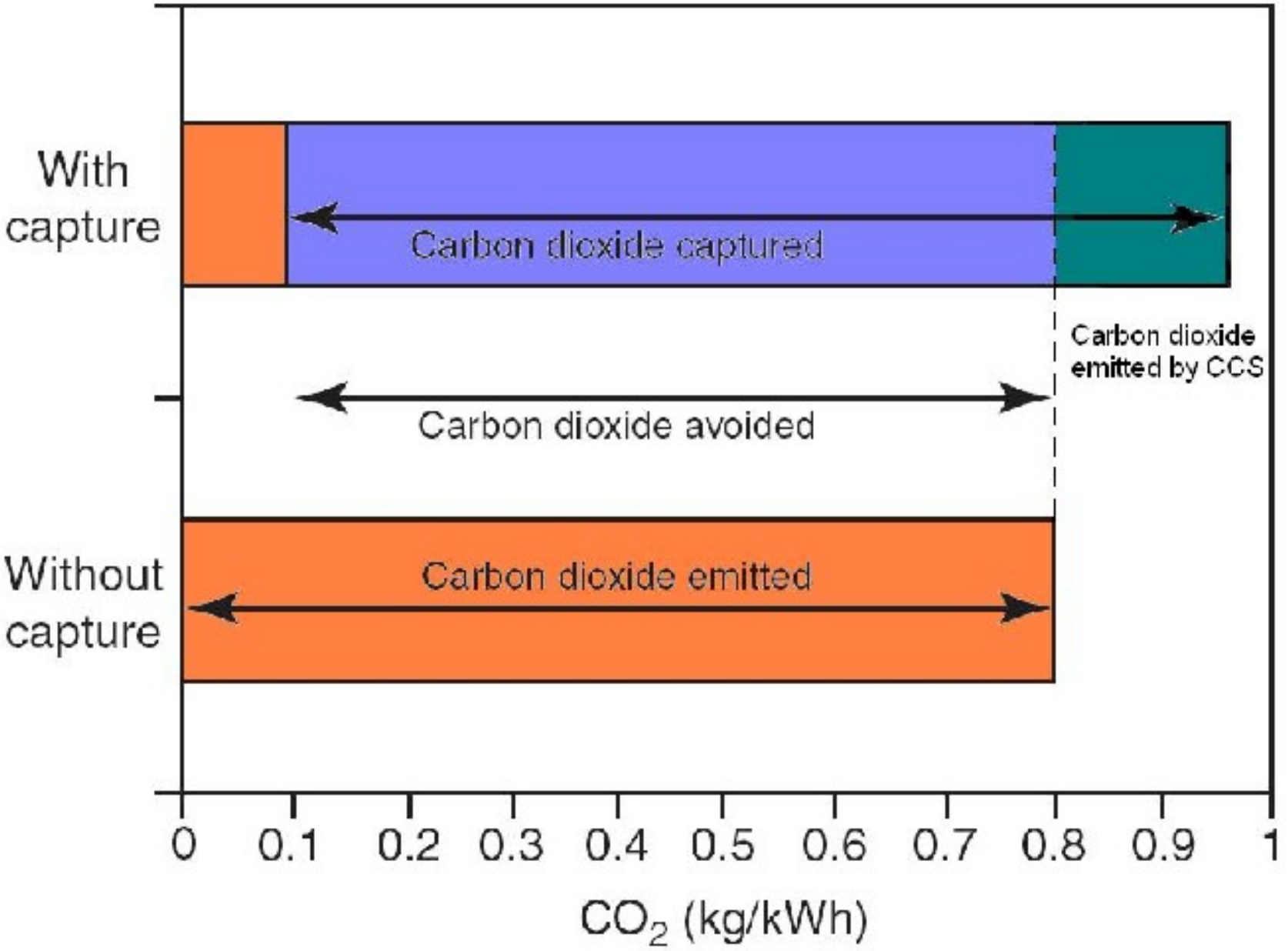
Adding up the costs of:

- Capture + compression,
- Transport: pipeline or ship
- Storage; siting, injection, monitoring

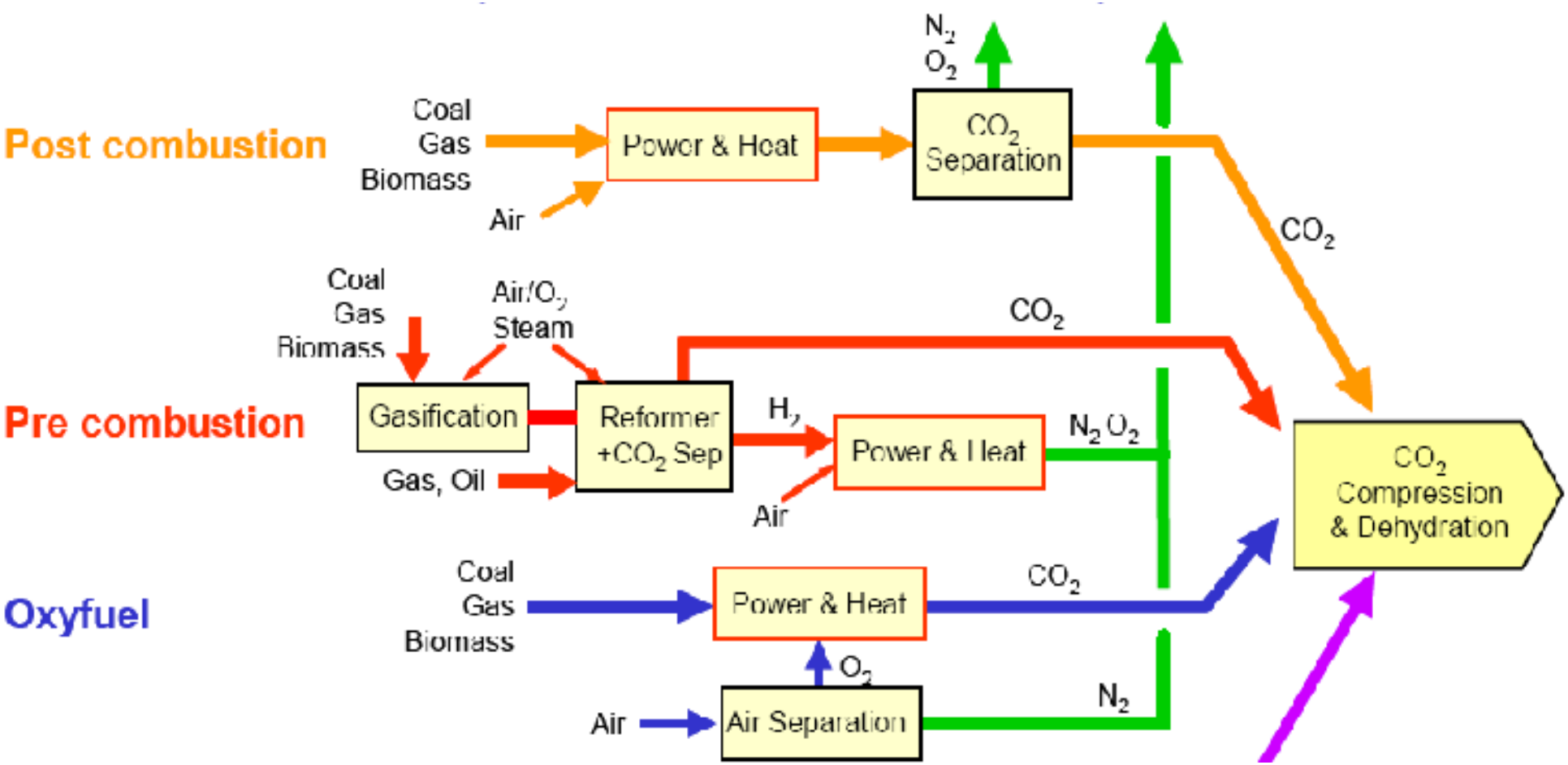
Technologies known, but

We need large scale, integrated pilots

CO_2 avoided = CO_2 captured - emissions of CCS

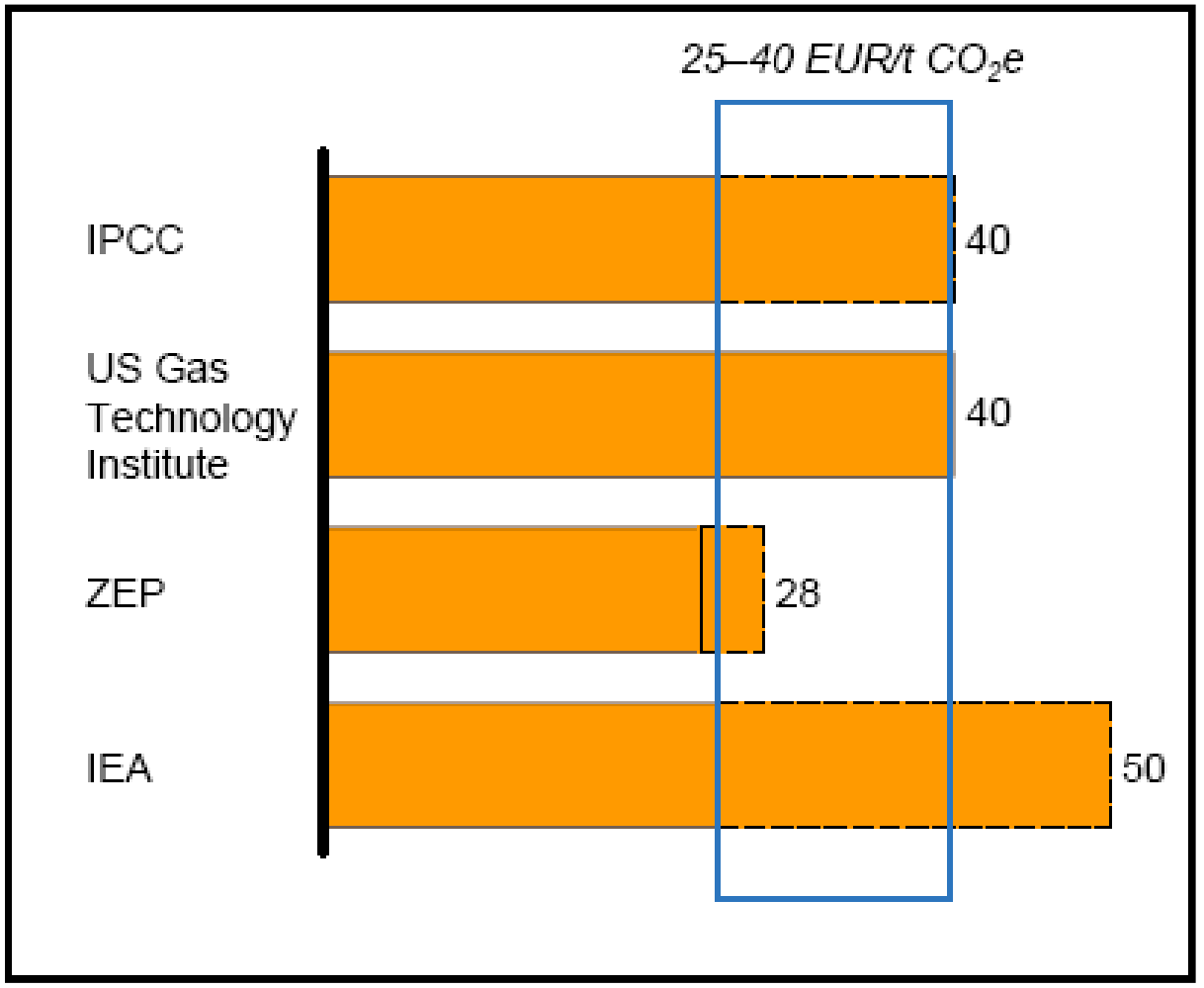


3 ways to capture



Source : Bolland (2004)

Capture costs estimates (€/tCO2)



Source : Vattenfall

Existing studies suggest 25-40 €/tCO2 in 2020, but no technology is mature.

Between post- and oxy-combustion, it's unclear which is cheapest.

Post-combution as retrofit on coal plant: + 10-20 €/tCO2, but it's the only choice

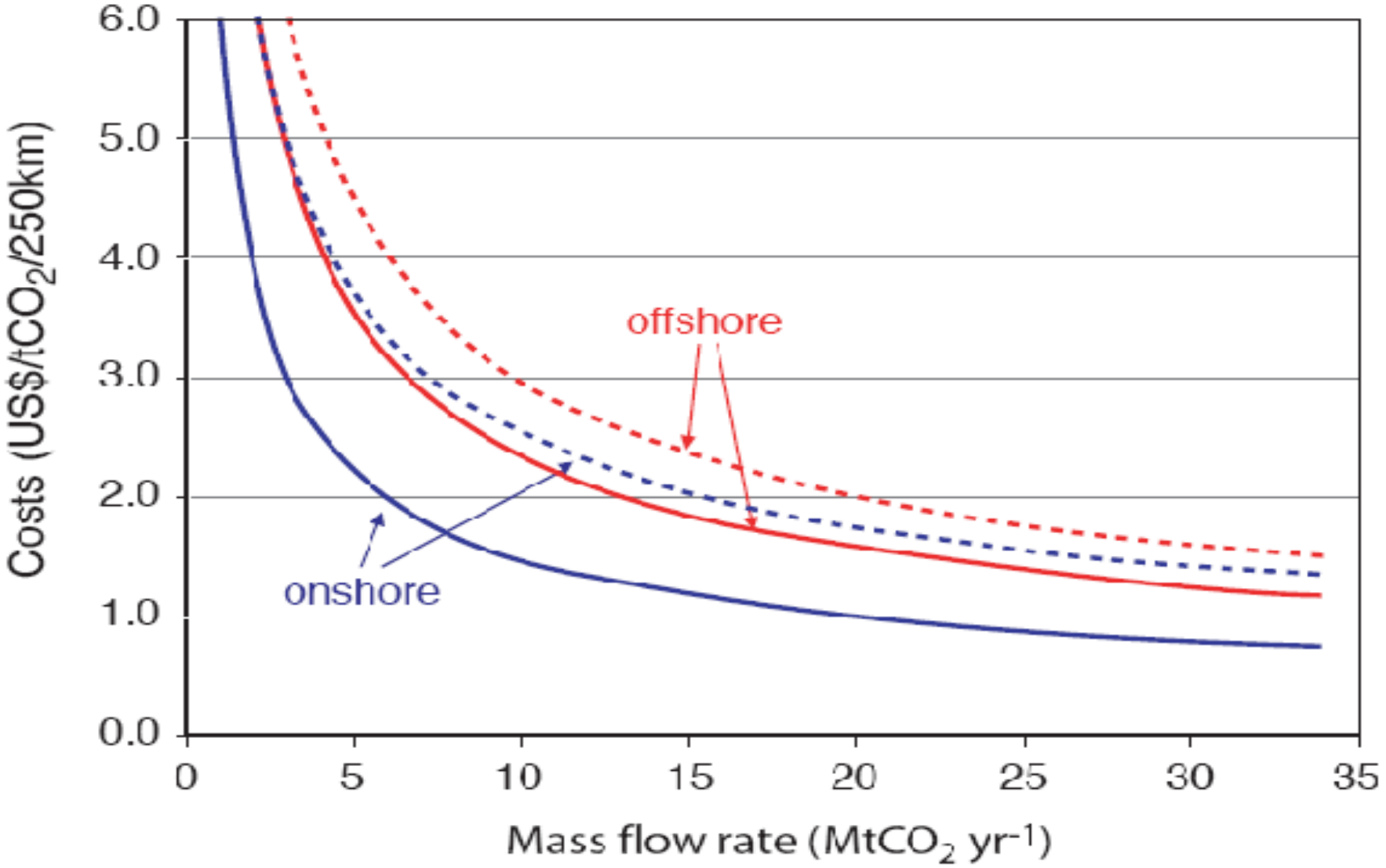
Moving CO_2 around

Pipeline
(supercritical dense phase)

Ship
(oversea/offshore storage)

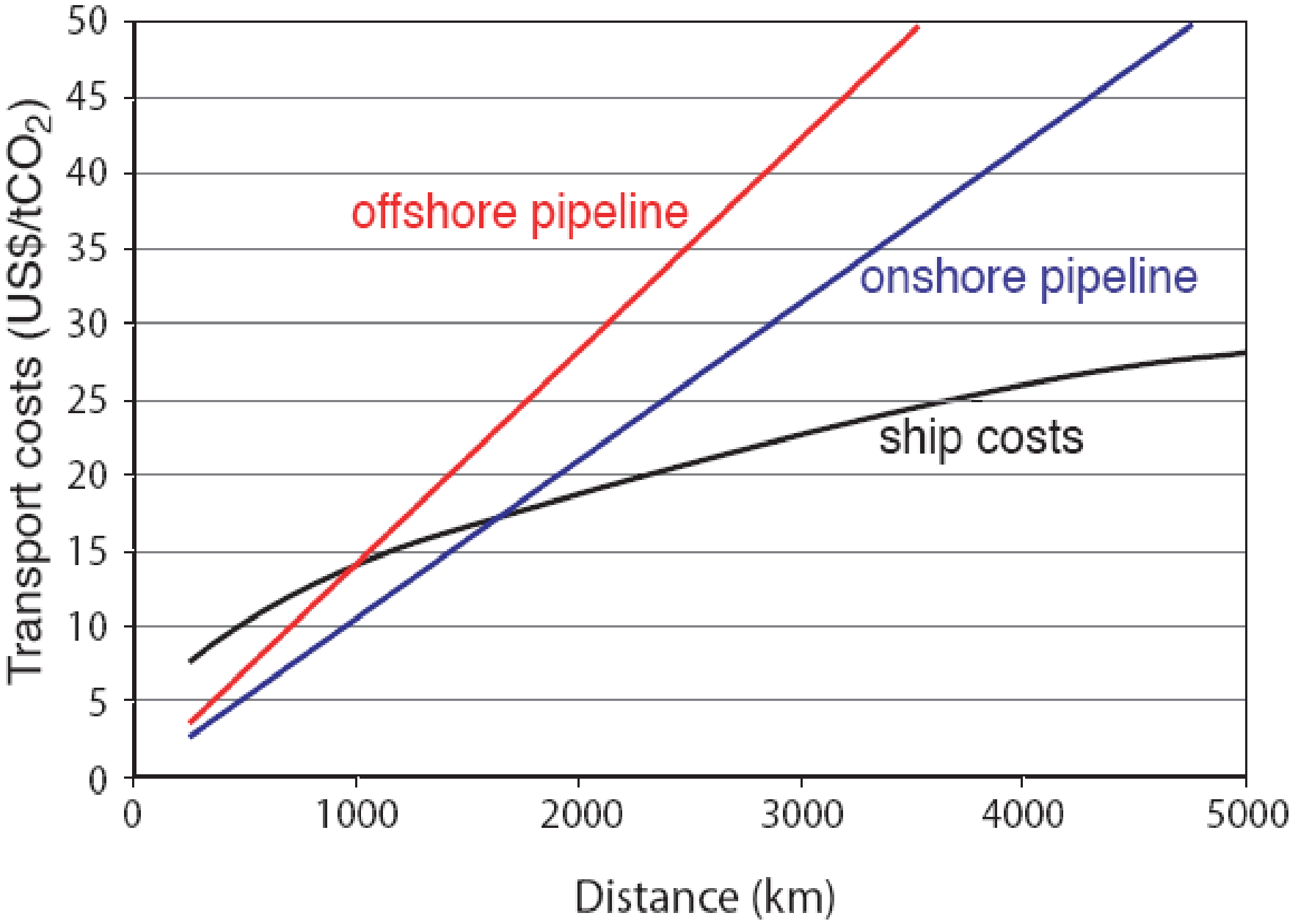
- Commercially available technologies
- Low technical progress
- Economies of scale

Costs with pipelines (US$/tCO2/250km)



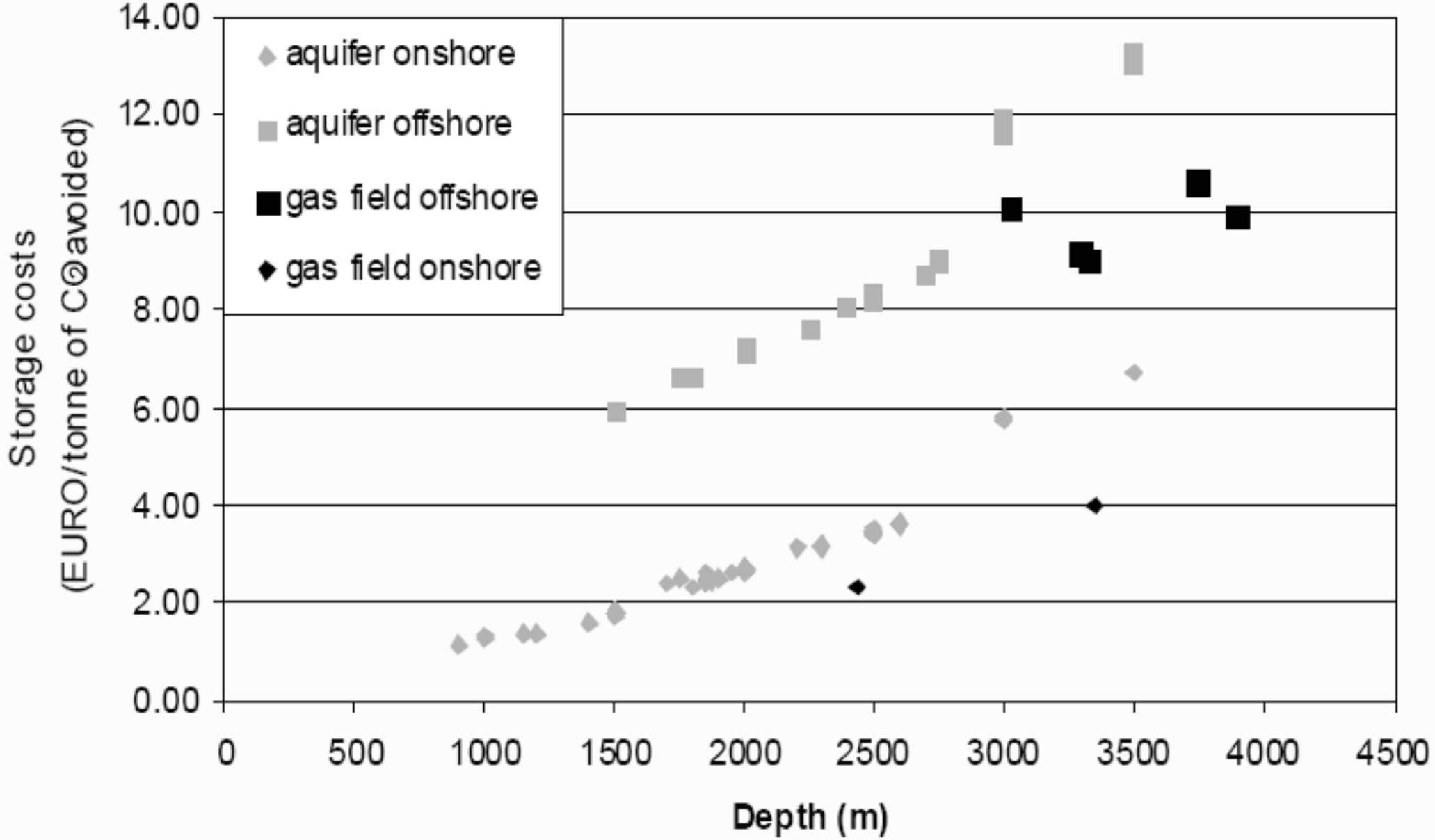
Source : Special report IPCC

Shipping cheaper over 2000km



Source : Special report IPCC

Storage costs - €/tCO2 avoided (TNS-Ecofys 1999)



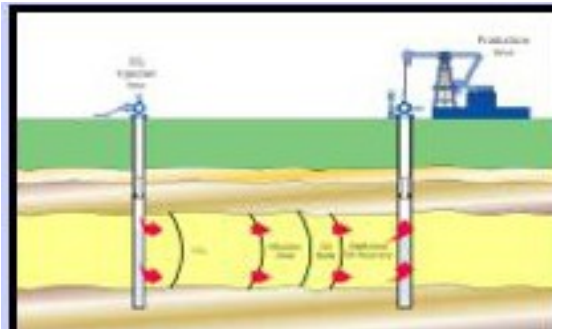
But there are uncertainties

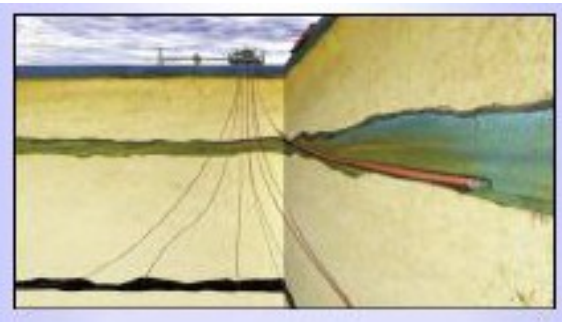
Risks of leakage:

Imply long term monitoring

Economic framework is uncertain (post Kyoto regulation, ETS...)

No public opinion exists yet





Estimated total cost, today

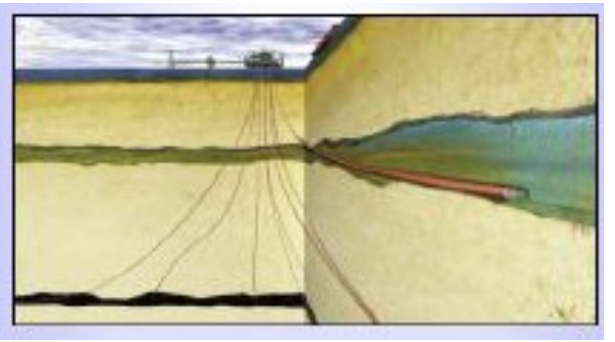
43 - 52 € / tCO2 avoided for 10 M t/yr

Capture
compressed to 110 bar

37-44 €/tCO2

Transport
100km

1-3 €/tCO2

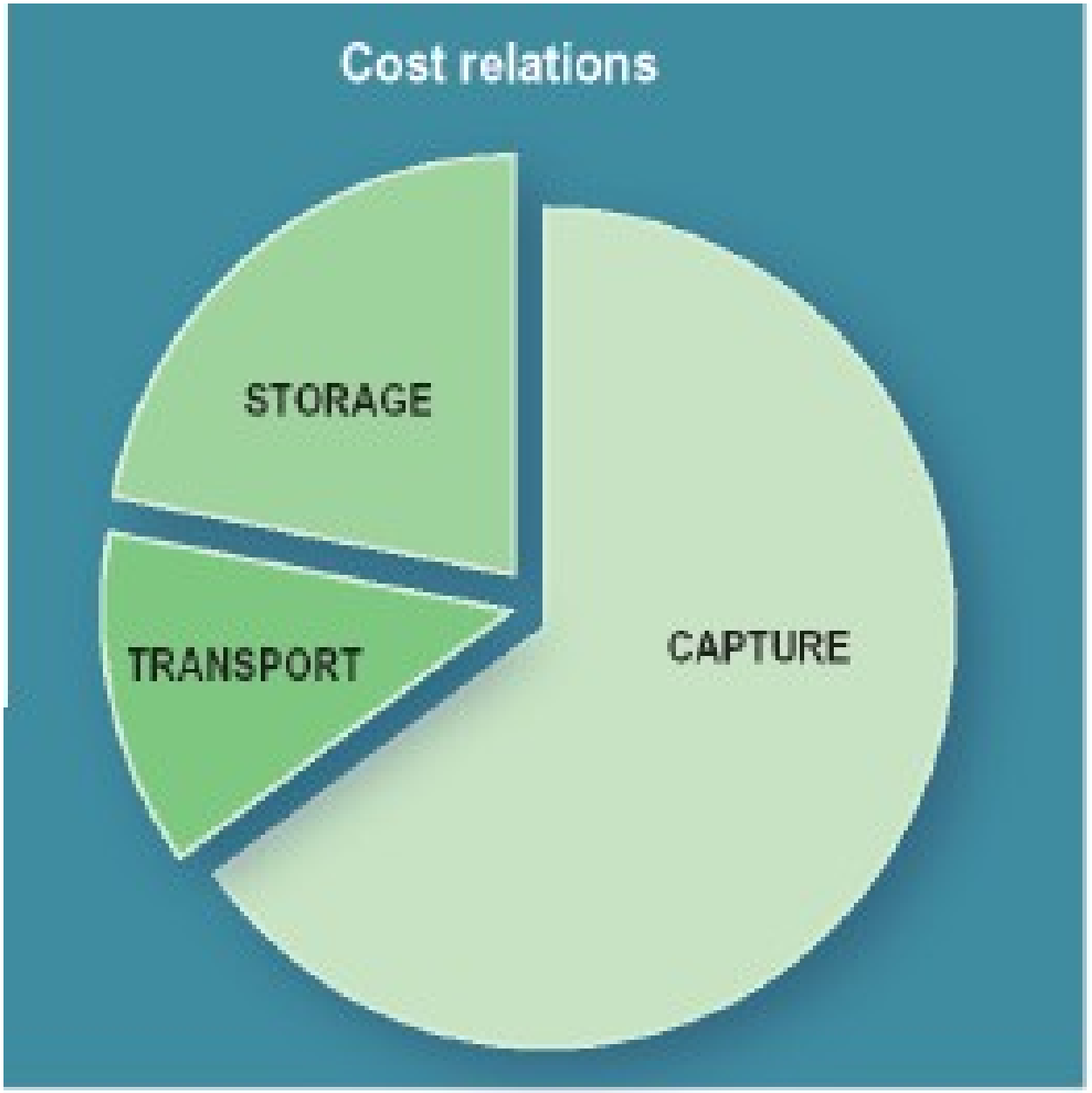


Storage

1Mt/yr **15 €/tCO2**

10Mt/yr **5€/tCO2**

Capture is the expensive step



CCS is way over CO_2 market price

Incitations are needed

50 €/tCO_2 (CCS) > 20 €/tCO_2 (ETS)

There are public benefits to R, D & D

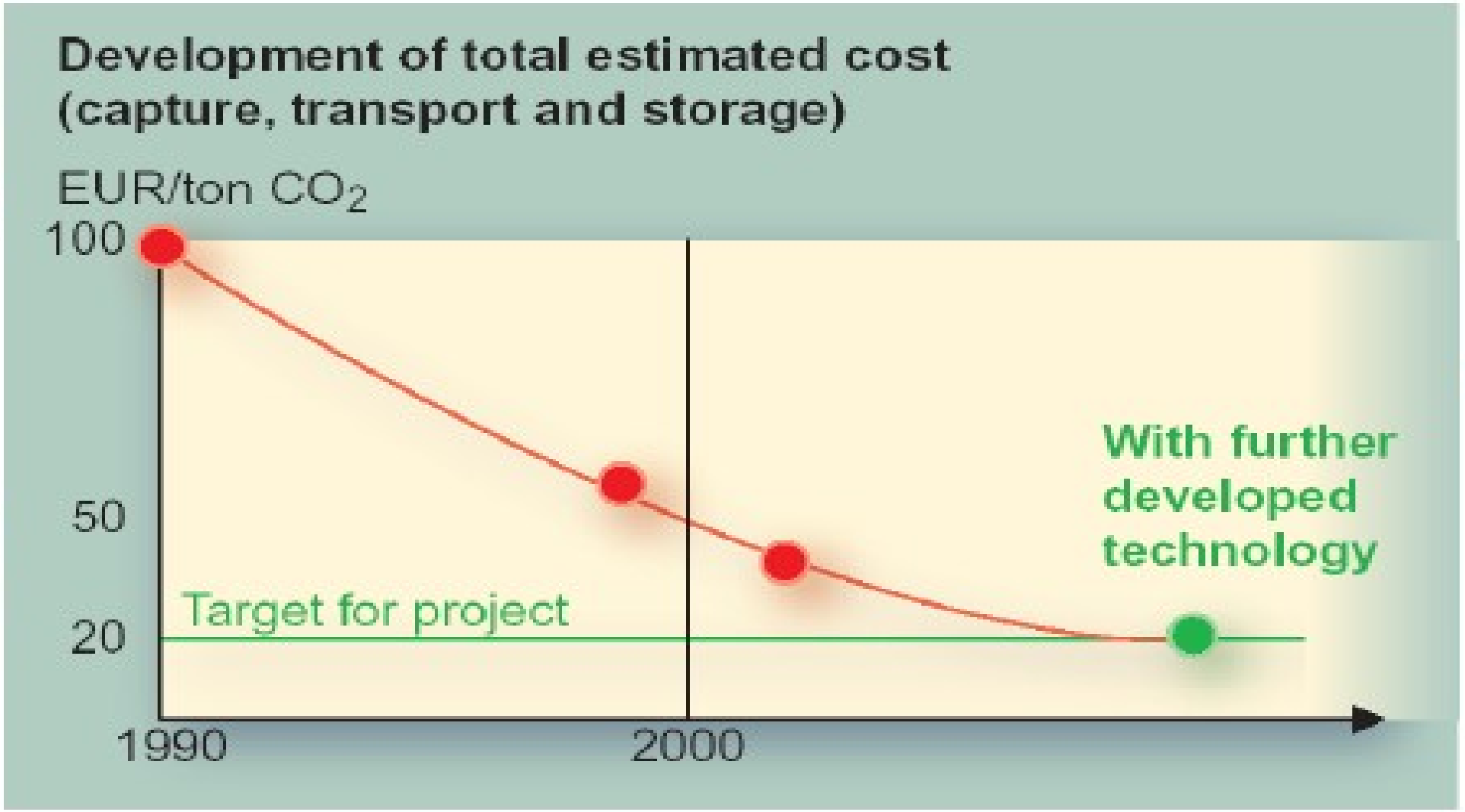
Electricity production cost increases by >30%

- Coal plant:
  from 4.3-5.2 c/kWh without
  to 6.3-9.9 c/kWh with CCS
  400M$ additional investment

- Natural gas combined cycle:
  3.1 - 5.0 c/kWh without
  4.3 - 7.7 c/kWh with

Source: IPCC SRCCS

Cost reduction target: 20€/tCO2



Vattenfall

Conclusion

- European market (ETS) ~$20_{\pm 5}$ €/tCO_2
- CCS costs ~50 €/tCO_2 today
- Capture is expensive

II. On CCS risks

Messages

- Risks are lived with
- Acceptability is politically constructed with communities
- Climate change is a bigger risk

1. CO2 risks are lived with

- CO2 tends to leak
  - Lighter than water
  - An acid than may react with the rock
- But
  - Natural analogues (volcanism)
  - Artificial analogues (workers ≠ public)
  - Models are improving

Volcanism: CO_2 is dangerous

- Rabaul, Papua New Guinea: In June of 1990, three people died of suffocation in a vent of the east side of Tavurvur. Three more died trying to retrieve the bodies.
- Vestmannaeyjar (Heimaey), Iceland: During the 1973 eruption a sleeping man was killed by carbon dioxide as it pooled in the basement of his house.
- Italy 1650 : eruption of Etna caused about 40 deaths; some caused by opthalmias from sulfurous vapors and suffocation. The crew of a ship suffocated as it passed the volcano.

Lac Nyos, Cameroun: August 21st, 1986, 1700 deaths.

Artificial risks
CO_2 in the workplace

- Coal mining
- Agriculture and food industry
- Fire suppression systems

Community risk: A more plausible analog of orphaned well leakage

CO2 leaks already managed

Summary:
CCS risky but manageable

- People live near industrial risks
- People live near CO_2 leaks

2. The acceptance issue

- What is acceptability ?
- Psychological approach
- Sociological studies

Acceptability by whom ?

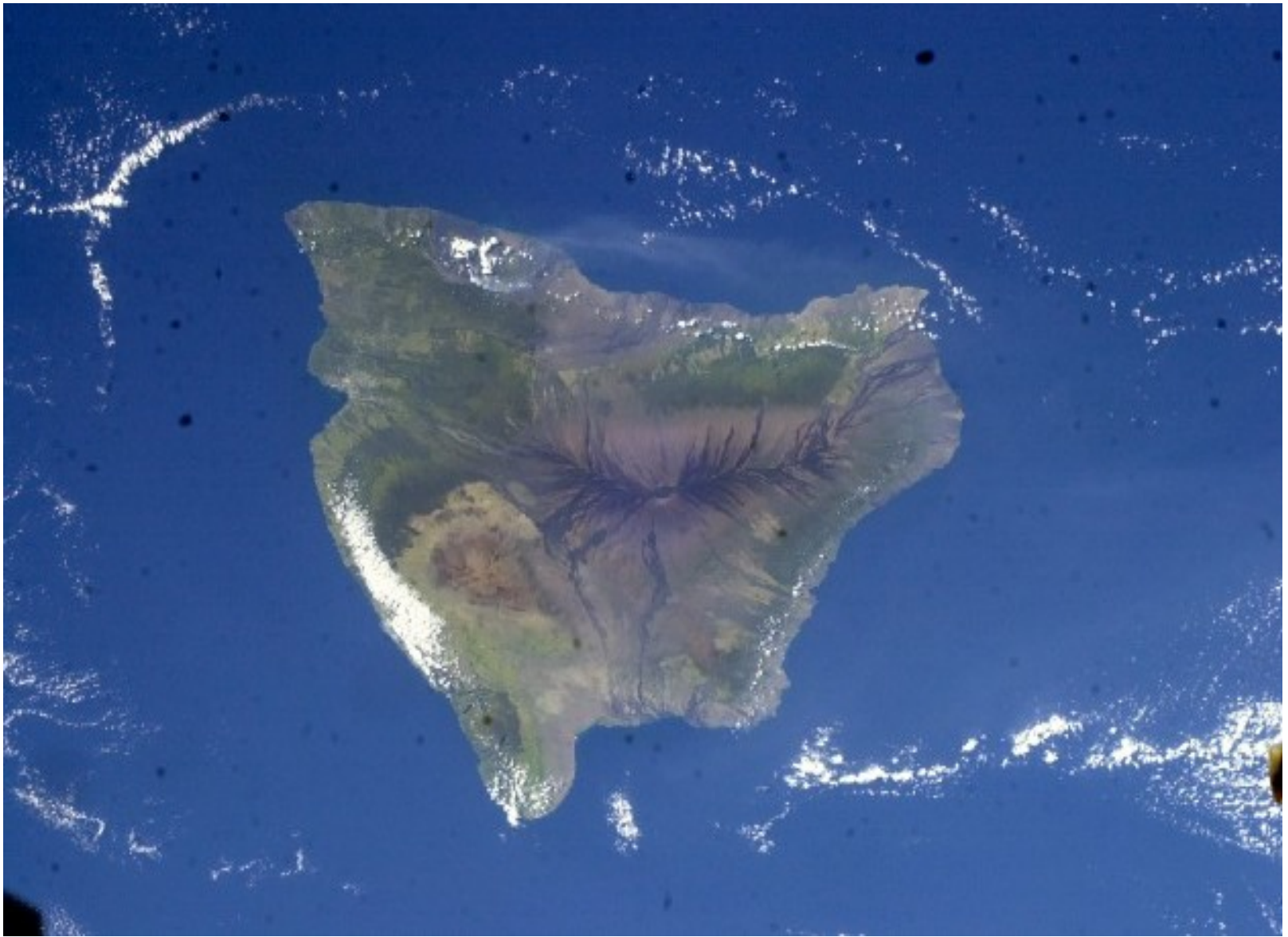
- Stakeholders:
  - Local administration
  - Central administration
  - Industry
  - Non governmental organisations
- The public at large

Acceptability of what ?

- A technology: Market acceptability
- An reply to climate change: Sociopolitical acceptability
- A project: Community acceptability

Non-acceptance case

"Feds to Test Impact of Dumping CO2 into Kona Waters" *West Hawaii Today*, 18/3/1999.



Regulation and acceptance in other projects

- Existing “large” projects (1MtCO2/yr)
  Sleipner, In Salah, Weyburn

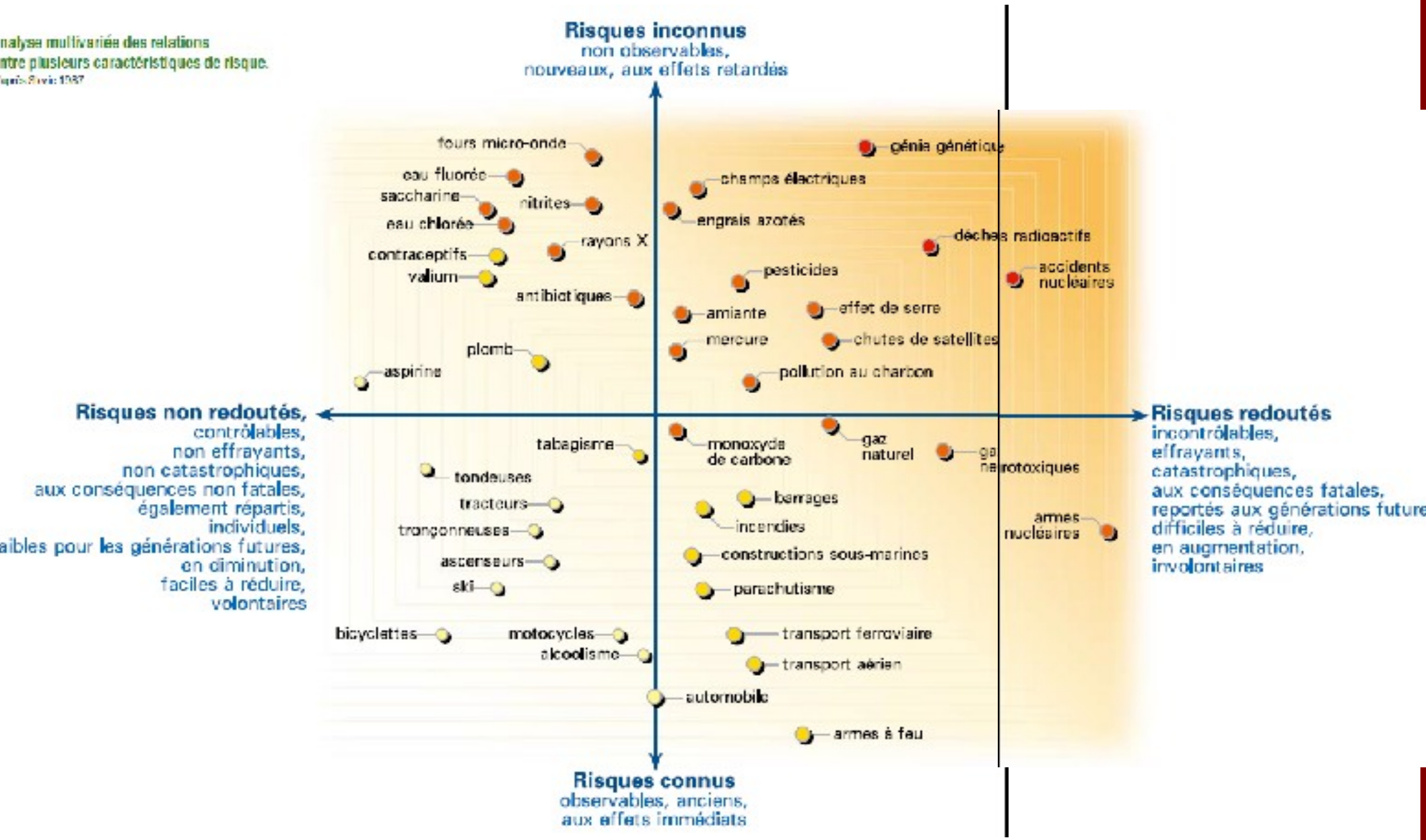
- Many smaller, pilot projects today to
  - Master the technological chain
  - Engage the administrations
  - Explore local acceptance issues

Psychological risk attributes

Bad	Good
Imposed	Just
Artificial	Moral
Catastrophic	Controlled
Unknown	Familliar
Memorable	Trusted actors
Feared	

Ref: Afsset, Janvier 2006 Perception du risque et participation du public

Perceived risk attributes: Multivariate analysis



Lessons of sociological studies: sociopolitical acceptability

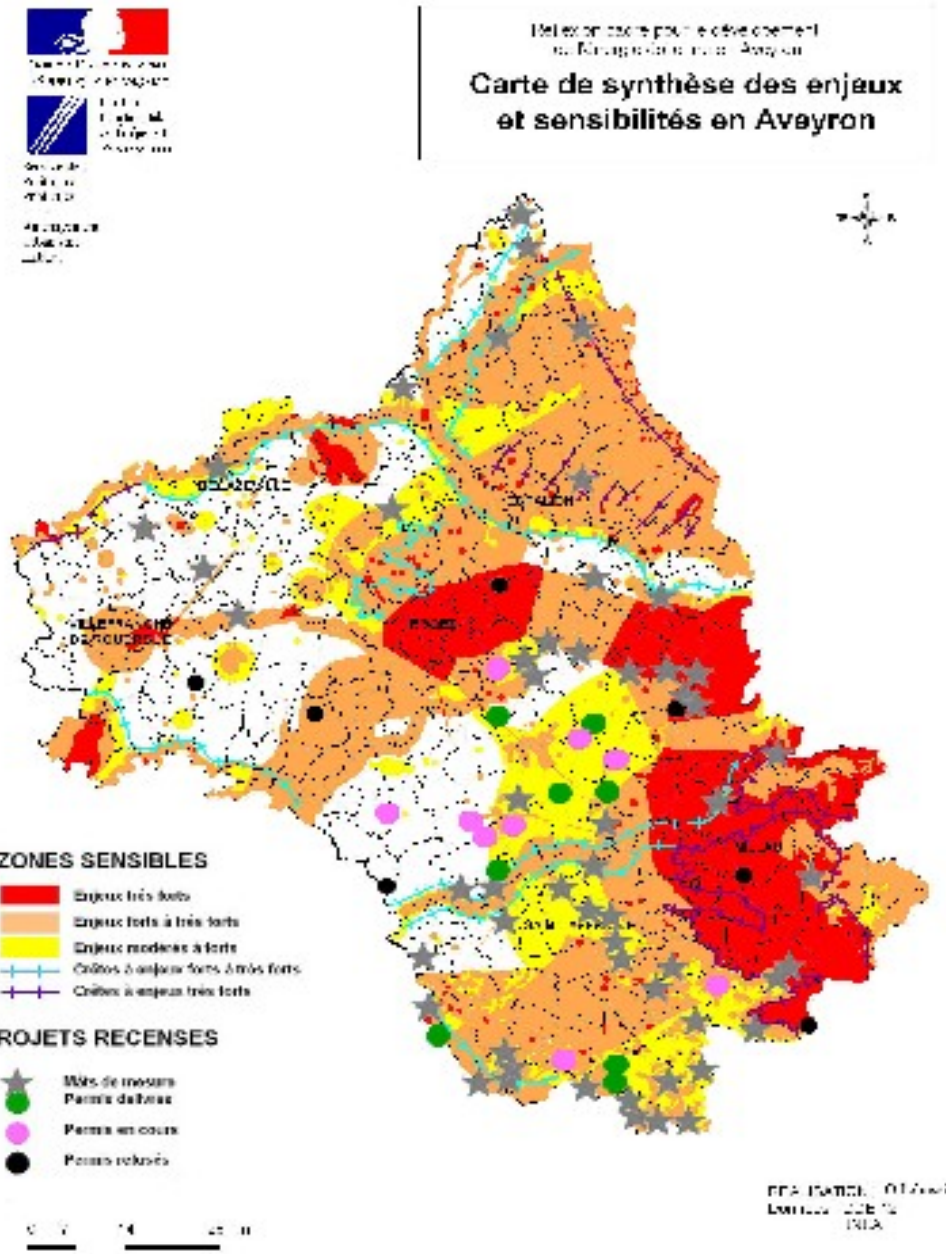
- Oceanic storage is out
- Onshore still in (France at least)
- Approval conditional on accepting the necessity of climate change action
- CCS < renewables or conservation

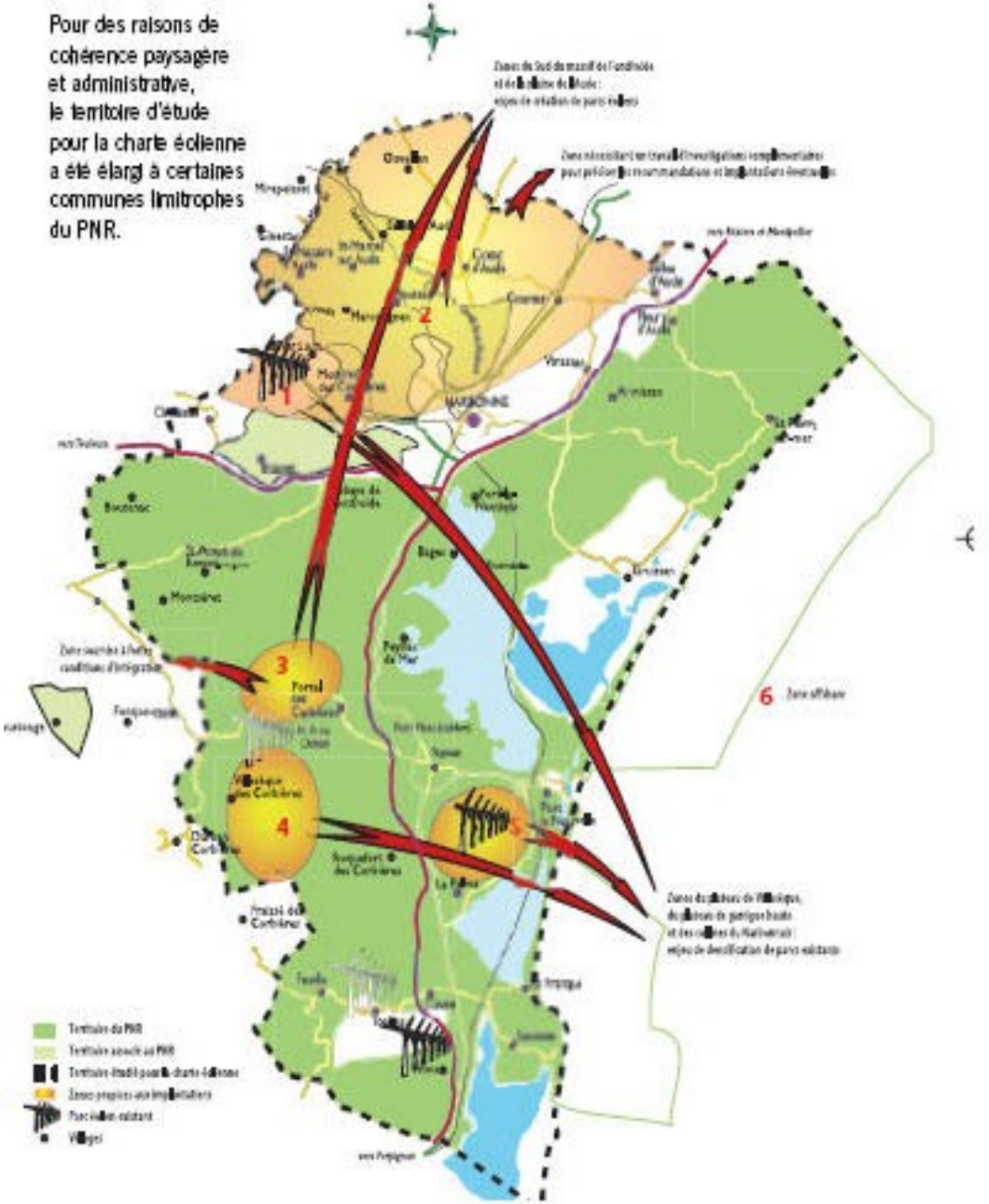
Lessons of sociological studies: community acceptability

- No CCS cases yet
- Lessons from windmill sitting plans:

Technical approach (SIG layers)
vs.
Political approach (negociation)

Technical map vs. political map

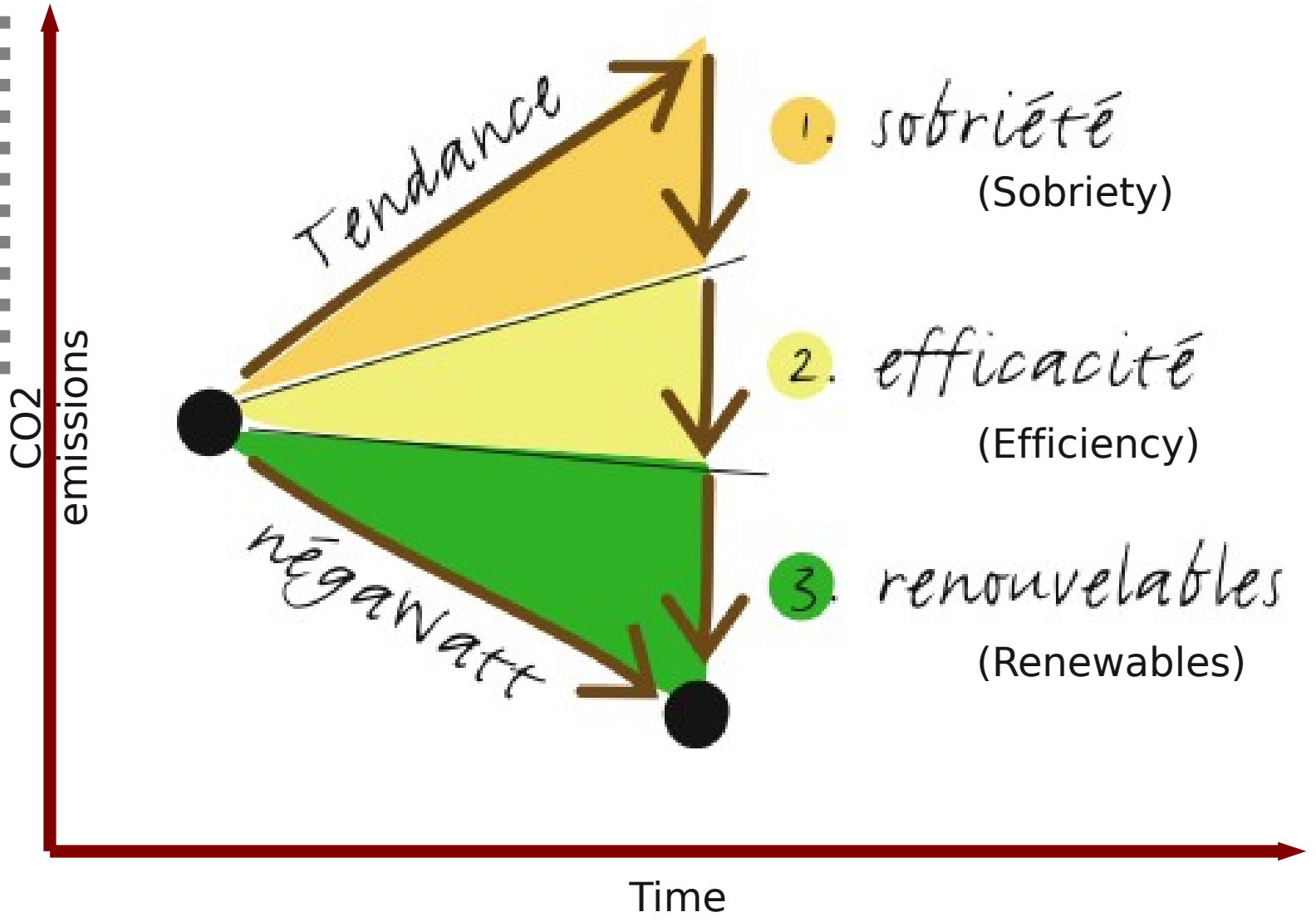




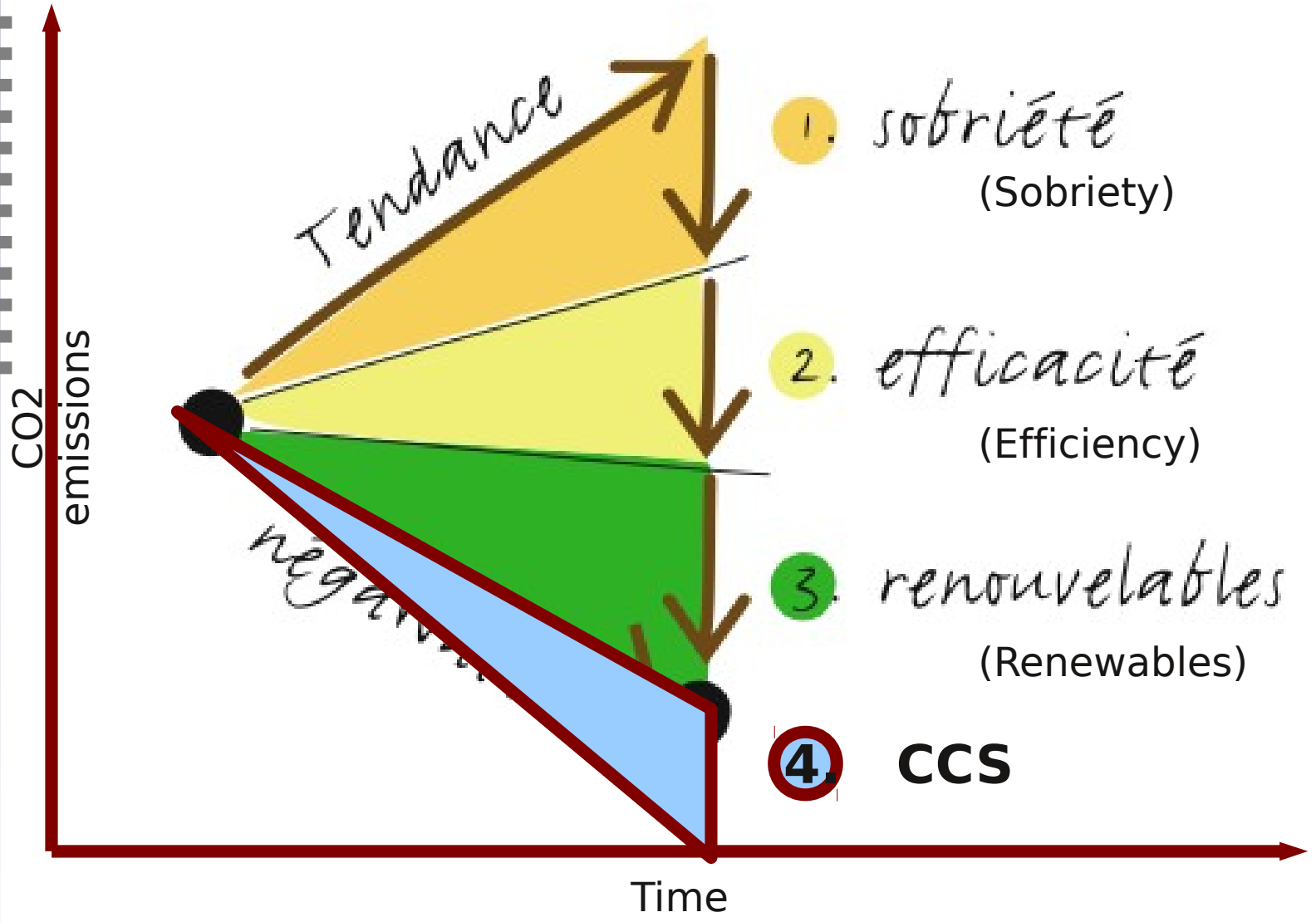
3. A climate policy option

Why was the CCS idea so good ?
A cost-benefit analysis

The stabilisation triangle



A wedge of CCS ?



Step		2007	2050	Assumptions
Coal Mining	Mt	0	5 257	All emissions are from coal-fired power plants. All coal carbon content is lignite.
Capture	sites	3	1 500	Intermediate between G8 and IEA estimations
	Mt	3	4 889	1GtC emissions avoided, 20% energy penalty, 95% capture efficiency
Transport by pipeline	km	1	100	For each capture site.
	Mt	3	4 000	About 90% of quantity captured.
Transport by shipping	miles	0	5 000	Average distance transported
	Mt	0	400	About 10% of quantity captured.
Injection	wells	12	2 000	Corresponds to about 2.4 Mt CO2/well yr
				On average 4 active injection wells/storage site
Storage	sites	3	500	From ~1 today to ~10 Mt CO2/site in 2050
	offshore	25%	10%	
	aquifers	50%	85,00%	

Additional activities required to not emit 1 GtC by using CCS at power plants	**Fatality rate per year, per unit of activity**	**Expected fatalities in 2050**
Mining 5 257 Mt of coal	0.03 to 0.06	266 to 490
Processing 4 889 Mt of CO2	0.001 7	8
Employing 7 500 to 15 000 workers (for capture at 1 500 sites)	3 to 14 10^{-5}(utilities industry) 4 to 17 10^{-5}(chemistry industry)	0.2 to 2 1 to 3
Operating 0.15 Mkm of CO2 pipelines	5.4 to 8.5 (US analogue) 11 (Europe analogue) 50 (Worst case assumption)	0.8 to 1.3 1.6 7.5
Shipping 2.2 billion tons nautical miles of CO2	11.4 (oil tankers) 28.6 (all goods trade)	23 57
Employing 5 000 to 15 000 workers (to maintain, develop and monitor 2000 wells.)	20 to 30 10^{-5} (oil & gas industry)	1 to 4.5
Exposing 2.5 10^{5} to 10^{6} persons to a small diffuse environmental risk	10^{-6} (negligible level for individual risk)	0.25 to 1
Operating 500 man-made big installations	10^{-3} (actual risk per site, Europe analogue) 5 10^{-2} (Worst case assumption)	0.5 2.5
Total		**290.25 to 569.5**

+300 to 600 fatalities in 2050 ?

- Same as fossil fuels industry today
- Nuclear, hydro can be catastrophic
- Weather already causes 100.000s of fatalities

Conclusions

- CCS risks seem more manageable than many other risks: climate change, nanotech, GMOs
- Sociopolitical and local acceptability remain to be co-constructed
- As a global option, seems a good idea

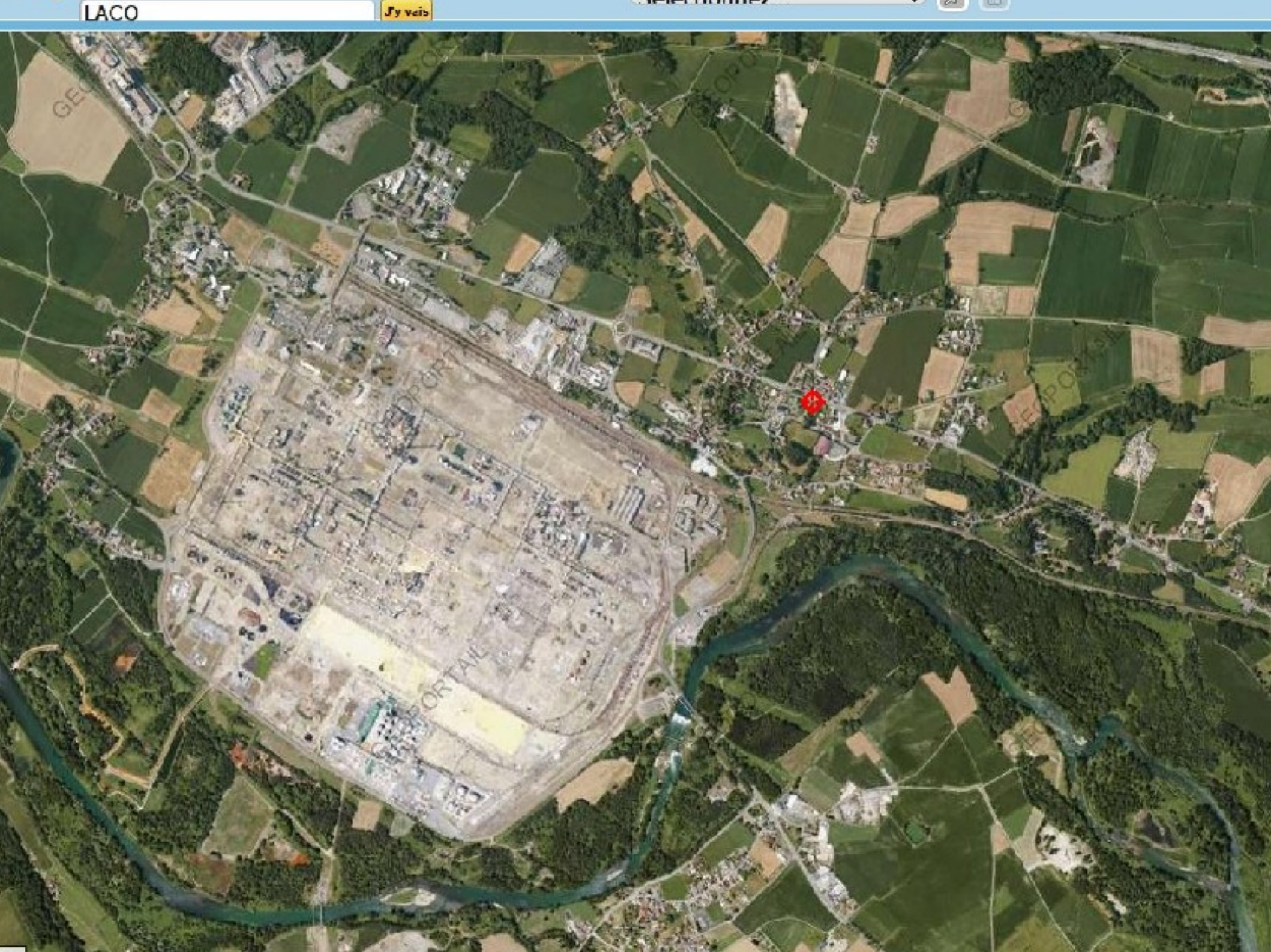
III. A case in France

Social aspects of Total's Lacq project

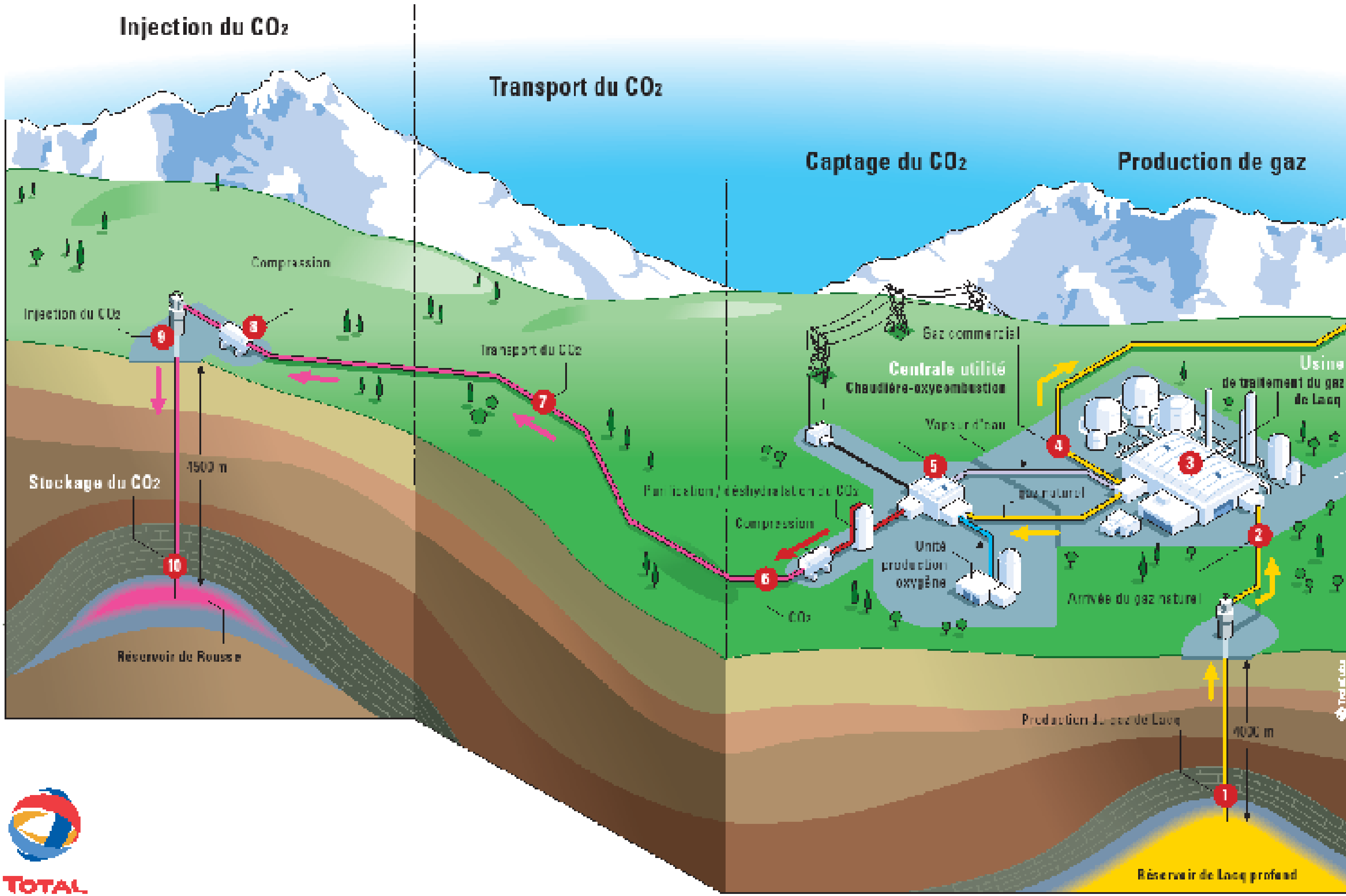
Reinventing a valley, after a 50 year industrial history

- 1951: natural gas discovered at -3 550 m
- 1957: plant opens at 1 million m³ /day
- 1982: peaks at 33 million m³/day
- Today: < 10 million m³/day
- 2013-17: not the end

- 16 % H_2S, 10 % CO_2
- High Temp. & Pressure


LACO
J'y vais

Pilote CO_2



aptage co2 pilote lacq concertation_15966.htm

35 months from intention to action

- **Total** press conference (Feb. 8Th 2007)
- ~40 key local actors meeting (Jun-Sep/07)
- Concertation: Web, paper, 3 public meetings (Nov. 07, help from **C&S Conseil)**
- **CLIS:** Local information and surveillance commission meetings (April 08 - present)
- Administrative public survey (July - Sep 2008)
- Authorization (May 13th, 2009)
- Formal opening (January 11th, 2010)

Total's concertation

Nov. 2007: 3 public meetings (~300 persons, 3h)
National level experts, real participation
Experience from Cretace 4000 concertation

Topics: risks, transparency, control, economic interest, the platform's future.

Outcome: Climate change information day, CLIS

The CLIS (local information and surveillance commission)

- Legal institution, mandatory in some cases
- Composition: 4 State / 9 locally elected / 2 unions / 4 associations / 5 experts / 4 Total
- Installed 4/2008, met 7 times since
- Hears Total, can order additional investigations
- Reports and documents are made public at http://www.pyrenees-atlantiques.pref.gouv.fr/sections/actions_de_l_etat

The public survey

- 21/7/2008 – 22/9/2008 (64 days), 4 cities
- Double feature: Capture, Transport & storage
- Very weak participation (capture), contrasted (Transport and Storage) with 90% at Jurançon
- Favorable

Other actors

- ENGOs
  SEPANSO Béarn (federation affiliated to France Nature Environment)
  Côteaux du Jurançon (local opposition)

- Research institutes (science comitee)
  BRGM, **IFP**, **INERIS**, **CIRED**/CNRS
  APESA (expertise, questionnaires)

Conclusion

- Favorable social and technical conditions, constrained but elements negociable
- Pro-active concertation works, but people always want more
- For NGOs, October 2007's « Grenelle de l'environnement » was only the beginning

IV. A case for CCS in Vietnam ?

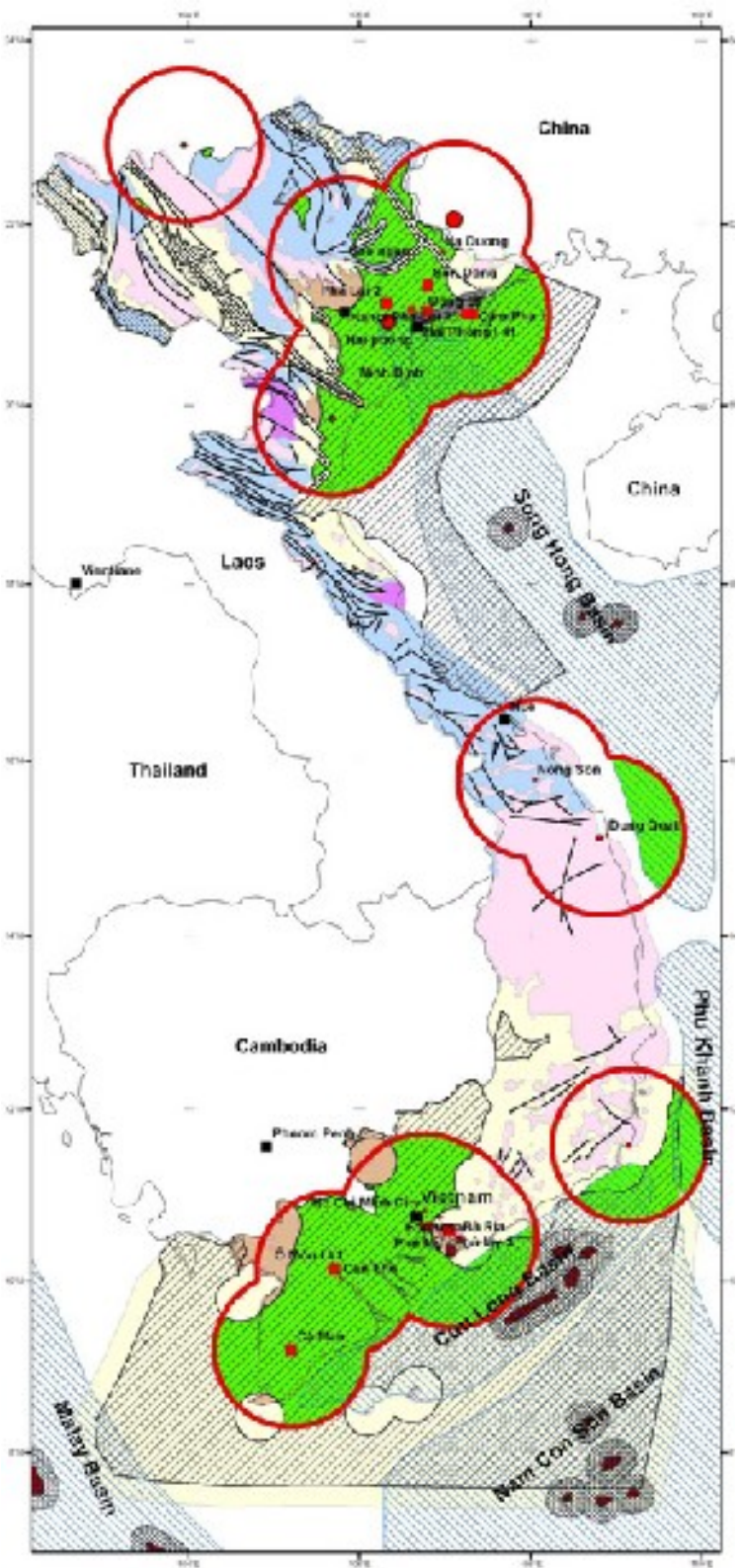
- Potential (BRGM 2009)
- The Bach Ho proposal

Power plants above 2.5 Mt CO2 / yr

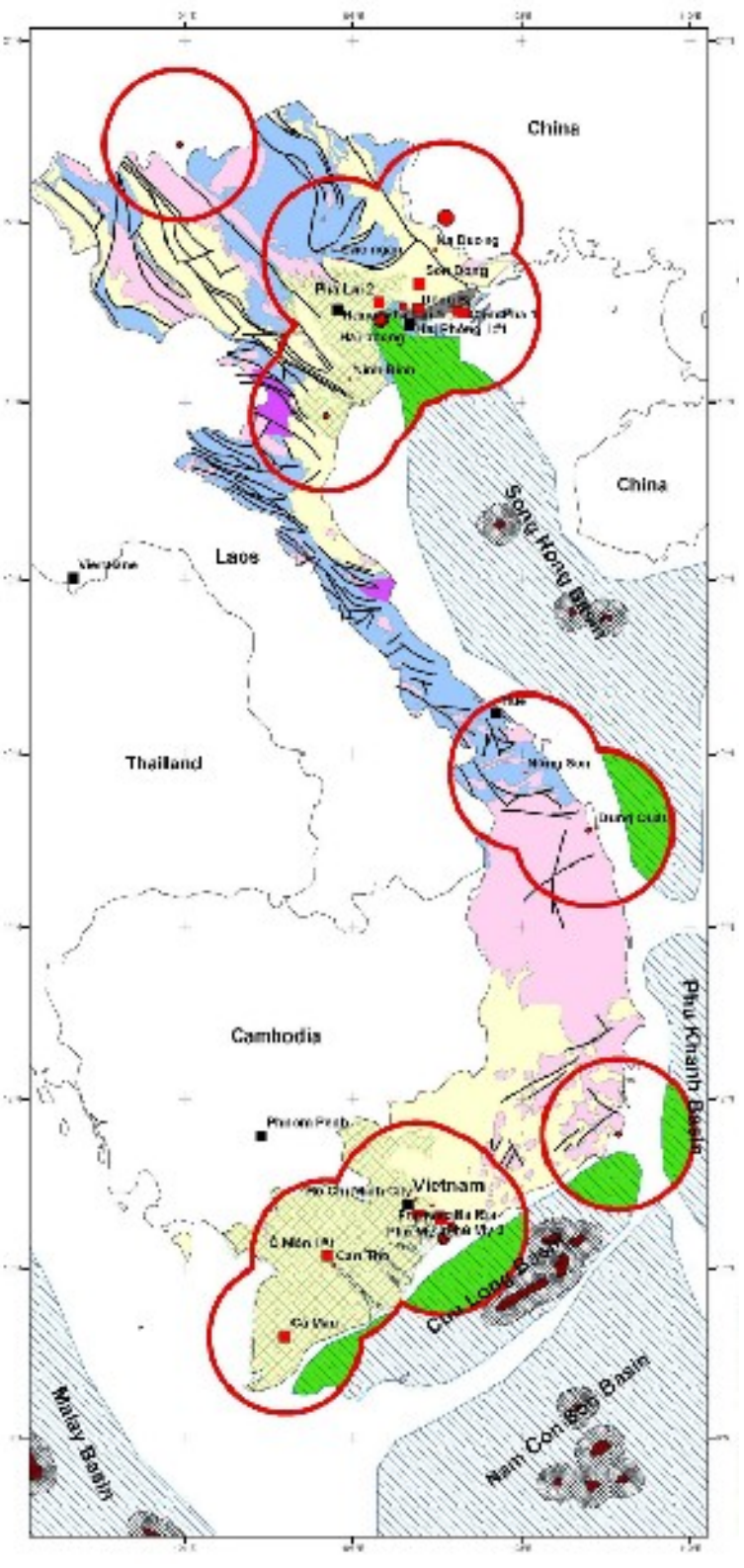
Existing and future coal-fired/natural gas combined cycle power plants (Pha Lai, Uong Bi, Hai Phong, Cam Pha, Quang Ninh, TBKHH Mien Trung, Coal Mien Trung, etc) in the river basin area of Song Hong and the North end.

Existing and future natural gas combined cycle/coal-fired power plants (Phu My, Ca Mau, TBKHH Mien Nam, Tra Vinh, Kien Giang, Coal Mien Nam, etc) in the river basin area of Cuu Long.

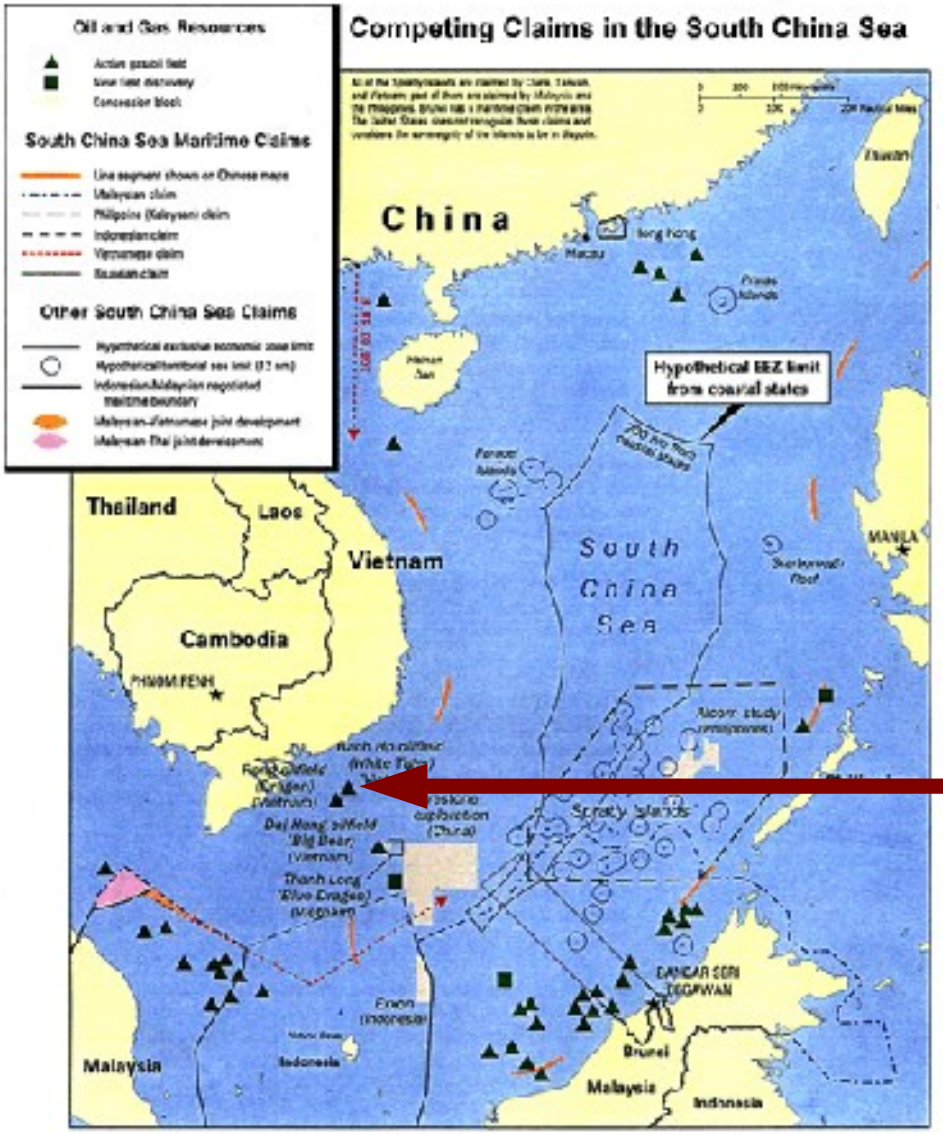
Storage opportunities



Storage potentials near Vietnam shores and power plants



An early proposal at White Tiger field



Source: Central Intelligence Agency

The White Tiger (Bach Ho) Field project involves CO2 capture from Natural Gas Combined Cycle (NGCC) plants, pipeline transport, storage in offshore/onshore oil fields and enhanced oil recovery.

A big CO_2 reduction opportunity

As the first commercial CCS project in Asia, it would have a high demonstration value, and could potentially generate emission reductions of approximately 7.7 million tCO_2 per year, facilitating the recovery of an average of 50 thousand barrels of crude oil per day.

But CDM does not finance CCS

Work to include CCS in the CDM started in 2006, but has not yet been concluded as of December 2009.

Pending methodological and political issues

- The technology is still evolving
- The scale is out of proportion relative to the average CDM project: out of 2236 requested and registered projects in February 2010, only 7 are larger than the White Tiger project in terms of avoided emissions.

Conclusions

- Big reductions, big money
- Enhanced oil recovery means CO2 storage now
- No new coal plants without carbon capture in Europe