

Costs, CO₂ emission, markets



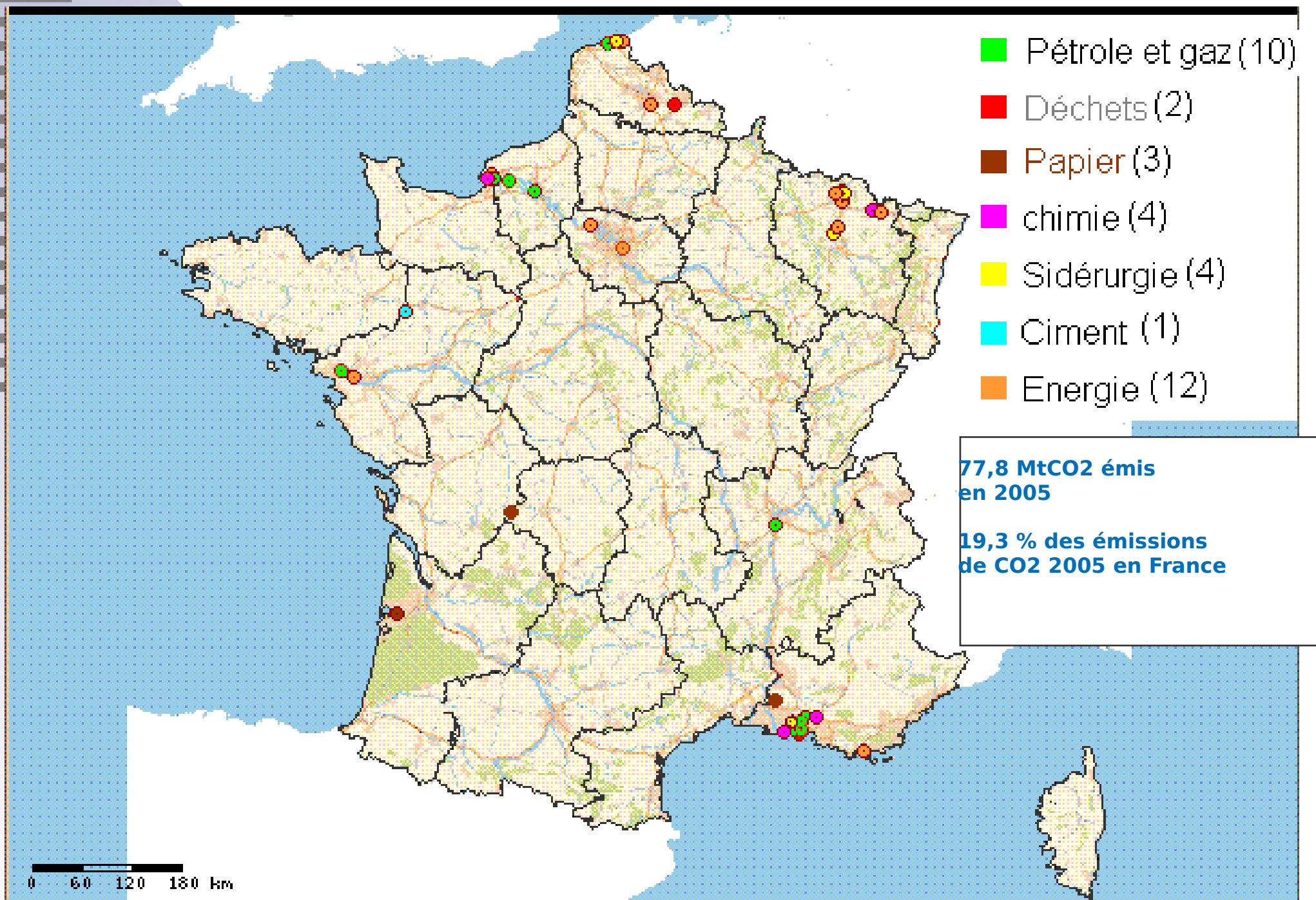
Message

- Saving CO₂ is worth <10 €/t (2012 market price)
- CCS costs ~50 €/tCO₂ (capture expensive)
- Therefore something must be done

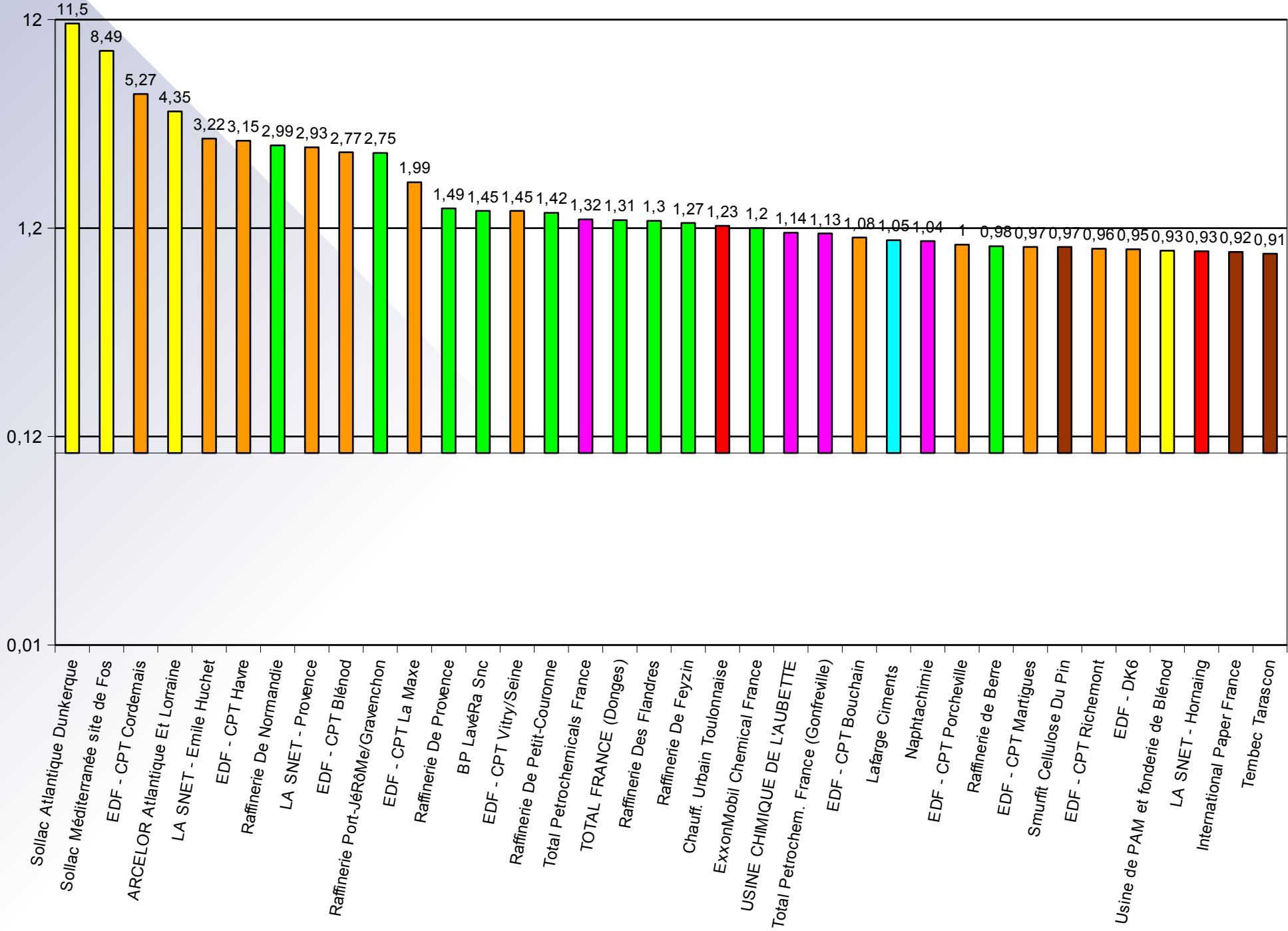
CO₂ emission permits market

- There is a wide variety of industries
- One market to rule them all is efficient

36 largest CO₂ emitters industry & energy



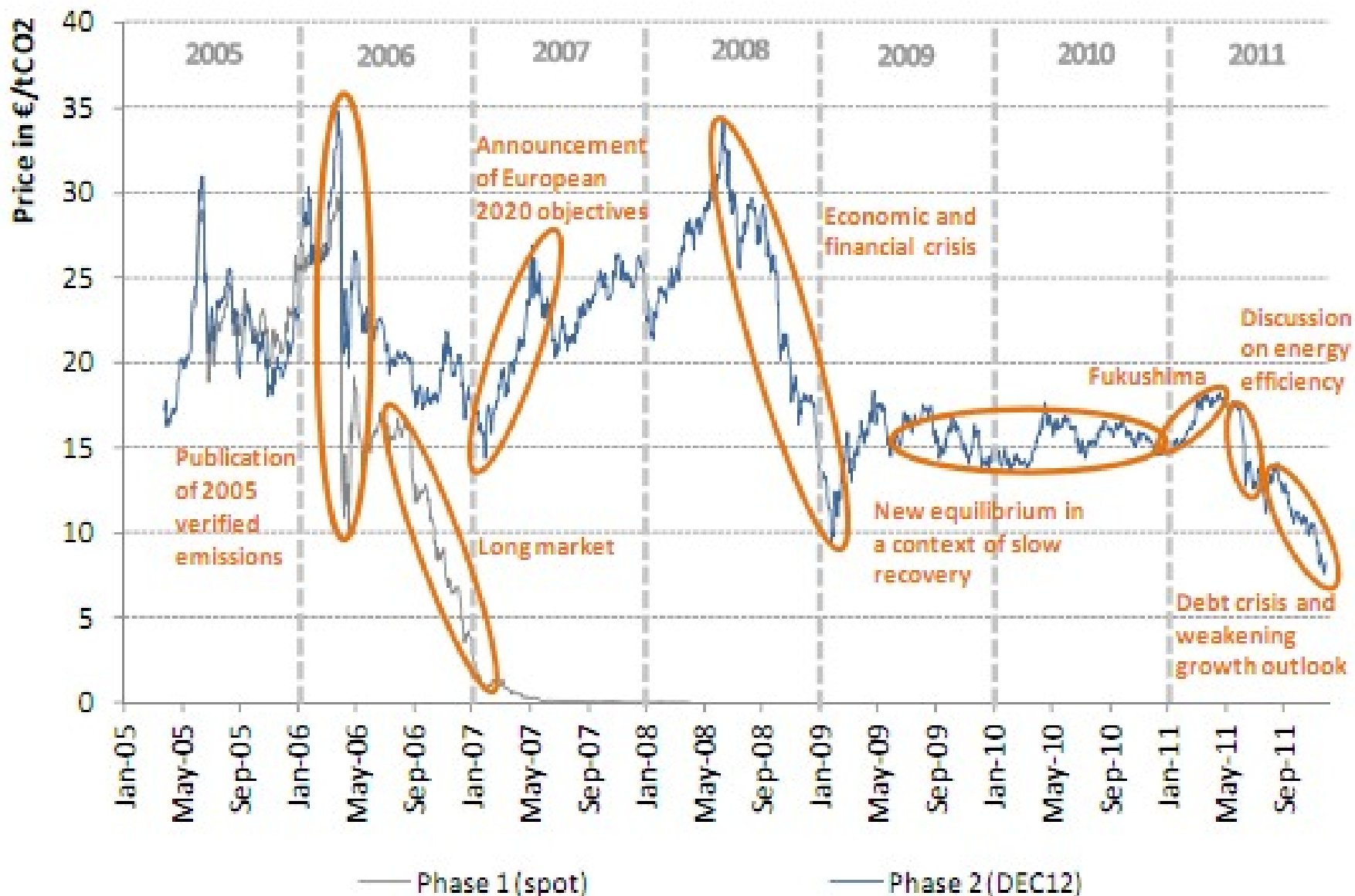
36 largest (MtCO₂, 2005)



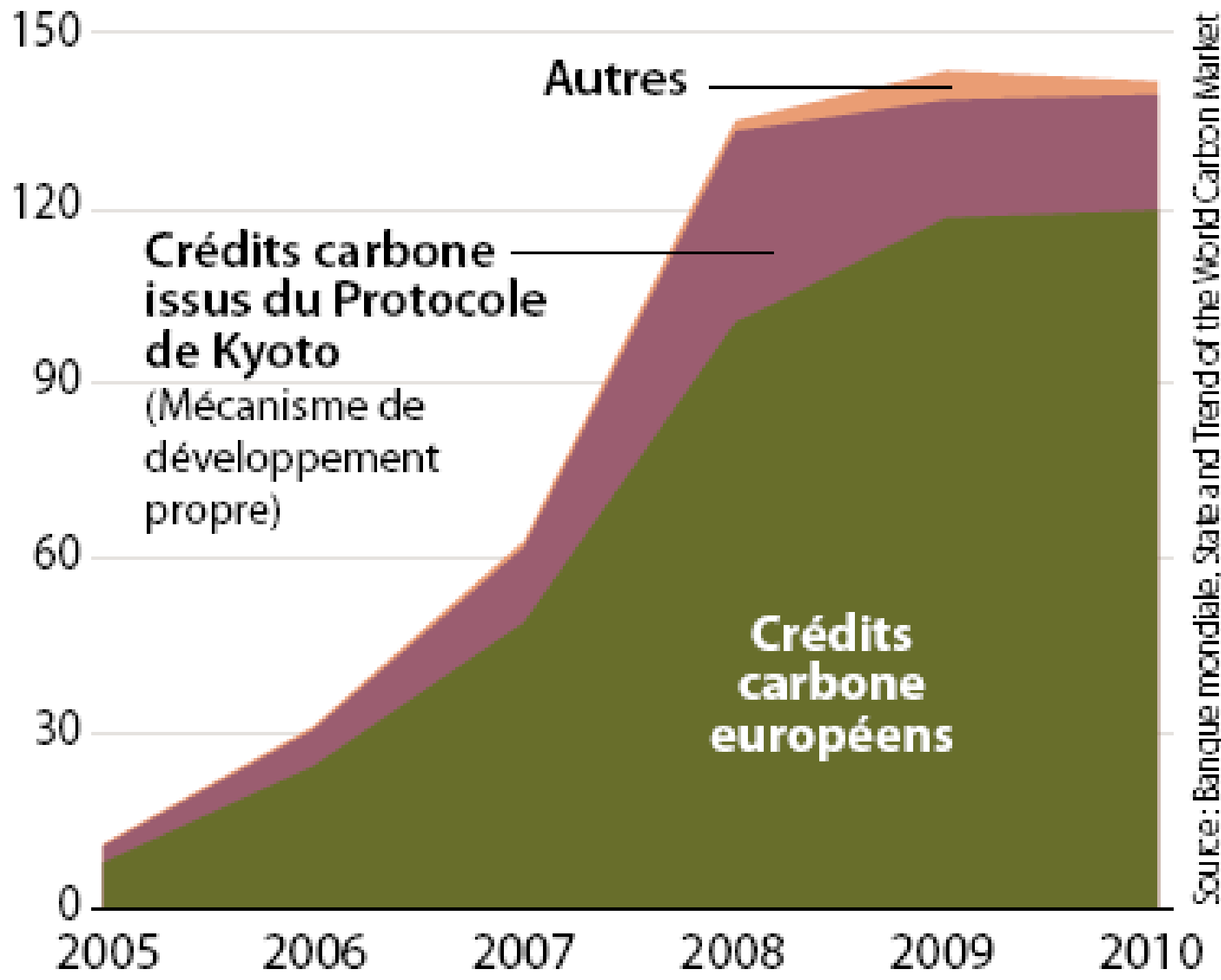
ETS: Emission Trading System

- To emit CO₂ european firms must have *allowances*
- Allowances can be sold or bought
- Initial quantity given free in 2005, Auctions increasingly used in later periods

ETS CO₂ allowances: Price history



Source: Climate Economics Chair from BlueNext and ICE ECX Futures



Source: Banque mondiale, State and Trend of the World Carbon Market



ETS allowance is $<10 \text{ €/tCO}_2$

Is that enough to justify CCS ?

2. Costs along the CCS chain

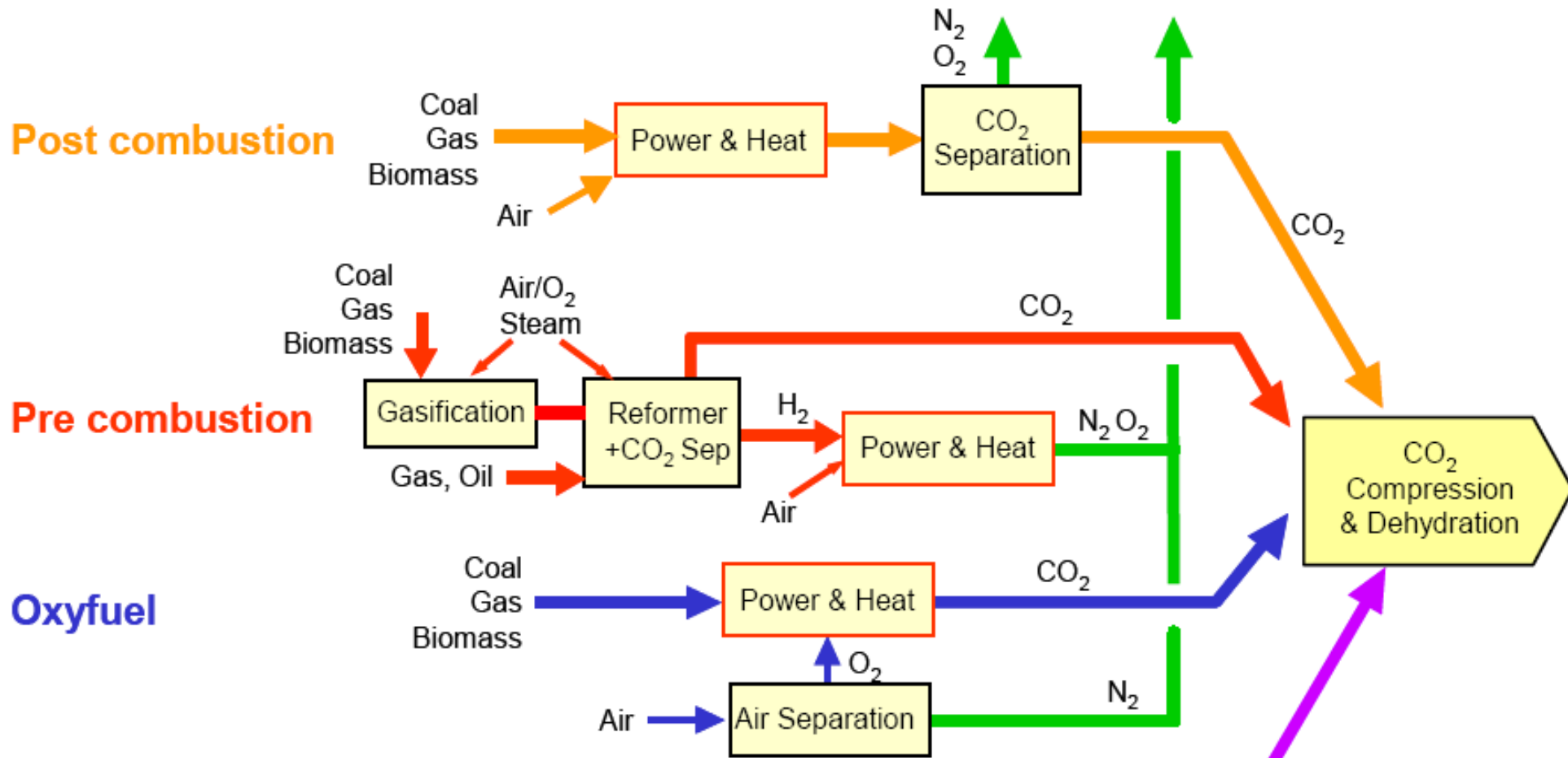
Adding up the costs of:

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

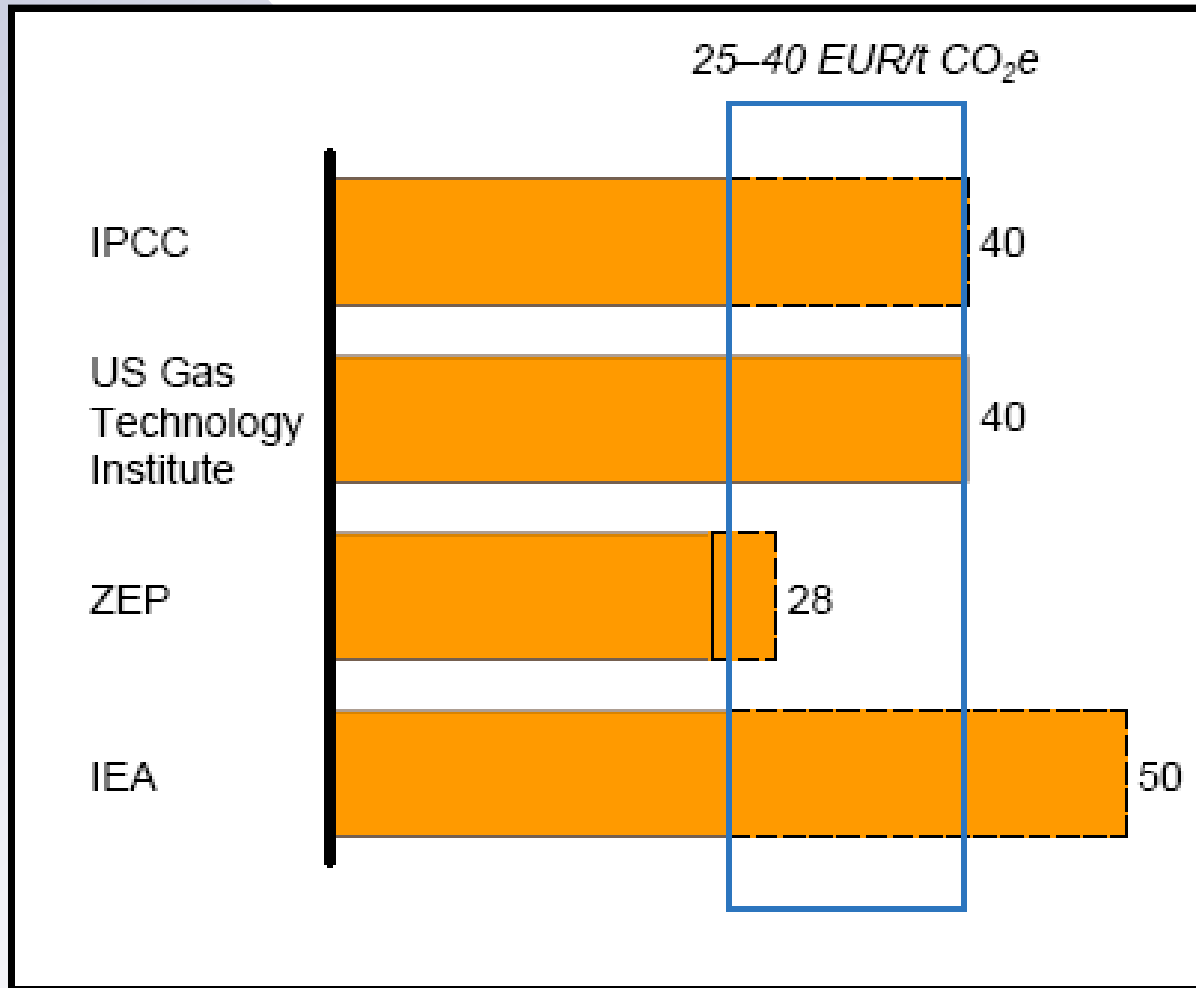
Technologies known, but

We need large scale, integrated pilots

3 ways to capture



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

Moving CO₂ around

Pipeline

(supercritical dense phase)

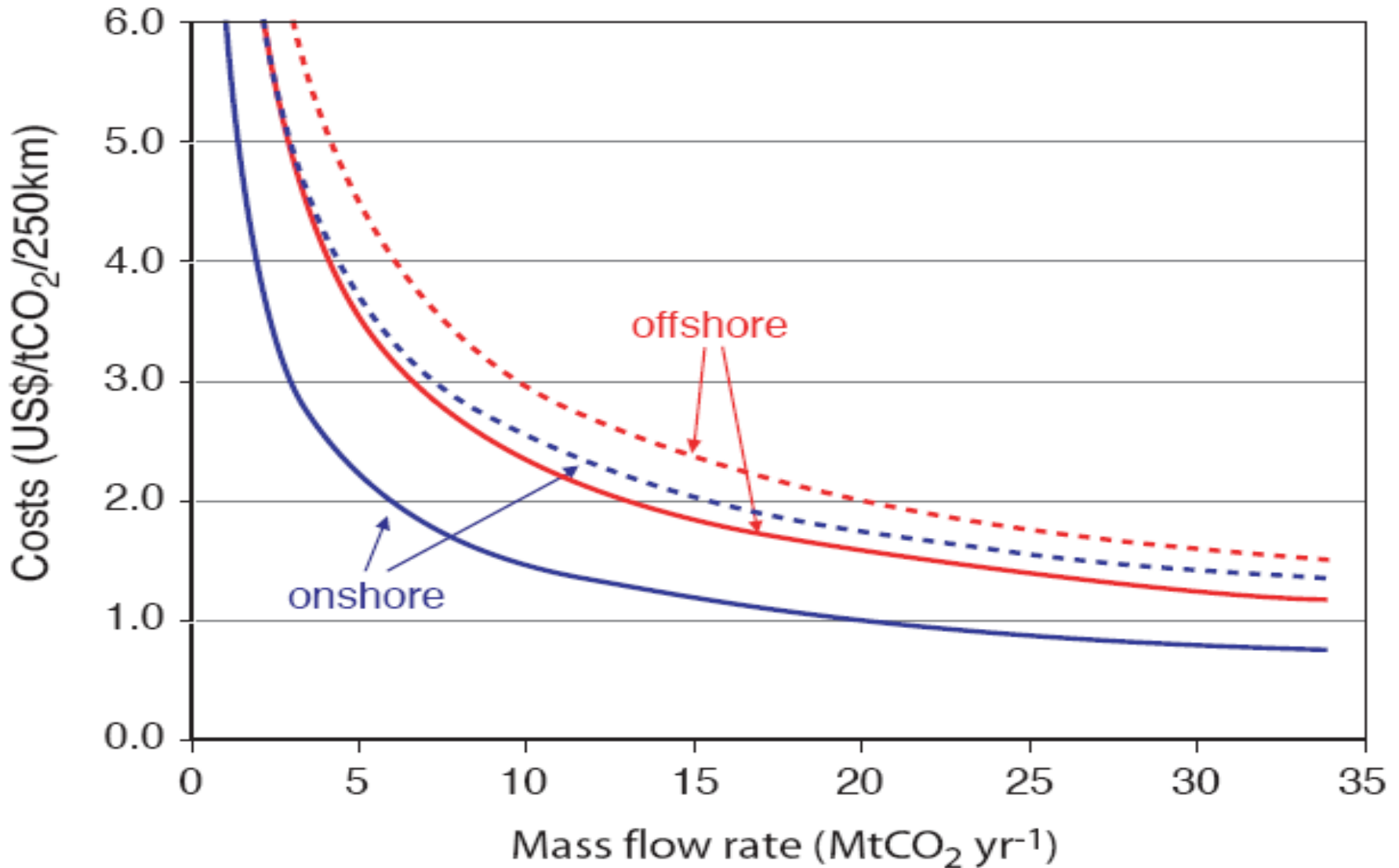
Ship

(oversea/offshore storage)

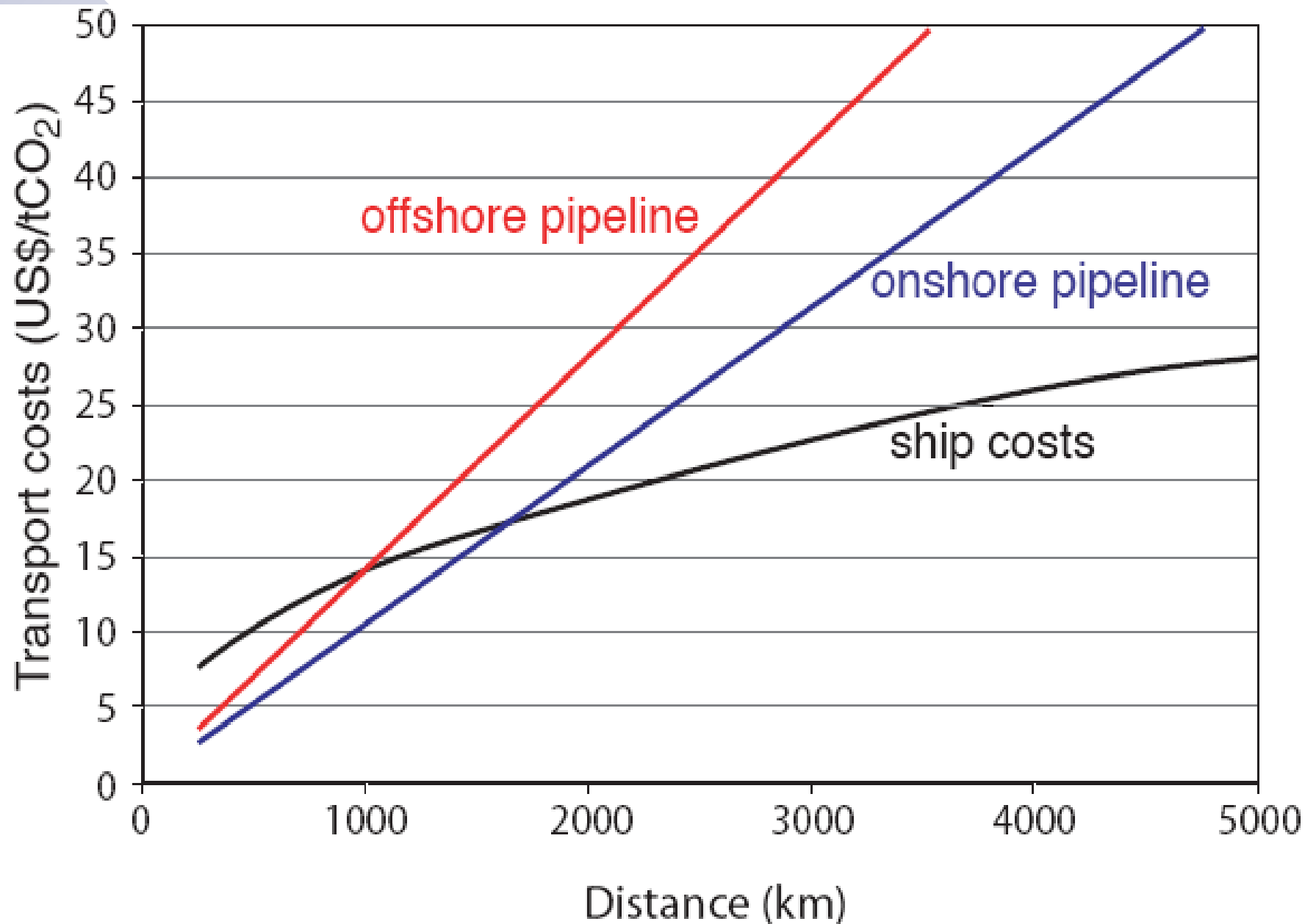


- Commercially available technologies
- Low technical progress
- Economies of scale

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



Shipping cheaper over 2000km



Comment transporter 30Mt de CO₂ / an

Les cylindres représentent les sources (en rouge) et les puits (en bleu). Leur hauteur correspond aux coûts, leur diamètre au flux de CO₂. Le secteur foncé indique la part d'utilisation de la source ou du puits.

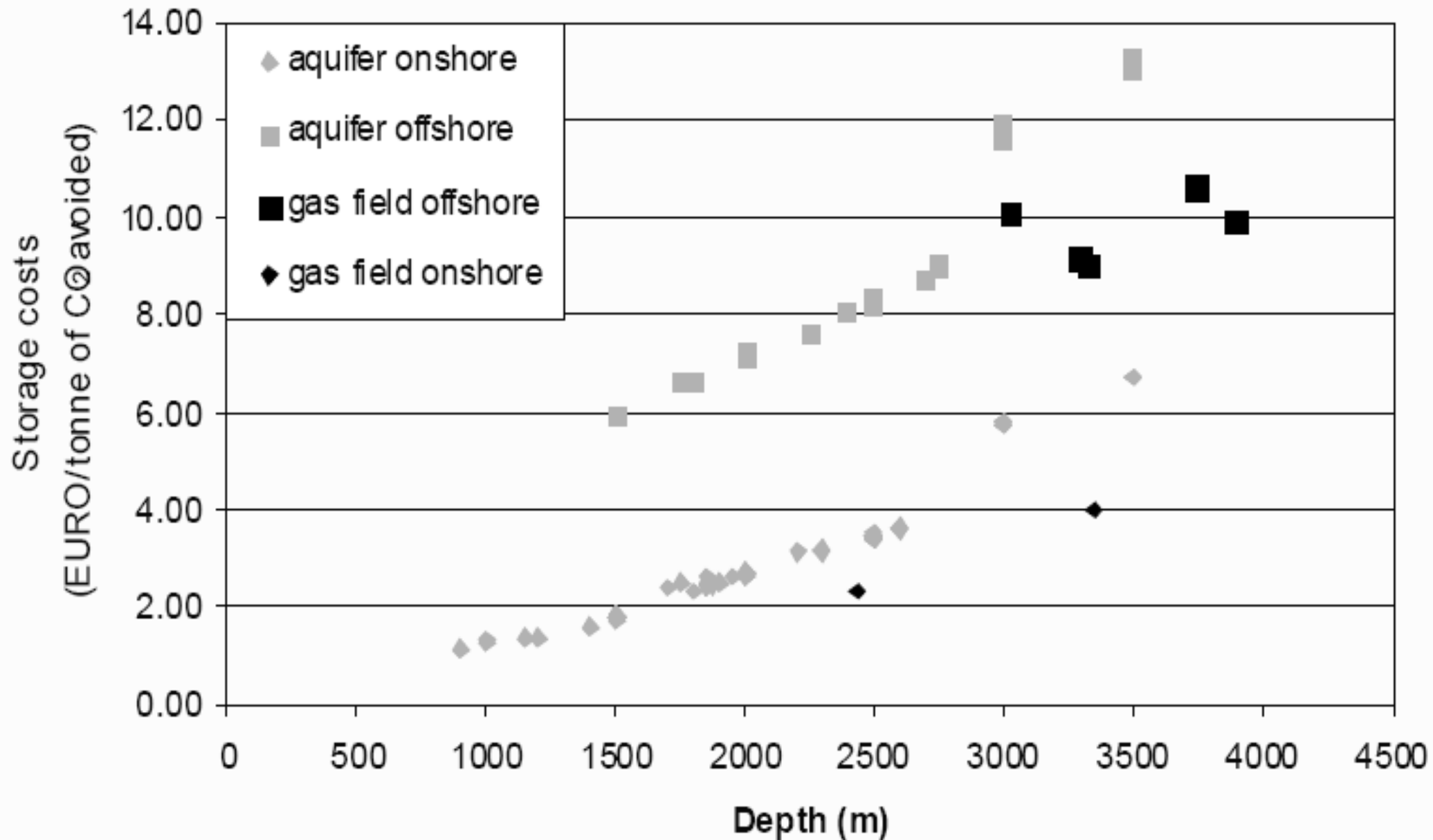
Le réseau est en vert. Le diamètre des canalisations est représenté par l'épaisseur du trait.

Modèle: SimCCS.

Source : G. Callas (2011) CIRED



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



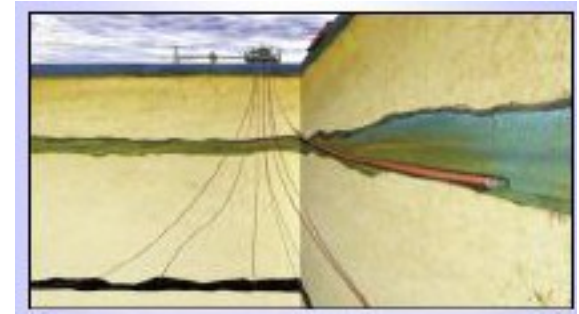
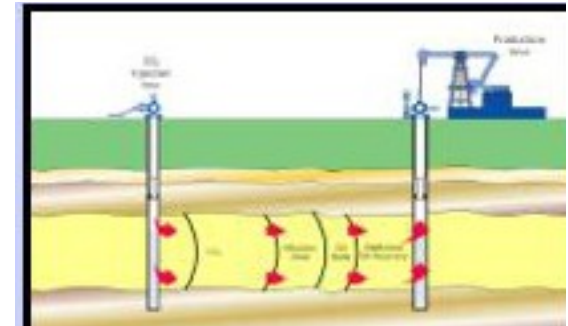
But there are uncertainties

Risks of leakage:

Imply long term monitoring

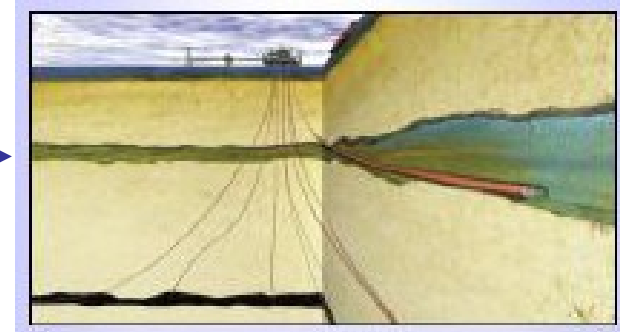
Economic framework is uncertain (post
Kyoto regulation, ETS...)

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

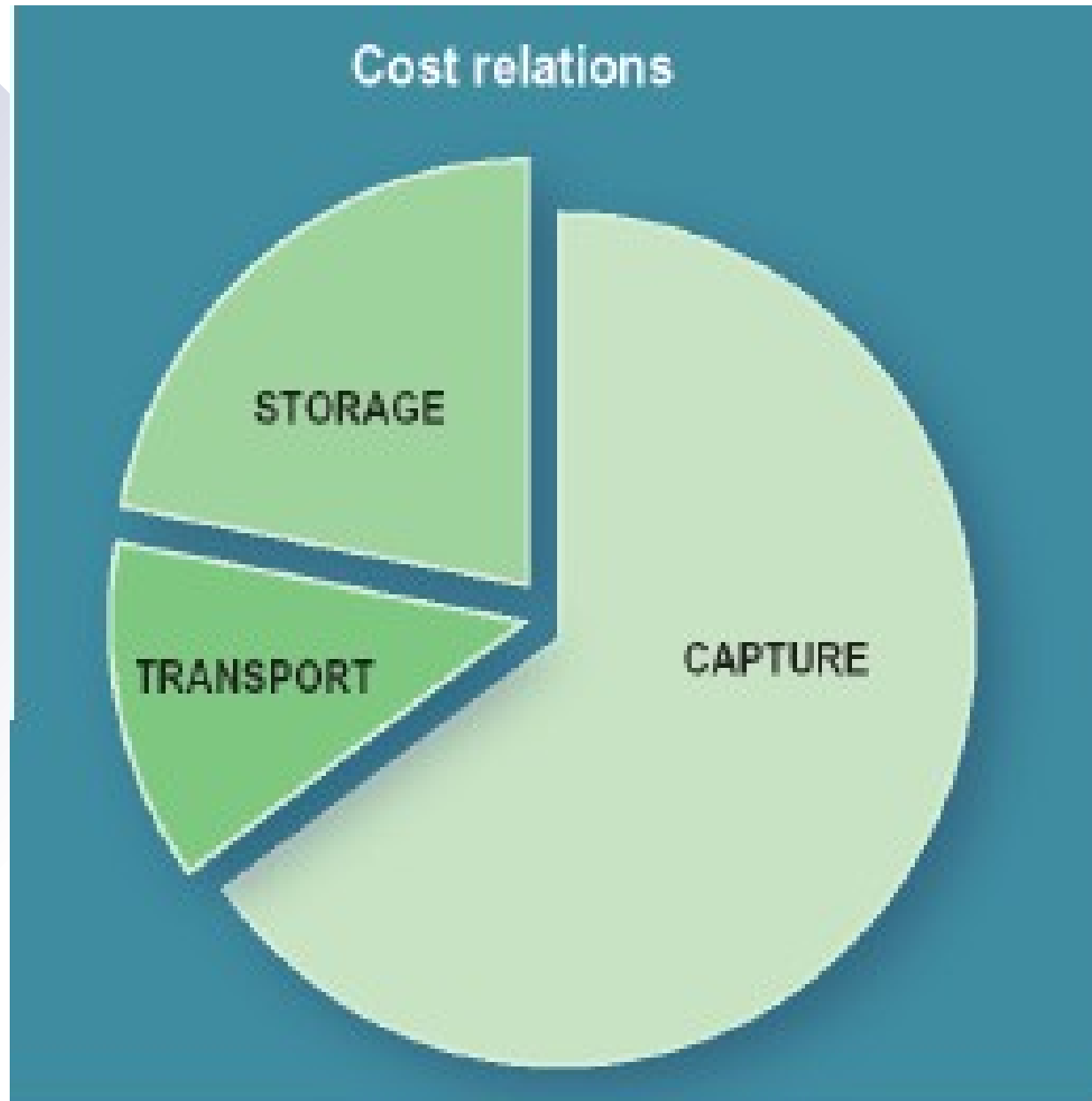
**Storage
1Mt/yr**

15 €/tCO₂

**Storage
10Mt/yr**

5€/tCO₂

Capture is the expensive step



CCS is way over CO2 market price

Incentives are needed

$$50 \text{ €/tCO}_2 \text{ (CCS)} > 10 \text{ €/tCO}_2 \text{ (ETS)}$$

There are public benefits to R, D & D

Electricity production cost increases by >30%

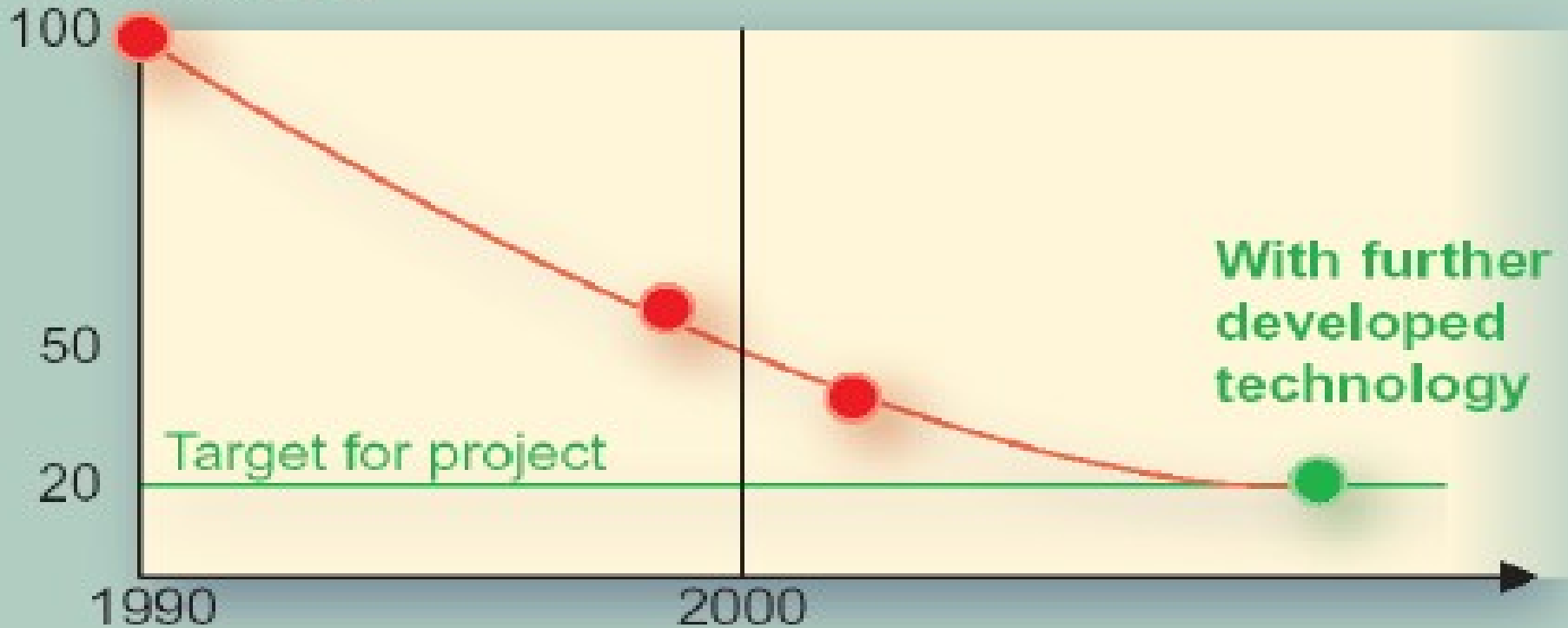
- Coal plant:
from 4.3-5.2 c/kWh without
to 6.3-9.9 c/kWh with CCS
400M\$ additional investment
- Natural gas combined cycle:
3.1 - 5.0 c/kWh without
4.3 - 7.7 c/kWh with

Source: IPCC SRCCS

Cost reduction target: 20€/tCO₂

Development of total estimated cost
(capture, transport and storage)

EUR/ton CO₂



Conclusion

- European market (ETS) $<10 \text{ €/tCO}_2$
- CCS costs $\sim 50 \text{ €/tCO}_2$ today
- Capture is expensive