# Cost assessment of mitigation options with the Imaclim-R model

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# What is at stake?

- Updated data about costs is a ‘primary’ input to model discrete technology choices in a **consistent** hybrid model
- Calibration of learning and other ITC mechanisms largely hypothetical but interesting to include and test, with an increasing robustness (cf. Nordhaus critique)
- Need to refine the representation of regional discrepancies, to assess the potential (or even legitimacy) for technology transfers, sectoral agreements (=> Copenhagen)

- BUT no intention to refine again and again the representation of discrete technologies in the model

# Outline of the presentation

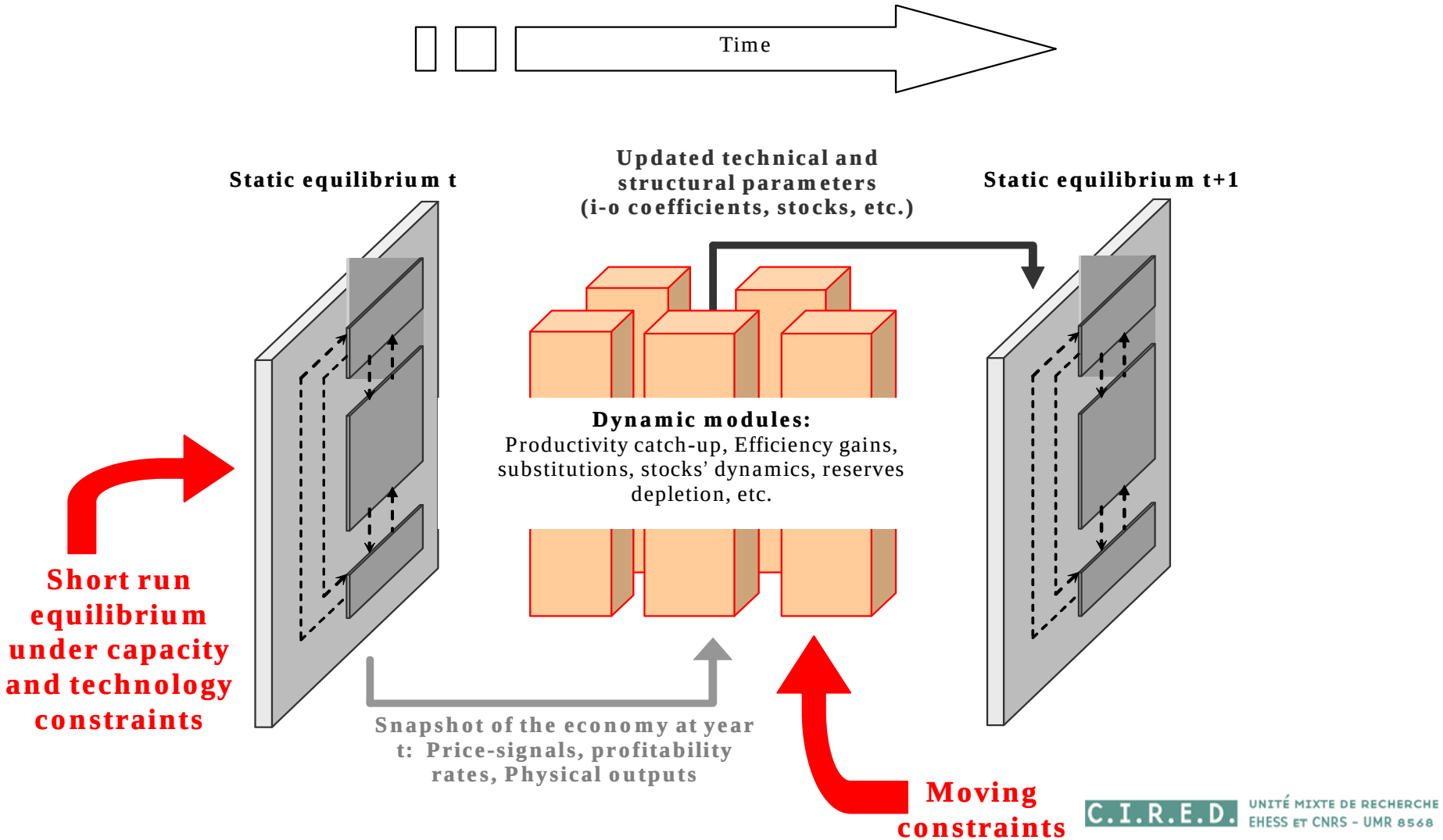
- The Imaclim-R model
- Technologies in power supply
- From *ex ante* technology costs…

  …to *ex post* costs with changing economic conditions

# The Imaclim-R model

- Hybrid Recursive dynamic framework :
  - Succession of **static equilibriums** under short-term constraints
    - Consistent Macroeconomic snapshot (inc GE effects)
    - Technology and capacity constraints (i-o coefficients + capacities)
    - Flexible utilization rates (Johansen, Kalecki, Malinvaud…)
  - **Moving constraints** informed by reduced forms from BU models
    - No explicit production function
    - Stock dynamics, technological asymptotes, technological choices
  - **Price and Physical quantities account** (mtoe, pkm, tons of steel)

# An attempt to disentangle short run constraints/adjustments and long run dynamics



# Additional features

- One-year time steps
- Capital flows fixed or endogenized
- Unemployment: wage curve
- 12 regions (inc. USA, Europe, China, India, Brazil, OPEC, CIS)
- 12 sectors (5 energy supply and conversion, 3 transportation, building, energy-intensive industry, agriculture, composite)
- Induce technical change for specific new technologies
- Endogenous labor productivity growth (on/off)

# Bottom-Up modules

- **The replacement of sectoral production functions by a static input-output structure allows/requires to:**
  - Represent the evolution of each i-o coefficient, in function of sector-specific expectations and investment decisions
  - Avoid the mathematical constraint and the lack of robustness of usual calibration on one single point
  - Freely incorporate heterogeneous sectoral data and expertise
- **This modular structure can afford the coexistence of:**
  - Very detailed sector-specific optimization (e.g. power supply, oil depletion, vehicles)
  - Reduced forms of BU models (e.g. coal and gas)
  - Aggregate logit sharing (industry)
  - Exogenous routines (e.g. freight transportation input in all sectors)

- **An open space alternative assumptions about expectations**

# The power sector

- 26 discrete technologies inspired from the TECHPOL database (Criqui et al.)

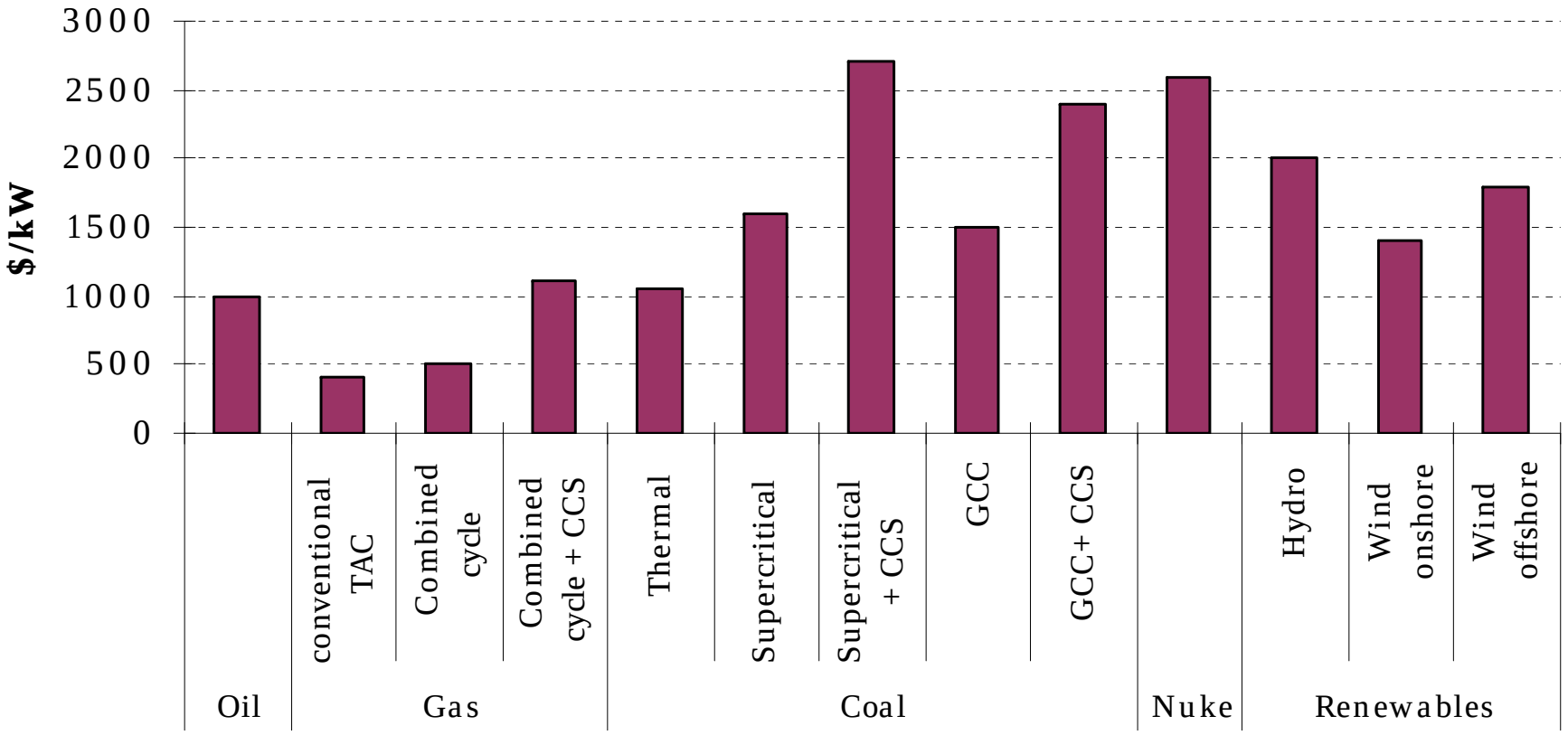
  Coal 6(2), Gas 4(1), Oil 2, Nuke 2, Hydro 2, Wind 2, Solar 3, Biomass 2

  Updated with IEA data
- Investment choices rests on a sectoral optimization with
  - adaptative expectations of future prices, total demand and load curve
  - Perfect expectation of carbon price
  - Exogenous constraint on Nuke; Routines on renewables
- Marginal investment aimed at closing the gap between existing capacities and the optimal park under an investment constraint
- Learning curves on renewables and CCS
- Currently on development: ‘S’ curve for penetration of new technologies
- No refinement of regional heterogeneity of costs

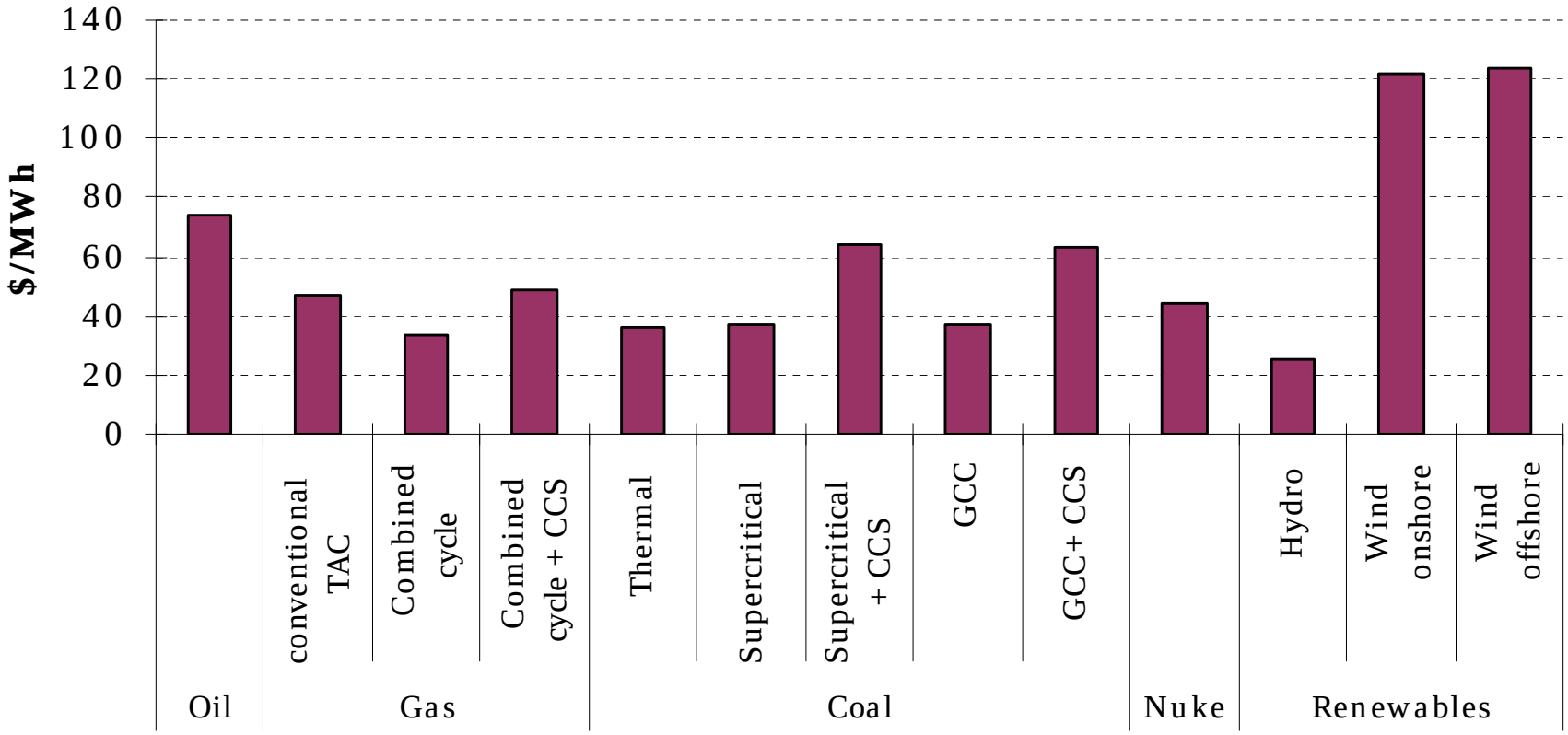
# The power sector

| | | Traditional Coal | Supercritical coal |
|---|---|---|---|
| Time of Availability | | Now | endogenous |
| Investment cost | $ 2001/kW | 1050 | 1600 |
| O&M costs by capacity | $ 2001/kW | 53 | 35 |
| Lifetime | Years | 30 | 30 |
| Variable Costs by output | $ 2001/kWh | 0.0024 | 0.0028 |
| Efficiency | % | 35 | 45 |
| Availability rate | % | 90 | 90 |

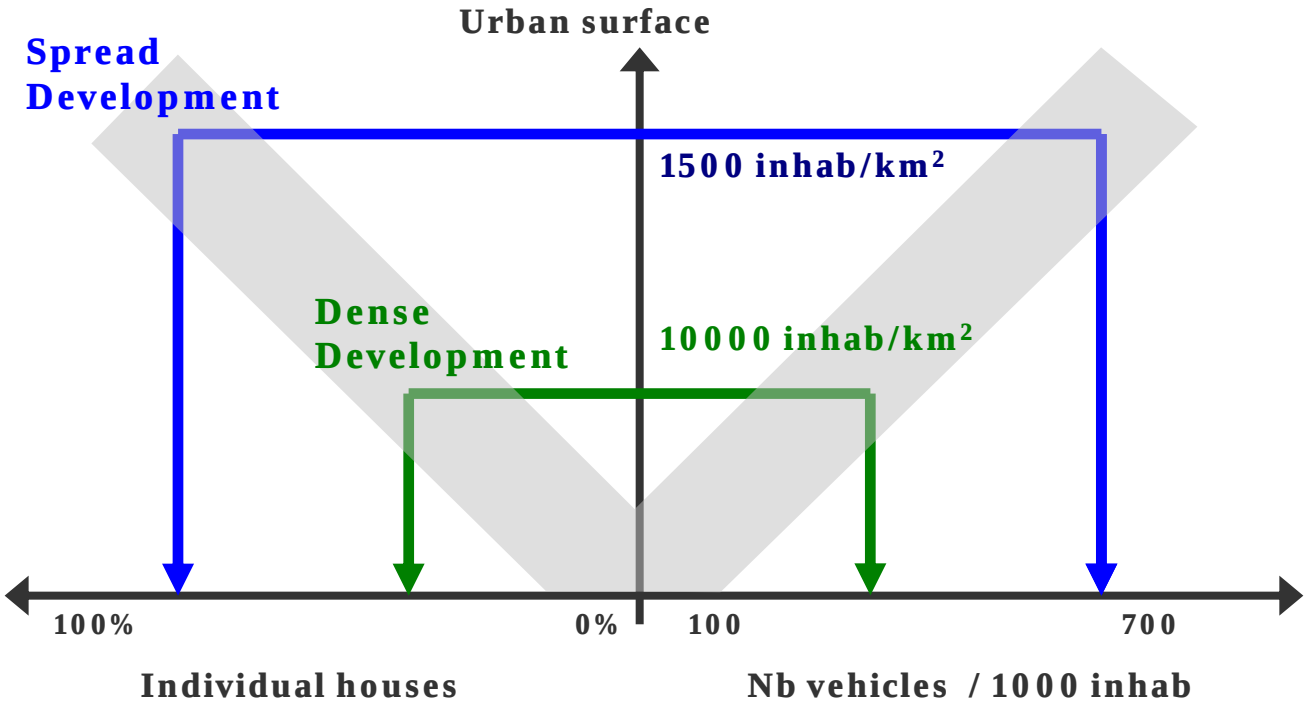
# Investment costs in the power sector



# Levelized costs in the power sector



# Future challenge for the electric sector:two paradigms?




(Criqui et al., 2007)

# From ex ante cost data to ex post cost variations in the model

- Many reasons why future costs will depend on future conditions of regional and global economic situations:
  - Materials
  - Wages (what productivity catch-up?)
  - Fossil fuel dynamics
  - Climate policies
  - Infrastructure choices
  - Global demand for electricity
  - International agreements (to foster convergence)

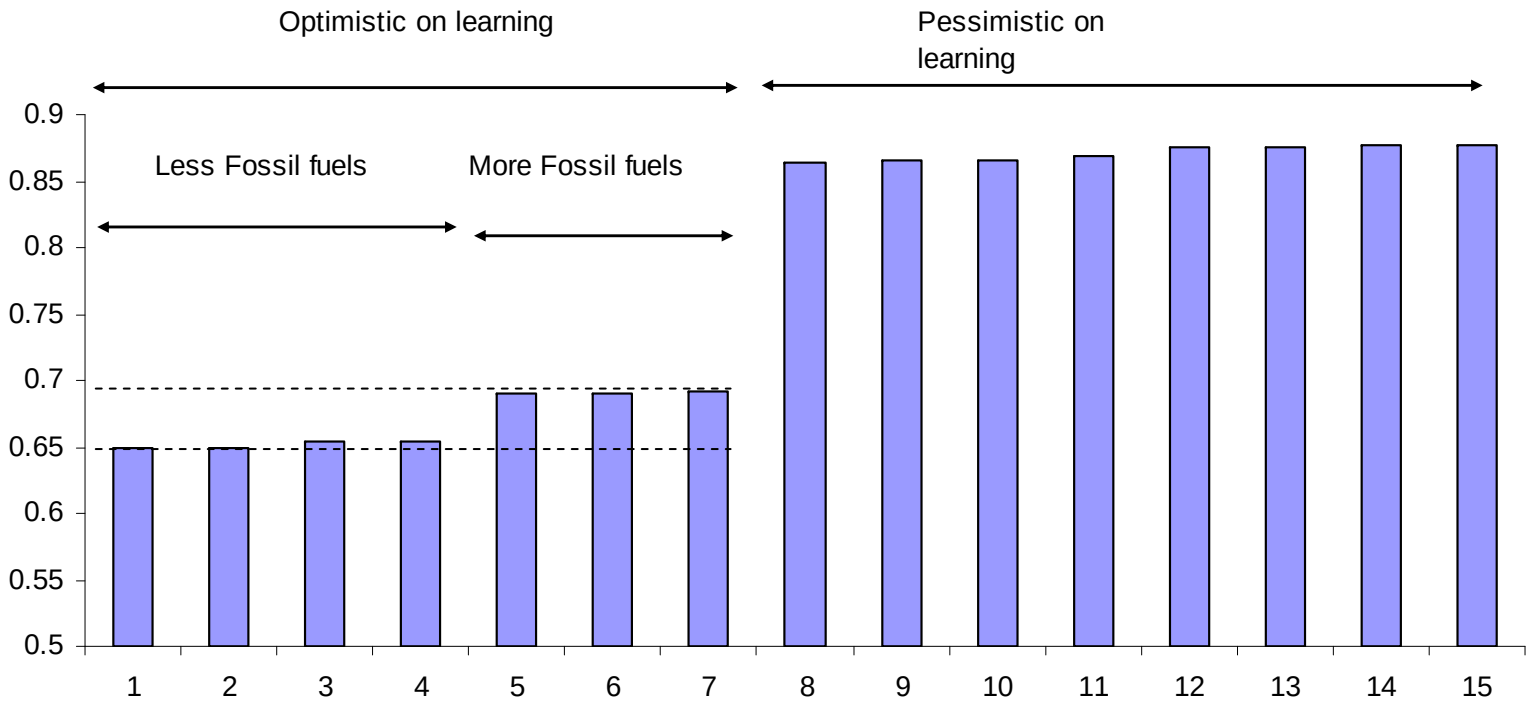
- What are the first/second-order drivers of costs variations?

# From ex ante cost data to ex post cost variations in the model

- Experiments with a 450 ppm CO2 scenario with sensitivity analysis of:
  - Fossil fuel availability
  - Learning on CCS + renewables
  - Efficiency of energy end-uses (transportation, housing, sectors)
  - Development styles (GDP elasticity of nb of cars/ m2)

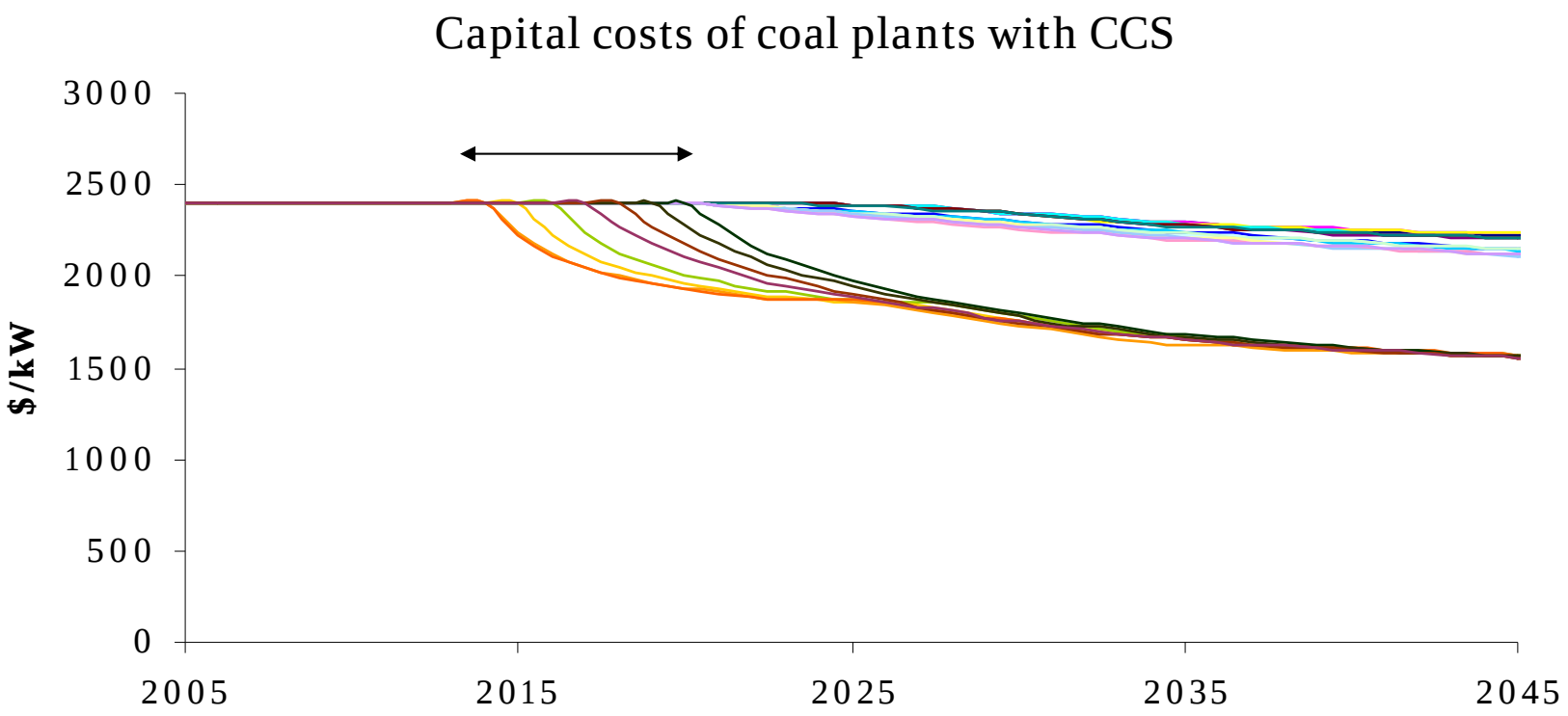
# Ex post costs with changing economic conditions

**investment cost reduction for wind onshore in 2050 vs 2005**

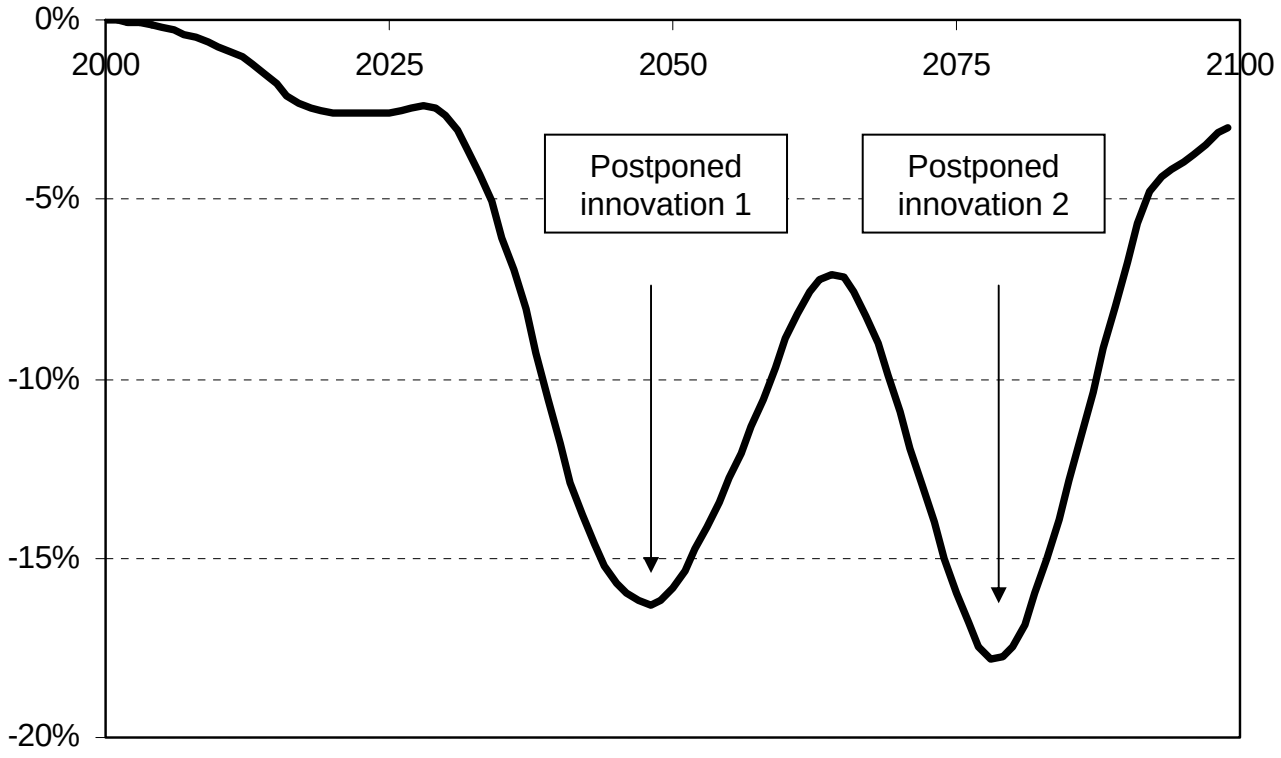



**-13%**

# Impact on technology penetration



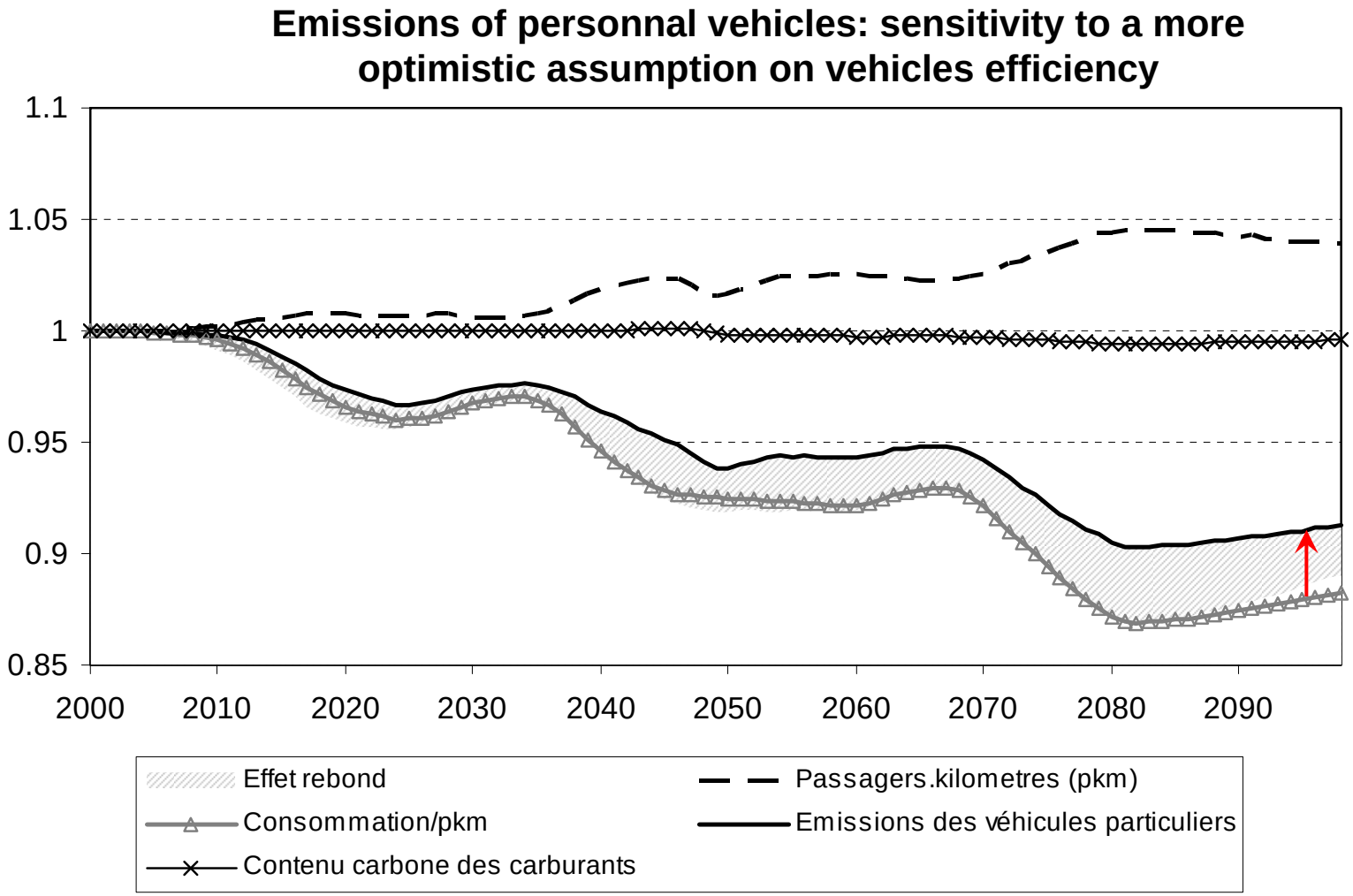
# Non trivial interplay between policies:
## Modal shift away cars vs. innovation?




**Vehicle efficiency with infrastructure policy compared to a central 450 ppm scenario**

(Sassi, 2008)

# Non trivial interplay between policies:
## Rebound effect in the absence of additional infrastructure policy




(Sassi, 2008)