Arbitrage between Energy Efficiency and Carbon Management in the Industry Sector: An Emerging vs. Developed Country Discrimination

N. Maïzi , S. Selosse, E. Assoumou – CMA/MINES ParisTech - PSL*
M. Thiboust , V. Mazauric – Schneider Electric

June 4th, 2015
IEW – Abu Dhabi – UAE

The energy dilemma is here to stay

The facts		The need
×2	vs	÷2
Energy demand By 2050 Electricity up 80% by 2035		CO_2 emissions to avoid dramatic climate changes by 2050
Source: IEA 2010		*Source: IPCC 2007, figure (vs. 1990 level)*

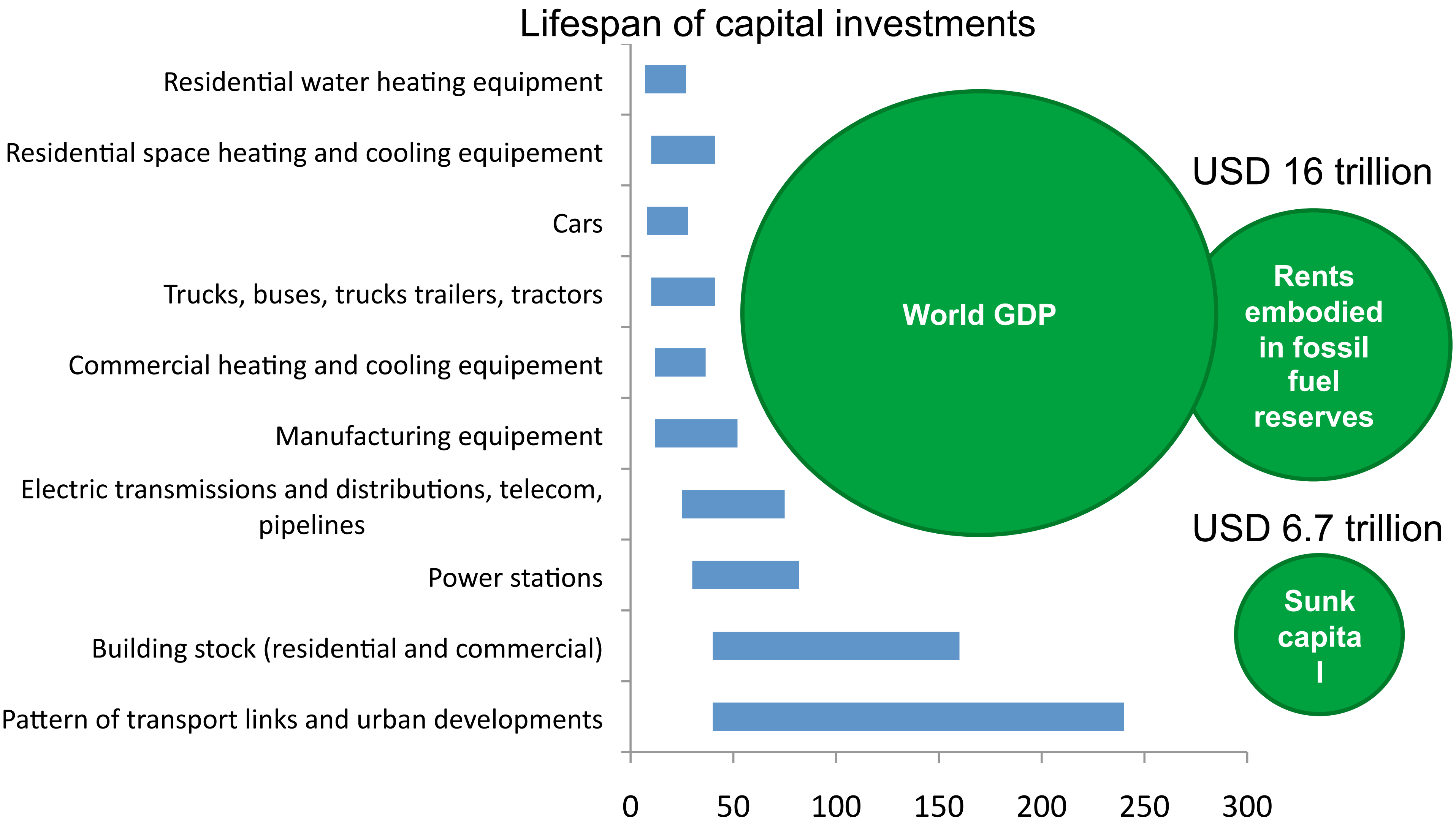
Energy scarcity, Demography Resource access Energy prices

GHG emissions Climate change

- **Dispersed generation *vs.* dense urban zone**
- **Energy efficiency**

Reliability of supply

The "big picture" for changing
Build a technology path to overcome the inertia



Source: OECD (Forthcoming) Green Growth Studies: Energy; World Bank.

Abatement strategies and competitions

- Energy efficiency:
  - Demand side included in the techno
  - Supply side add-ins, extra invests

➔Usually defined as input (to reach…)

- CO_2-free technologies:
  - CCS extra consumption
  - Nuclear risk, waste
  - Renewables reliability

➔Potentially compete with EE…

- Beyond the forecast…Long-term exercises!
  - "bottom-up" technology models are relevant for industry

  www.modelisation-prospective.org

ParisTech INSTITUT DES SCIENCES ET TECHNOLOGIES PARIS INSTITUTE OF TECHNOLOGY

ADEME Agence de l'Environnement et de la Maîtrise de l'Energie

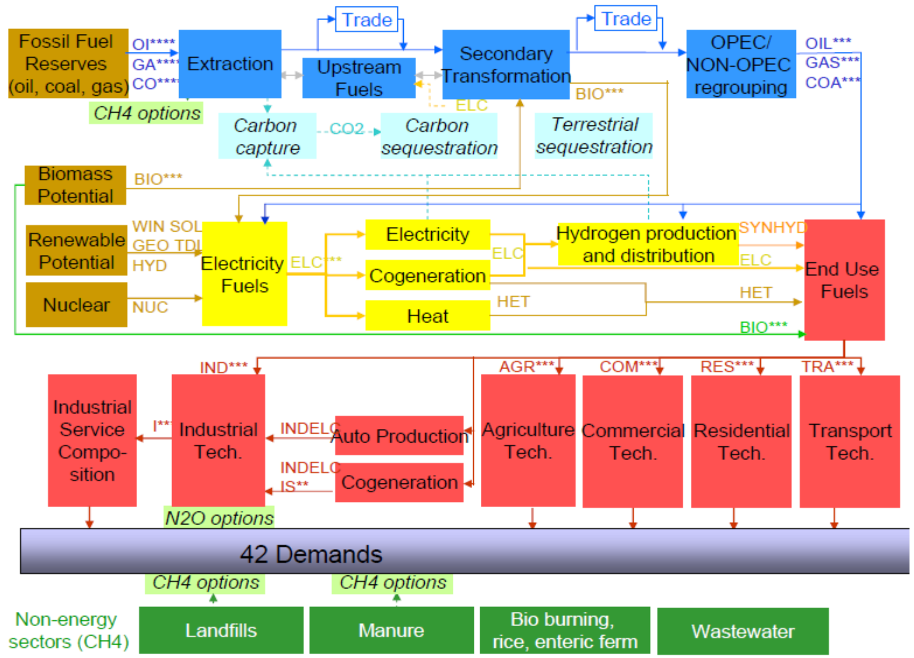
EDF GRTgaz Schneider Electric

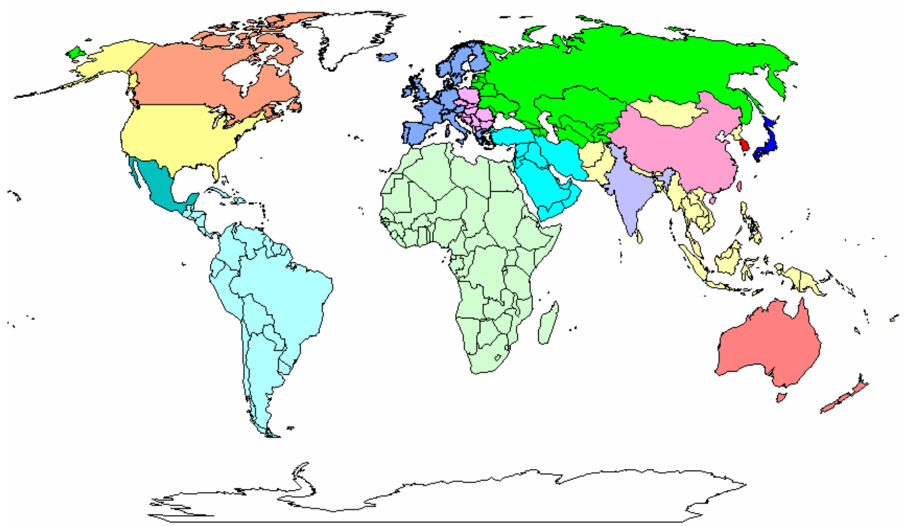
Modeling issues

- The TIAM-FR model:

  A technical linear optimization model driven by demand achieving a technico-economic optimum:

  - for the reference energy system:
    - 3,000 technologies,
    - 500 commodities;
  - subject to a set of relevant technical and environmental constraints
  - over a definite horizon, typically long-term (50 years)
  - 15 regional areas



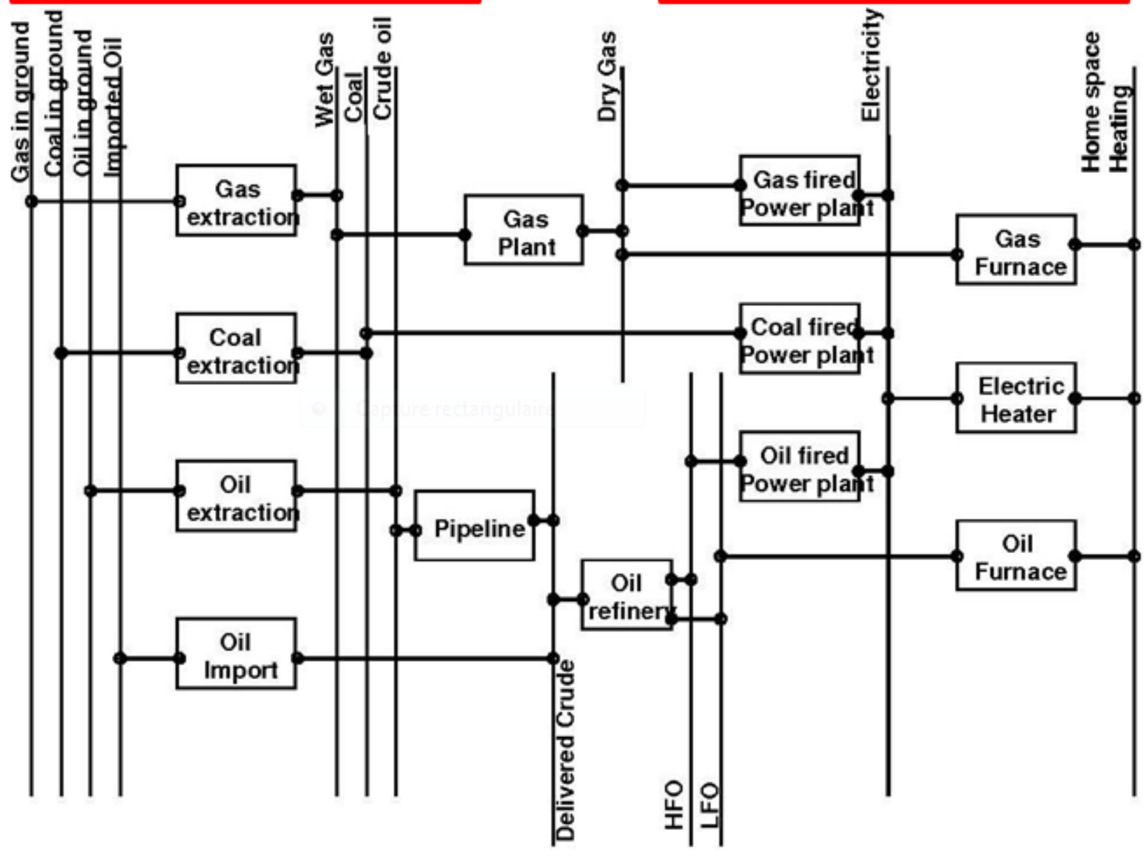


Reference Energy System
within the TIMES formalism

Technical constraints:
- Investments, O&M costs
- Efficiency
- Life-time
- …

Non-technical constraints:
- Political strategic choices
- Social acceptation
- Environmental constraints
- …

Resource constraints:
- Prices
- Reserves
- Geographical availability
- …

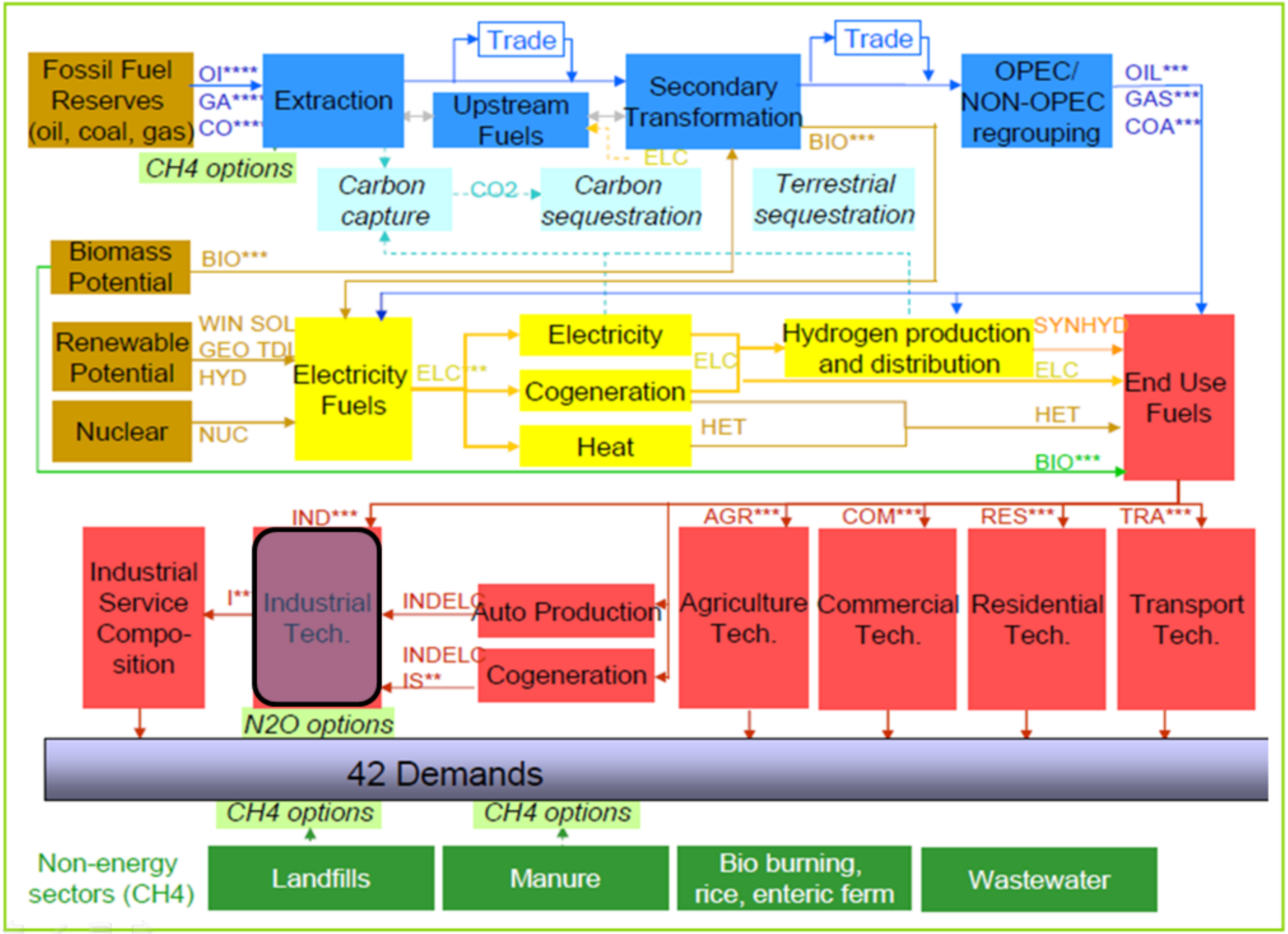


Resource constraints:
- Demand scenarios (GDP)
- Price elasticity
- …

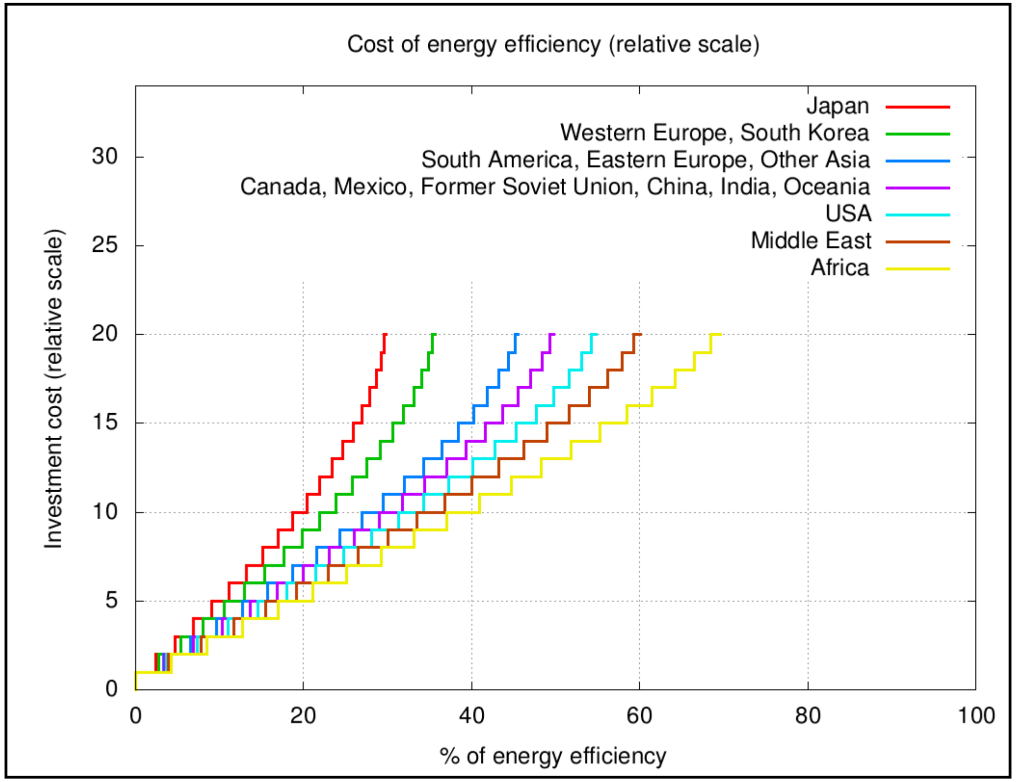
Energy flows | Investments | Emissions

Energy efficiency modeling

Global Reference Energy System:
Industry-sector disagregation



Energy efficiency implementation costs



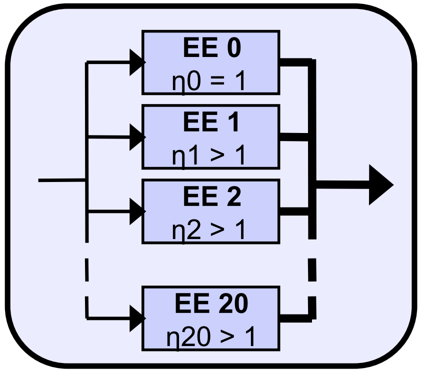
- Model refinement:
  - Provide the cost of the next EE step for an already achieved level (demand side)
- The model selects the rate of EE to implement at the demand side:
  - for each sector and
  - each region

  according to the competition with other abatement technologies (CCS…)

For each region and each sector

η1, η2,…, η20
cost1, cost2,…, cost3

DS-EE technologies

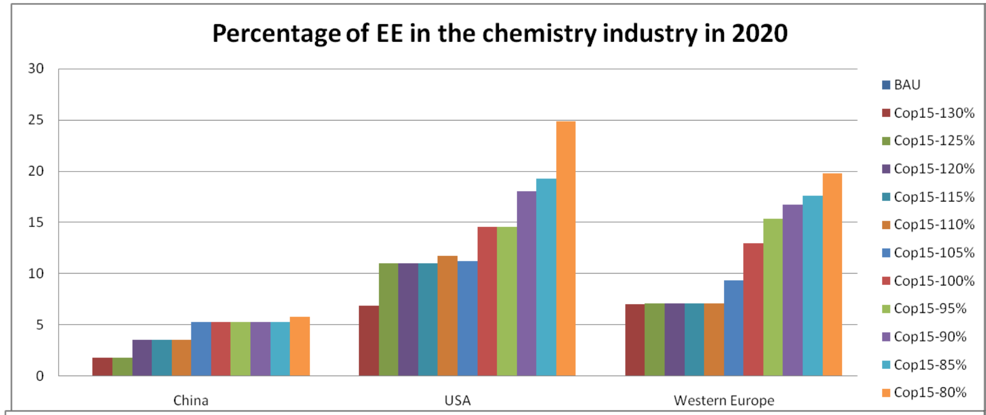


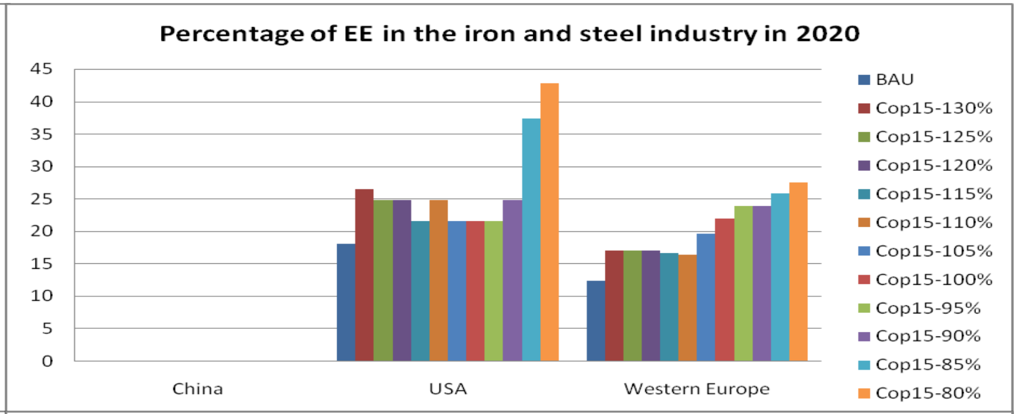
Climate scenarios for 2020

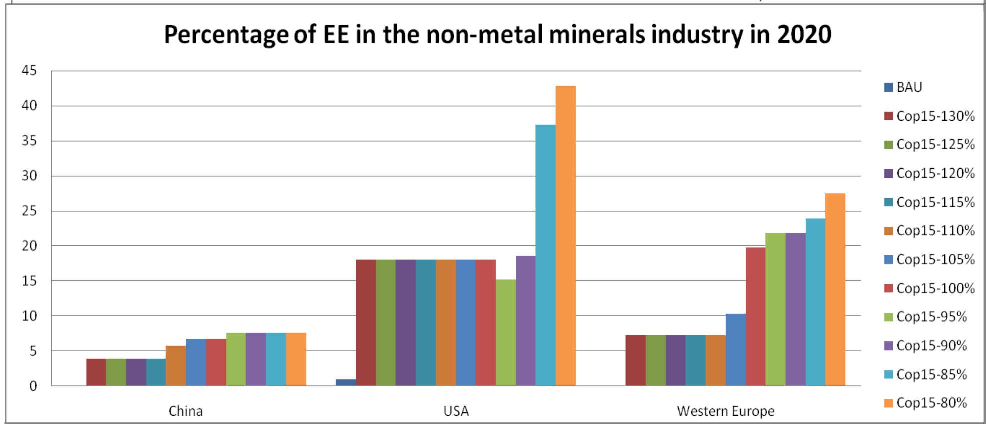
	Europe	USA	China
Business As Usual	No constraint		
COP15 – 80%	20% more constrained than COP15		
COP15 – 85%	15% more constrained than COP15		
COP15 – 90%	10% more constrained than COP15		
COP15 – 95%	5% more constrained than COP15		
COP15	20% on emissions (1990)	17% on emissions (2005)	40% on Carbon intensity (2005)
COP15 – 105%	5% less constrained than COP15		
COP15 – 110%	10% less constrained than COP15		
COP15 – 115%	15% less constrained than COP15		
COP15 – 120%	20% less constrained than COP15		
COP15 – 125%	25% less constrained than COP15		
COP15 – 130%	30% less constrained than COP15		

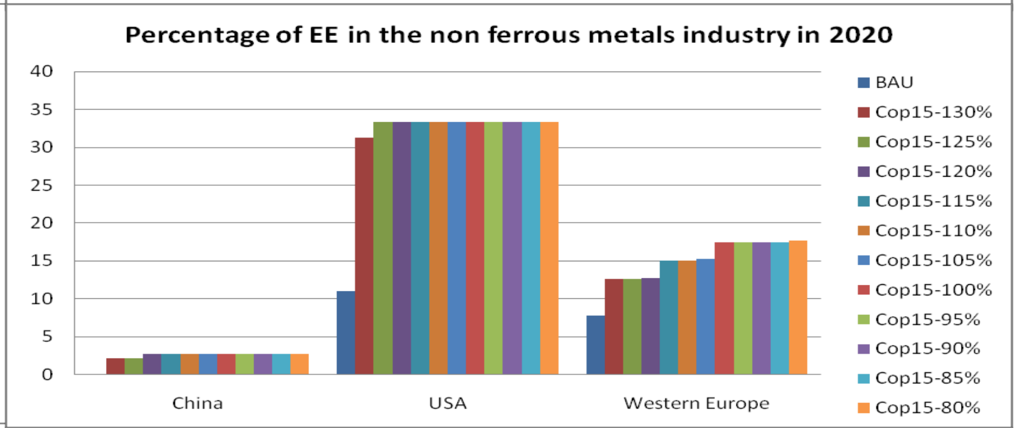
Results

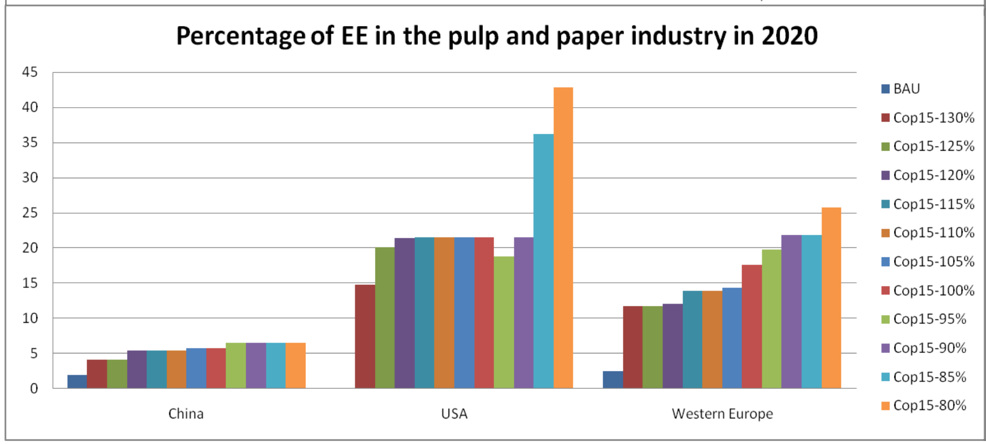
Energy Efficiency implementation in industry

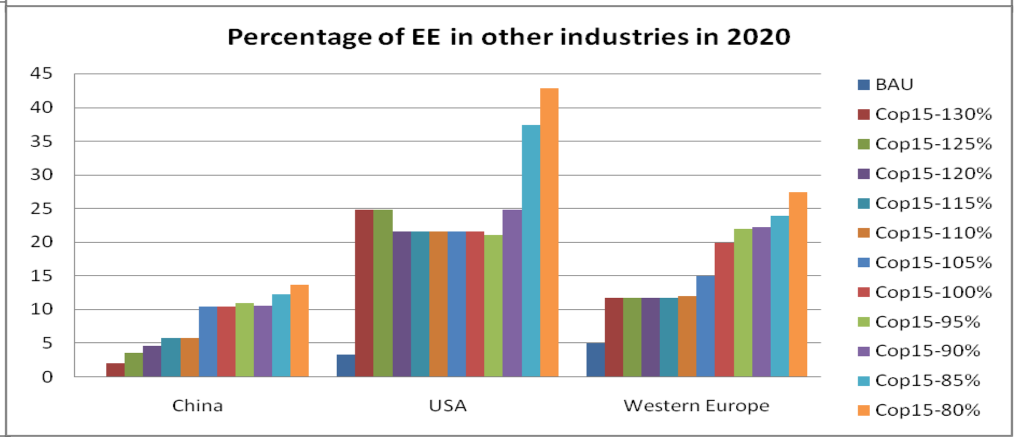




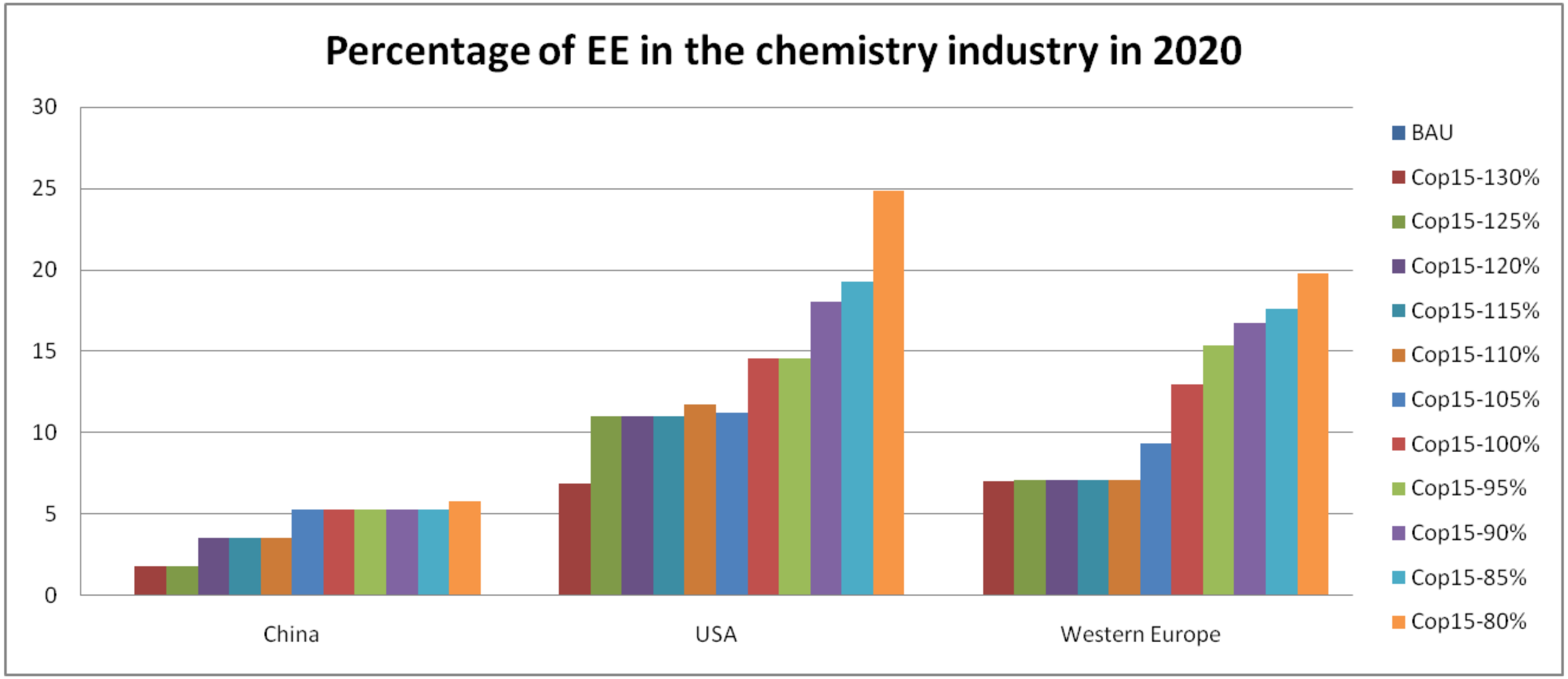








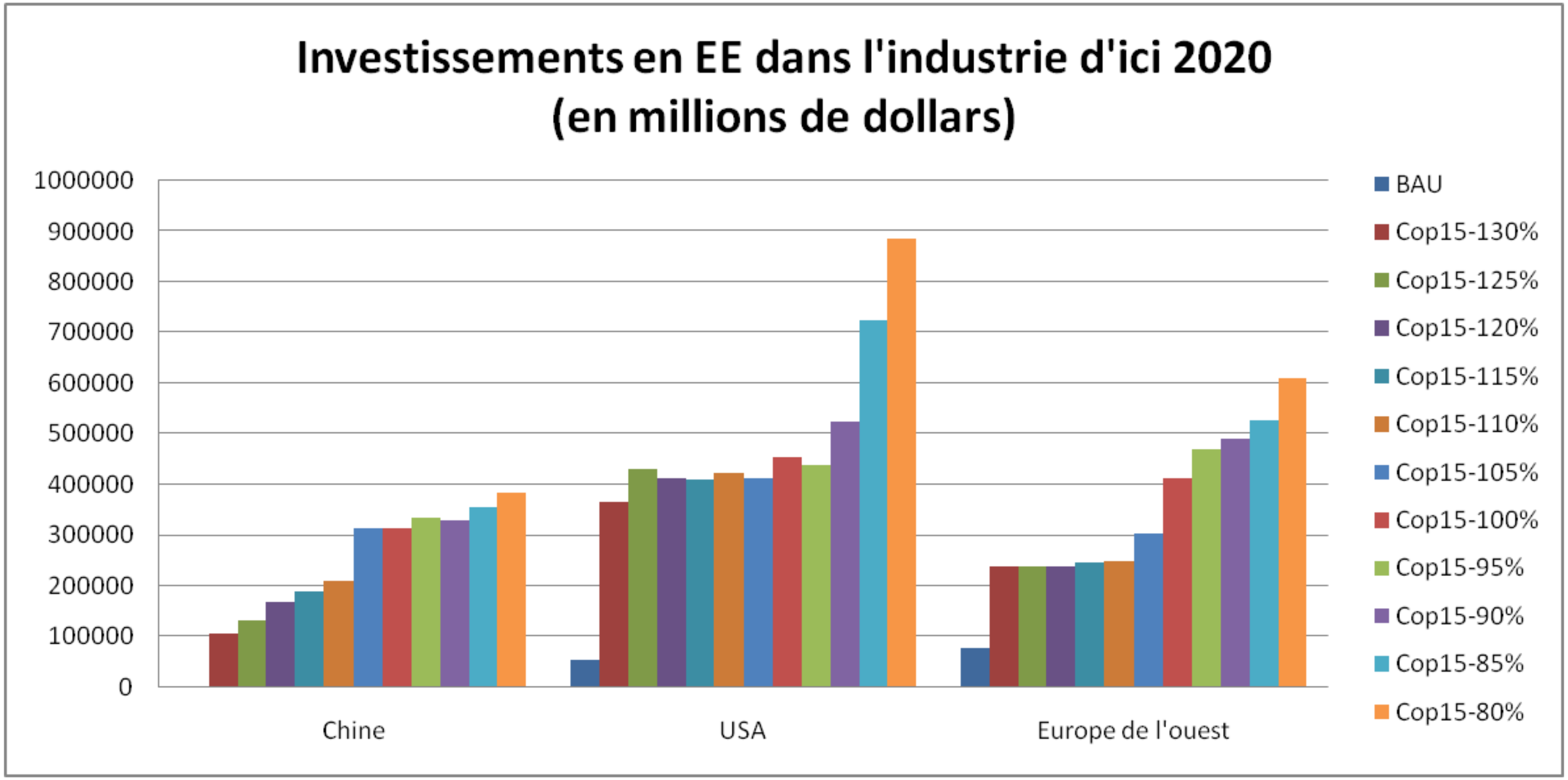
Rate of energy efficiency implemented at the demand side in the industry sector



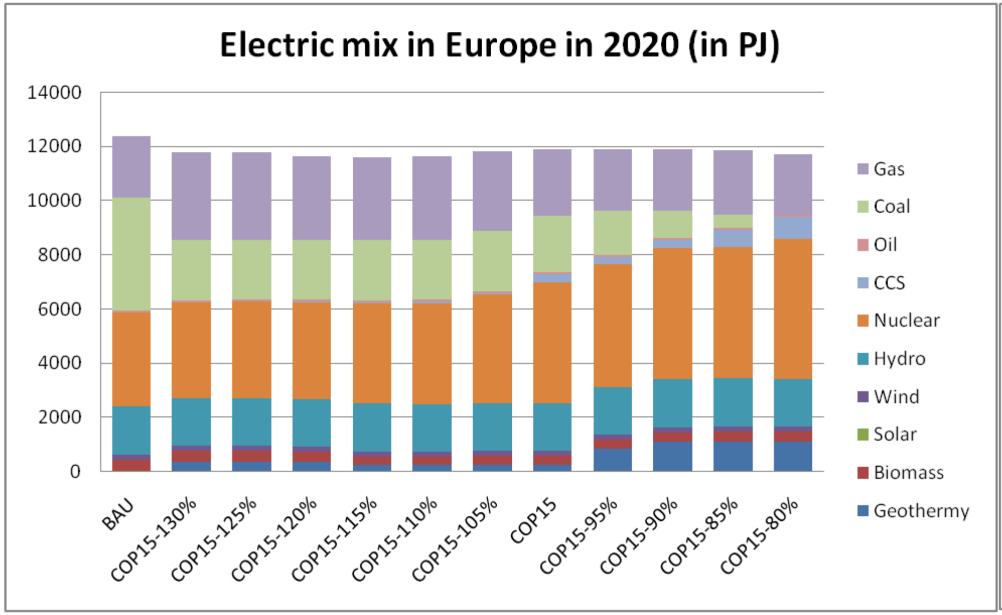
- No implementation for BAU
  - Investments are driven by the climate constraint, not by the economic returns
- The rate grows with the climate constraint
- China has the lower rate of implementation
- Stronger sensitivity for USA and Europe than for China

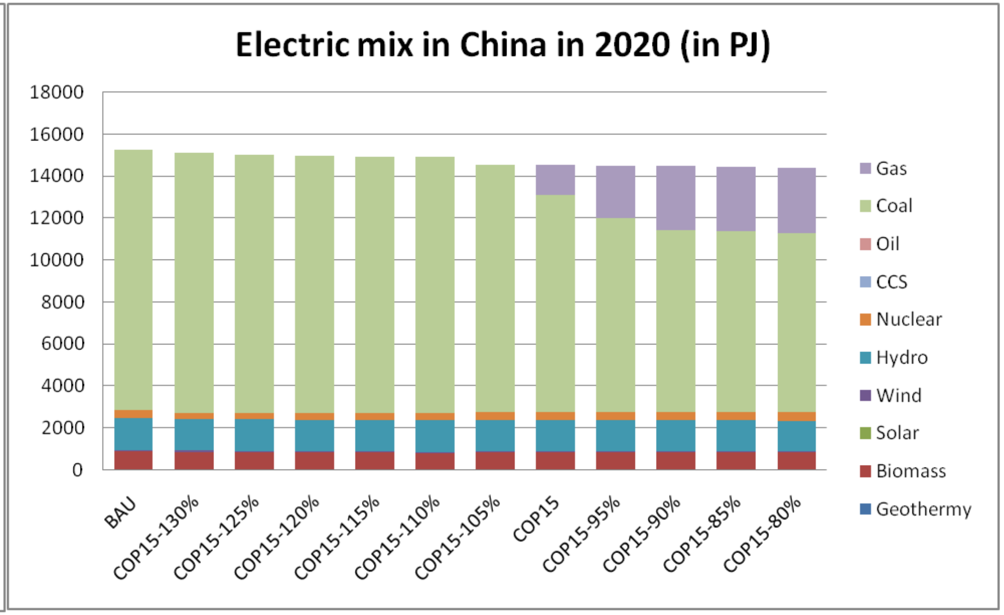
Energy Efficiency market in industry

- No saturation for USA and Europe



Generation Mix sensitivity

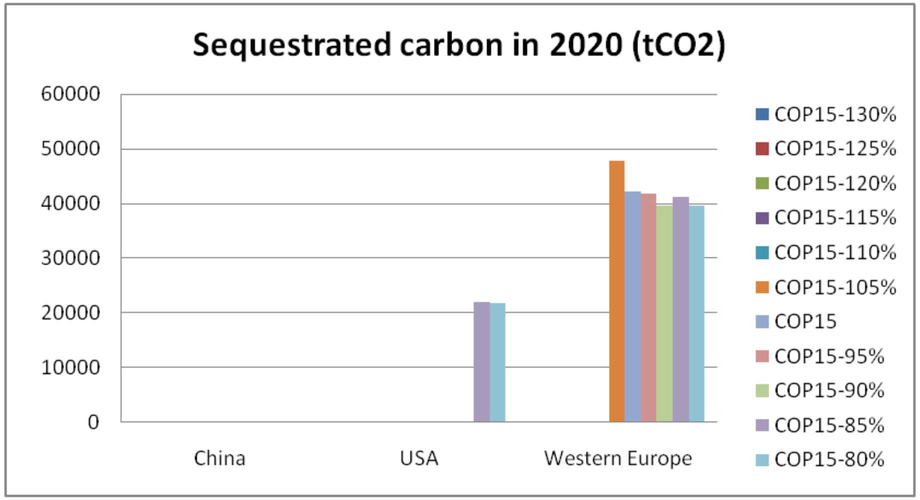




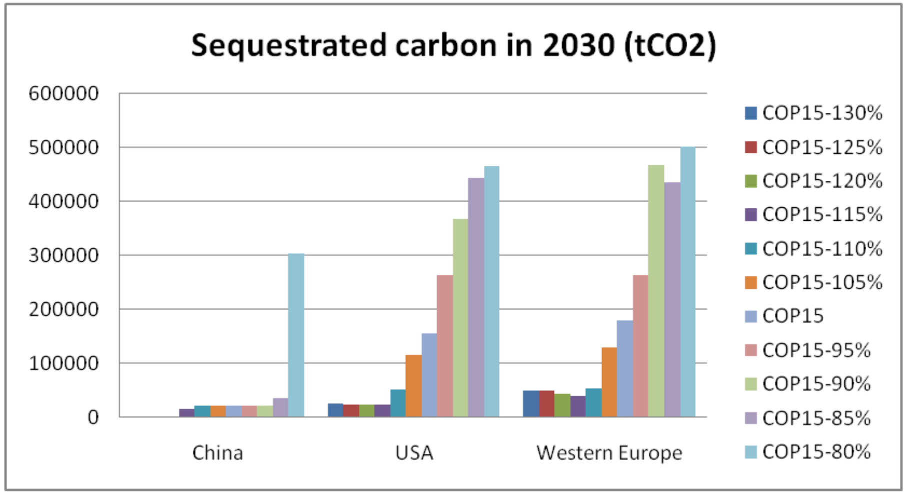
- Low sensitivity to a weaker constraint
- High sensitivity to a stronger constraint
  - Coal substitution by nuclear, gas, geothermy
  - Coal phase-out for Cop15-80% !

- Vanishing sensitivity to a weaker constraint
  - BAU til COP15-105% !
- High sensitivity to a stronger constraint
  - Replacement of coal by gas

Competition with CCS



- Low level of CCS in 2020
- Only driven by EE potential saturation in Europe



- CCS is a long-term solution

Conclusion

- No implementation of EE technologies for BAU
  - Investments are driven by the climate constraint, not by the economic returns
- The rate grows with the climate constraint
  - China has the lower rate of implementation due to clean generation competition
  - Stronger EE-sensitivity for USA and Europe than for China to climate pledges
- CCS appears as a marker of EE saturation

Remark: The study was done with no nuclear limitation (no post Fukushima policy)

A tight equation towards sustainability

- Demography:
  - Rise of energy systems in developing countries
  - Refurbishment of existing capabilities in developed countries
  - Urban population, from 50% today to 80% in 2100, claims for high density power networks
- *The Earth*: An isolated chemical system
  - Fossil (and fissil) fuels depletion:
    - Peak oil around 2020
    - Peak gas around 2030 (excluding shale gas)
    - Around two centuries for coal or Uranium
  - Climate change:
    - Whole electrical generation provides 45% **of CO_2 emissions**
    - **Global efficiency** of the whole electrical system is just 27% (37% for all fuels)
    - Despite a thermodynamic trend toward reversibility
- *The Earth*: A fully open energy system
  - Domestic energy is 10.000 times smaller than natural energy flows:
    Solar direct, wind, geothermy, waves and swell
  - But very diluted and intermittent