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

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The energy dilemma is here to stay

The facts

× 2

Energy demand
By 2050
Electricity up 80% by 2035

Source: IEA 2010

The need

÷ 2

CO₂ emissions to avoid dramatic climate changes by 2050

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

Life span of capital investments

- Residential water heating equipment
- Residential space heating and cooling equipment
- Cars
- Trucks, buses, trucks trailers, tractors
- Commercial heating and cooling equipment
- Manufacturing equipment
- Electric transmissions and distributions, telecom, pipelines
- Power stations
- Building stock (residential and commercial)
- Pattern of transport links and urban developments

USD 16 trillion
Rents embodied in fossil fuel reserves
USD 6.7 trillion
Sunk capital

World GDP

Source: OECD (Forthcoming) Green Growth Studies: Energy; World Bank.
Abatement strategies and competitions

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

→ Usually defined as input (to reach…)

- **CO₂-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
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

Energy flows
Investments
Emissions

Energy efficiency modeling
Global Reference Energy System: Industry-sector disaggregation
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

\[
\eta_1, \eta_2, \ldots, \eta_{20}, \text{cost}_1, \text{cost}_2, \ldots, \text{cost}_3
\]
## Climate scenarios for 2020

<table>
<thead>
<tr>
<th>Business As Usual</th>
<th>Europe</th>
<th>USA</th>
<th>China</th>
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<tbody>
<tr>
<td>COP15 – 80%</td>
<td>20% more constrained than COP15</td>
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<tr>
<td>COP15 – 85%</td>
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<td>COP15 – 90%</td>
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<td>COP15 – 95%</td>
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<td>COP15 – 130%</td>
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</table>
Results
Energy Efficiency implementation in industry

Percentage of EE in the chemistry industry in 2020

Percentage of EE in the iron and steel industry in 2020

Percentage of EE in the non-metal minerals industry in 2020

Percentage of EE in the non ferrous metals industry in 2020

Percentage of EE in the pulp and paper industry in 2020

Percentage of EE in other industries in 2020
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

**Investissements en EE dans l'industrie d'ici 2020**
(en millions de dollars)
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 CO₂ 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