Sectoral trading, a next step in the international agreements on climate change?  
Analysis of Sectoral Trading Proposition with EPPA
In the IEA reference scenario, non-OECD countries emissions in 2030 represent nearly 70% of the world emissions and in these countries, emissions from power generation represents nearly 50% of the national emissions.

## World CO₂ emissions in 2030 in the IEA reference scenario / EPPA No-policy scenario

<table>
<thead>
<tr>
<th></th>
<th>Total CO₂ emissions (Mt)</th>
<th>of which power generation (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>40.2</td>
<td>17.8</td>
</tr>
<tr>
<td>- OECD countries</td>
<td>12.4</td>
<td>5.0</td>
</tr>
<tr>
<td>- Non-OECD countries</td>
<td>26.4</td>
<td>12.8</td>
</tr>
<tr>
<td>- China</td>
<td>11.6</td>
<td>6.4</td>
</tr>
<tr>
<td>- India</td>
<td>3.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

*International marine and aviation bunkers are reported at the world level*

*Source: World Energy Outlook 2009*
Context

World CO₂ emissions

Chinese CO₂ emissions by sector

Indian CO₂ emissions by sector

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Sectoral Trading : What is it ? Why has it been proposed?

Example of sectoral trading between the Chinese electricity sector and a carbon market in some developed countries

- To avoid carbon lock-in and spur early investment in low-carbon technologies
- To make developing countries participate into a global agreement even if they do not make nation-wide commitments
- To move from a project-based mechanism (CDM) to a sector-based mechanism
- A way to link carbon markets ?

Proposed and discussed by the Europe Union, International Energy Agency, Öko-Institut, Center for Clean Air Policy, International Chamber of Commerce...

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Our Work: CGE analysis of Sectoral Trading

• Impact on the emissions of each country involved?

• Impact on the carbon price?

• Impact on the energy sector of the countries involved?

• Impact on the rest of their economy?

• Financial Transfers induced? Welfare changes?
Method: EPPA Model

**MIT Emissions Prediction and Policy Analysis (EPPA) Model**

- **Primary Factors**
  - Income
  - Expenditures

- **Goods & Services**
  - Consumer Sectors
  - Producer Sectors

- **Regions**
  - Region A
  - Region B
  - Region C

**Model Features**
- All greenhouse-relevant gases
- Flexible regions
- Flexible producer sectors
- Energy sector detail
- Welfare costs of policies

**Mitigation Policies**
- Emissions limits
- Carbon taxes
- Energy taxes
- Tradeable permits
- Technology regulation

---

**Regions in EPPA 5**
- United States (USA)
- Canada (CAN)
- Japan (JPN)
- Australia-New Zealand (ANZ)
- Europe (EUR)
- Mexico (MEX)
- Europe and Central Asia (ROE)
- Russia (RUS)
- East Asia (ASI)
- China (CHN)
- India (IND)
- Brazil (BRA)
- Africa (AFR)
- Middle East (MES)
- Rest of Latin America (LAM)
- Rest of Asia (REA)

**Sectors in EPPA 5**
- Agriculture – crops (CROP)
- Agriculture – livestock (LIVE)
- Agriculture – forestry (FORS)
- Food product (FOOD)
- Energy-intensive Industries (EINT)
- Transport (TRAN)
- Services (SERV)
- Other Industries (OTHR)
- Coal (COAL)
- Crude Oil (OIL)
- Refined Oil (ROIL)
- Gas (GAS)
- Electricity (ELEC)

**Electricity Generation**
- Coal
- Gas
- Refined Oil
- Hydro
- Nuclear
- Wind and Solar
- Biomass
- NGCC
- NGCC-CCS
- IGCC-CCS

---

*Figure 2.* The circular flow of goods and resources in EPPA.
Method: Model Extension on EPPA 5

Emissions permits in EPPA:

- International permits → International carbon price
- National permits → National carbon price
- National, sectoral permits → Sectoral carbon price

Model extension that was required:

Programming to allow trade between international or national carbon price and a sectoral carbon price

Scenarios on CO₂ only, in the time frame 2010-2030
Main results from our CGE analysis

Sectoral trading

- in the developing countries involved:
  - reduces the total amount of electricity generated
  - reduces the use of coal and increases fossil generation efficiency
  - does not justify low carbon technologies on an economic basis
  - induces some internal leakage

- in the developed countries involved:
  - lowers carbon price
  - cancels part of the electricity generation changes observed without sectoral trading

- induces substantial financial transfers between the countries, but benefits more the developed countries than the developing countries involved
Two case studies

- Sectoral trading between a U.S. cap and trade system and Chinese Electricity sector
  - Chinese Energy/Climate Policy
  - Scenarios used
  - Results
- Sectoral trading between the EU-ETS and the electricity sector of 4 emerging economies: China, India, Brazil and Mexico
  - European Union targets
  - Scenarios used
  - Main results
Two case studies

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  - Main results
Chinese Energy Policy

- 40-45% reduction in carbon intensity for 2005-2020
- 15% of non-fossil fuels in primary energy consumption in 2020
  (non fossil includes hydro, nuclear, solar, wind, biomass, etc)
- Increase forest coverage by 40Mha by 2020

- 70GW of nuclear by 2020 contracted, maybe 18 GW more
  (depending on capacity factor, 70GW is approximately 2 EJ of electricity);
- For 2015, 40GW of nuclear is expected; 400-500GW of nuclear by 2050;

Other targets:
- 100GW of wind by 2020 (currently 25GW in 2009);
- Feed-in tariffs for biomass and wind power;
- Increase gas : up to 10% of total energy use by 2020 (now 4%?);
- Requirement for large power firms are required to have more than 3% of their installed capacity from renewables excluding hydropower by 2010, and 8% by 2020;
- Rebates for electric cars and small cars.
### Scenarios Used

<table>
<thead>
<tr>
<th>Scenarios Used</th>
<th>Cap on US emissions</th>
<th>Cap on Chinese electricity emissions</th>
<th>Sectoral trading</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Policy</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>US-CAP</td>
<td>30% reduction below 2005 levels by 2030</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TRADE</td>
<td>30% reduction below 2005 levels by 2030</td>
<td>BAU emissions</td>
<td>Sectoral trading</td>
</tr>
<tr>
<td>Alternative constraints</td>
<td>30% reduction below 2005 levels by 2030</td>
<td>More stringent constraints</td>
<td>Sectoral trading</td>
</tr>
</tbody>
</table>
Emissions and Carbon Price

U.S. Emissions

Chinese Electricity Sector Emissions

Carbon Price

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Electricity Generation in China

7% increase in the efficiency of fossil electricity
Electricity Generation in the U.S.

No Policy

US-CAP Scenario

TRADE Scenario

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Rest of the Chinese economy

Increased emissions in all the other sectors of the Chinese economy, except in transport and refined oil sectors.

- Electricity price increases (+29% in 2030) → Output decreases in all sectors (-2% in energy intensive industries, -1% in transport)
- Coal price decreases (-15% in 2030) → Increased use of coal by all sectors except transport and refined oil

→ increased emissions in all sectors except transport and refined oil

In aggregate, internal leakage towards the rest of the Chinese economy:
0.38 Gt CO$_2$ in 2030
= 19% of the reductions in Chinese emissions from electricity
Or 12% of the reduction imposed by the US cap.
Welfare and Financial Transfers

Value of permits traded: $16 billions in 2020, $42 billions in 2030
total exports from the US to China in 2009: $69 billions
trade deficit between the China and the US in 2009: $227 billions

Welfare change in China: - 0.1% in 2030, compared to the US-CAP scenario

Welfare change in the U.S.: + 0.6% in 2030, compared to the US-CAP scenario

→ Further analysis when a more stringent constraint is imposed on Chinese electricity emissions
Alternative Constraints on Chinese Electricity Emissions

**Carbon Price**

**Financial Transfers from the U.S. to China**

**Welfare Change relative to the No Policy Scenario**

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Conclusions for the U.S.-China case study

In China
- Reduces the total amount of electricity generated in China by 4.4 EJ (12%) in 2030, compared to the US-CAP scenario
- Electricity from coal decreases by 6.9 EJ (30%),
- Electricity price increases by 29% in 2030, coal price decreases by 15% in 2030
- Fossil electricity efficiency increases by 7%
- Limited impact on the low carbon technologies in Chinese electricity sector
- Internal leakages due to this sectoral regime: 0.38 bmt CO2 in 2030 (=12% of the reduction imposed in the US)

In the US
- It lowers the carbon price from $105 to $21/t CO2.
- Less changes in the electricity generation

Substantial financial transfers:
- $16 billions in 2020, $42 billions in 2030 if there is no constraint on Chinese electricity sector.
- But welfare is improved in the U.S. and not really in China.

Note: The model allows to analyze the economic response of the Chinese economy to the proposition of sectoral trading, but China can support some technologies with other policies
Two case studies

- Sectoral trading between a U.S. cap and trade system and Chinese Electricity sector
  - Chinese Energy/Climate Policy
  - Scenarios used
  - Results

- Sectoral trading between the EU-ETS and the electricity sector of 4 emerging economies: China, India, Brazil and Mexico
  - European Union targets
  - Scenarios used
  - Main results
European Union climate policy

EU-ETS since 2005

European targets:
- 20% reduction of their emissions by 2020 below 1990 levels
- 20% of EU electricity generation to come from renewable energies
- 20% reduction in primary energy use, through energy efficiency improvement

Strong shares of fossil fuels in the electricity generation of developing countries: coal in China and India, coal, oil and gas in Mexico

Sectoral trading seen as a way to extend the EU carbon market to emerging countries.
### Scenarios Used

<table>
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<tr>
<th>Scenario</th>
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<th>Sectoral trading with</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Policy</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>EU-ETS</td>
<td>30% reduction by 2020, 44% reduction by 2030, below 1990 levels</td>
<td>No</td>
</tr>
<tr>
<td>EU-ETS-CHN</td>
<td>As above</td>
<td>Chinese electricity sector, Trading baseline : BAU</td>
</tr>
<tr>
<td>EU-ETS-MEX</td>
<td>As above</td>
<td>Mexican electricity sector, Trading baseline : BAU</td>
</tr>
<tr>
<td>EU-ETS-ALL4</td>
<td>As above</td>
<td>Chinese, Mexican, Brazil and India electricity sectors, Trading baseline : BAU</td>
</tr>
</tbody>
</table>

**Assumption**: no carbon policy in China or India, no banking behavior in EU

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22
Emerging Countries Emissions

Chinese Electricity Emissions

Indian Electricity Emissions

Brazilian Electricity Emissions

Mexican Electricity Emissions

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Electricity Generation in China

**No Policy**

**Sectoral Trading between the EU-ETS and China**

**Sectoral Trading with the Four Countries**

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Electricity Generation in Mexico

No Policy

Sectoral Trading between the EU-ETS and Mexico

Sectoral Trading with the Four Countries

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Electricity Generation in the European Union

No Policy

EU-ETS

Sectoral Trading between the EU-ETS and China

Sectoral Trading between the EU-ETS and Mexico

Friday Lunch Meeting, July 2011
Electricity Generation in the European Union

No Policy

EU-ETS

Sectoral Trading with the Four Countries

Friday Lunch Meeting, July 2011
## Carbon Price and Financial Transfers

**With China**

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon price</td>
<td>$ / t CO₂</td>
<td>1.9</td>
</tr>
<tr>
<td>Permits transfers</td>
<td>Mt CO₂</td>
<td>206</td>
</tr>
<tr>
<td>Financial transfers</td>
<td>$ millions</td>
<td>401</td>
</tr>
</tbody>
</table>

**With Mexico**

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon price</td>
<td>$ / t CO₂</td>
<td>11.7</td>
</tr>
<tr>
<td>Permits transfers</td>
<td>Mt CO₂</td>
<td>8</td>
</tr>
<tr>
<td>Financial transfers</td>
<td>$ millions</td>
<td>101</td>
</tr>
</tbody>
</table>

**Sectoral trading between the EU-ETS and the electricity sector of one country only**

**Sectoral trading between the EU-ETS and the electricity sector of the four countries**

European trade deficit with China in 2009 : 133 billions €, trade surplus with Mexico in 2009 : 6 billions €, trade surplus with India : 2 billions €, trade deficit with Brazil : 4 billions €
Conclusion for the EU case study

In the EU-ETS
- Lowers the carbon price to less than $10/t CO2 if trading with China or India (under our assumptions),
If such a mechanism were used, would there be conditions for the use of it or a limit to the number of credits that the European Union could buy?
- Changes in the European electricity sector due to the EU-ETS are canceled

In developing countries
- Impacts are much smaller than with the US, due to the smaller size of the EU-ETS
  - Little impact on Chinese electricity generation: 1 EJ (3%) decrease in the total amount of electricity generated.
  - Some impact on Mexican electricity generation if China is not involved: 0.08 EJ (9%) decrease in the total amount of electricity generated in 2030.
- Very limited impact on low carbon technologies

Financial transfers are strongly dependent on the nature and the size of the countries involved
## Conclusion

<table>
<thead>
<tr>
<th></th>
<th>Carbon Price</th>
<th>Volume of Permits</th>
<th>Financial Transfers</th>
<th>Trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/t CO2</td>
<td>Mt CO2</td>
<td>2005 $ billions</td>
<td>billions</td>
</tr>
<tr>
<td></td>
<td>2020 2030</td>
<td>2020 2030</td>
<td>2020 2030</td>
<td></td>
</tr>
<tr>
<td>US-China</td>
<td>13.6 21.4</td>
<td>1172 1940</td>
<td>16 42</td>
<td>- $ 227</td>
</tr>
<tr>
<td>EU-ETS-China</td>
<td>1.9 3.7</td>
<td>206 413</td>
<td>0.40 1.5</td>
<td>- 133 €</td>
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<tr>
<td>EU-ETS-Mexico</td>
<td>11.7 29.4</td>
<td>8 19</td>
<td>0.10 0.6</td>
<td>+6 €</td>
</tr>
<tr>
<td>EU-4 countries</td>
<td>1.5 2.7</td>
<td>221 451</td>
<td>0.32 1.2</td>
<td>- 129 €</td>
</tr>
</tbody>
</table>
Conclusion

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Some References

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