



# Burden Sharing: Estimating Global Demand and Supply Flows of Carbon Emission Reductions for 2020 and 2050

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Iva HRISTOVA

CGEMP

(Centre de Géopolitique de l'Énergie et  
des Matières Premières)

Université Paris- Dauphine

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# Introduction: Kyoto and the Burden Sharing

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- Adopted on 11 **December 1997**
- Fixed obligation reductions for **six greenhouse gases** (CO<sub>2</sub>, methane, nitrous oxide, hydro-fluorocarbons, per-fluorocarbons and sulphur hexafluoride)  
=> on average by 5.2 % below the 1990 levels during the first “commitment period” from 2008 to 2012.
- **Burden sharing: Differentiating between industrialized and developing countries (Annex 1 and non-Annex 1 countries),**  
=> no emission targets for the latter.
- **3 market-based “flexible mechanisms”:**  
Emissions trading  
Joint Implementations  
Clean Development Mechanism

# Introduction: Burden Sharing and CDM

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- **Clean Development Mechanism**

=> a lower-cost solution for developed countries to reduce their GHG emissions

=> positive spill-over effects for supplier countries (developing countries)

- ✓ monetary transfers
- ✓ technology transfers
- ✓ organisation/management skills and know-how
- ✓ energy efficiency improvements

=> **help foster a more important commitment of developing countries and a fairer burden sharing**

# CDM: major trends for 2009 (1)

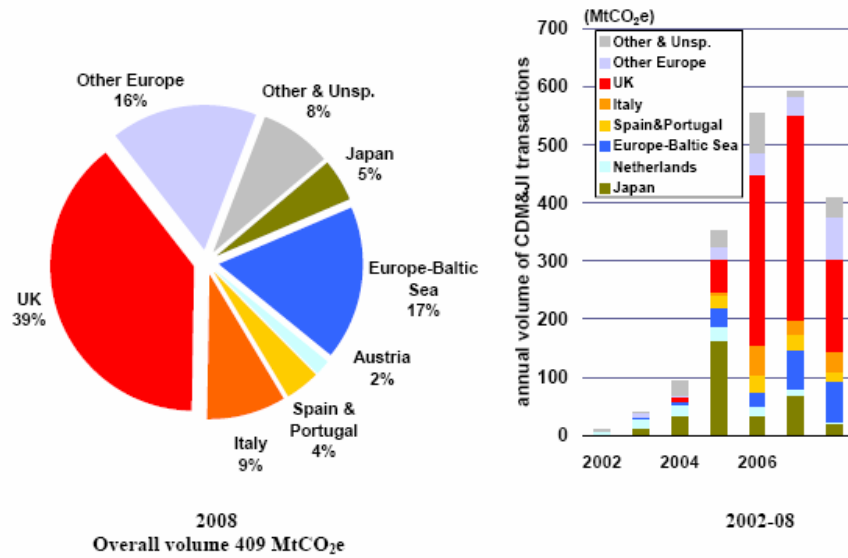
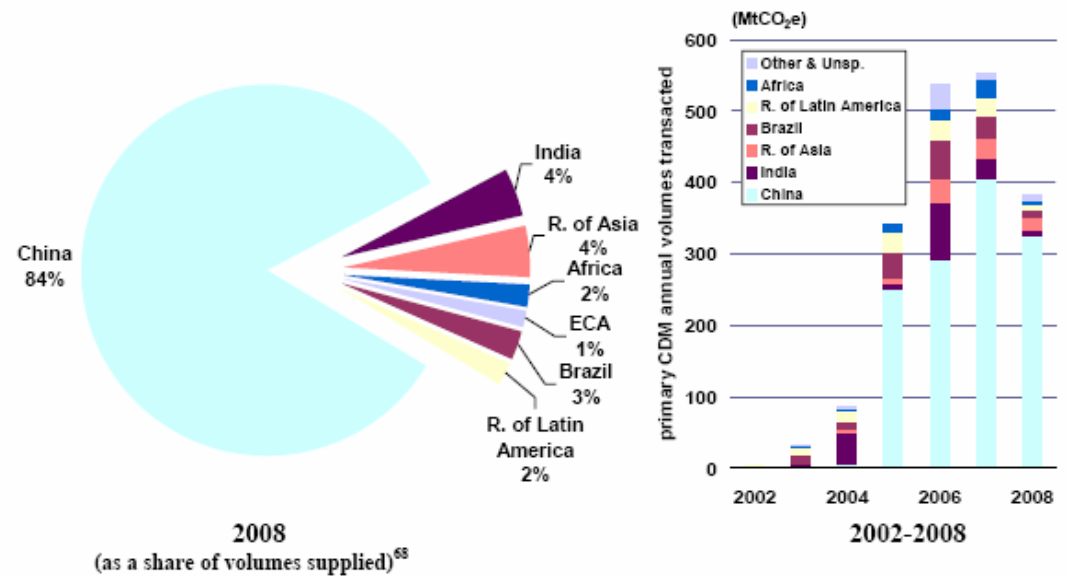


Figure 1: Primary CDM&JI Buyers (as shares of volumes purchased, vintages up to 2012)

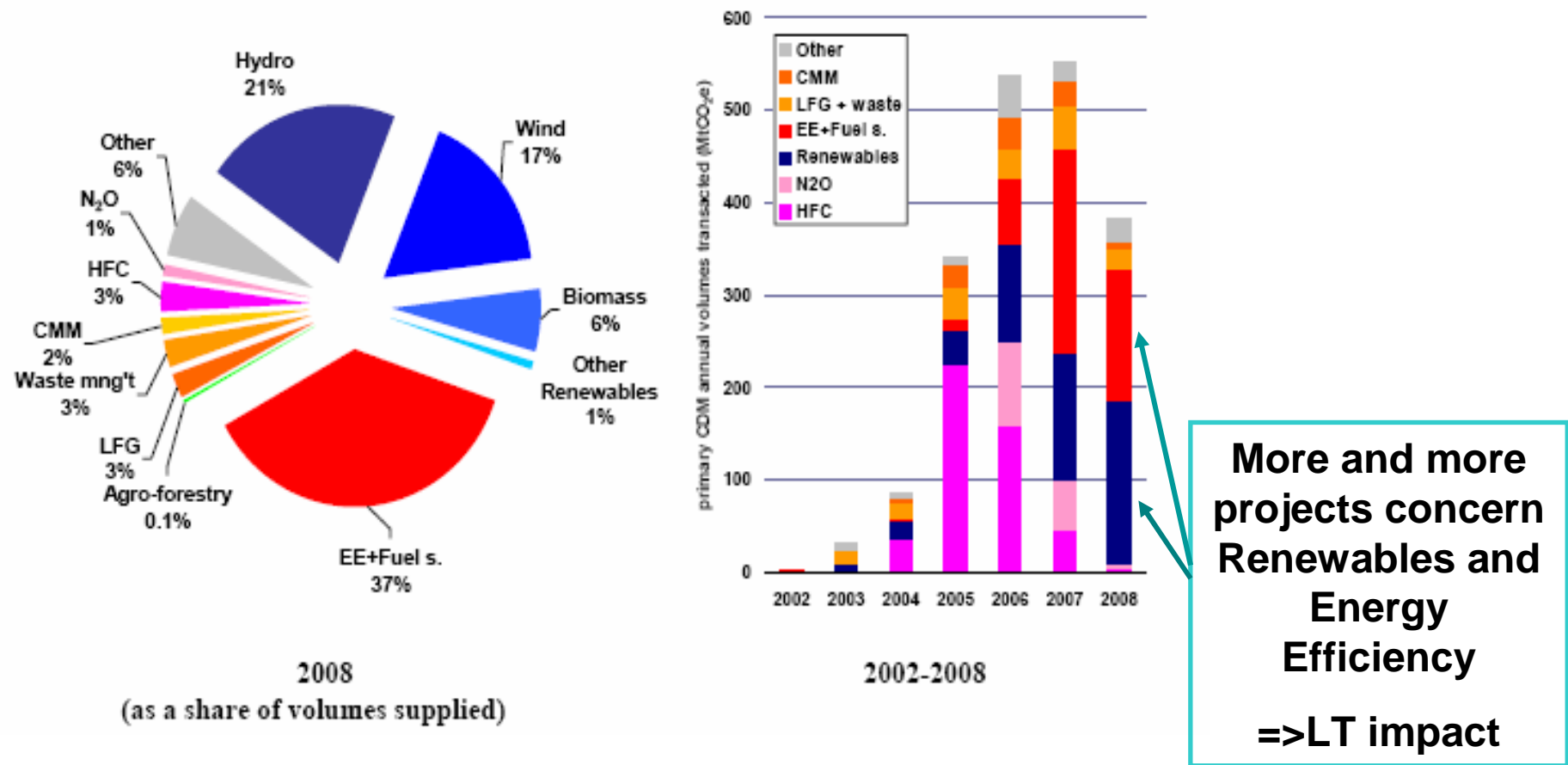
Figure 2: Location of CDM Projects



Source: WB Carbon Markets State and Trends, Capoor and Ambrosi (2009)

# CDM: major trends for 2009 (2)

Figure 3: CDM Project Types



Source: WB Carbon Markets State and Trends, Capoor and Ambrosi (2009)

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# Burden Sharing and the Post- Kyoto

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# Aim and Plan of the presentation

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**Define the burden sharing between developing and developed countries at a horizon of 2020 and 2050**

⇒ **Define the flows of demand and supply of Carbon Emission Reductions by country/region**

⇒ **Plan**

- Literature review
- The model
- Results
- Comparison with the literature
- Conclusions

# Literature Review: Models

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- **POLES** (Criqui, Cattier, Menanteau, and Quido, 1996; Criqui et Mima, 2009)
- **CERT** (Haites; 2004)
- **DART** (Klepper et Peterson; 2004)
- **FEEM-RICE** (Buchner et Carraro, 2005)
- **EPPA** (Ellerman et Decaux, 1998; Jacoby et alii; 2008)
- **Gherzi** (2001) uses also MACCs in an *ad-hoc* approach, but not based on CGE model  
=> not discussed in this paper

# The model: Burden sharing scenarios

- **Scenario I: Annex I countries leading role scenario**  
all financial effort supported by them

$$P^* = a_1 Q_1^2 + b_1 Q_1 = a_2 Q_2^2 + b_2 Q_2 = \dots = a_n Q_n^2 + b_n Q_n$$

$$P^* = P_1 = P_2 = \dots P_n$$

$$s.t. \sum_{i=1}^n Q_i \geq BAU \text{ Total Emissions } 2020 - (\text{admitted } 2020 / 2050 \text{ benchmark}$$

*emission level for 450/500/550ppm)*

- **Scenario II: Per capita equalization scenario**

$$Q_{BAU_1} - Q_1 / Pop_1 = Q_{BAU_2} - Q_2 / Pop_2 = \dots = Q_{BAU_n} - Q_n / Pop_n$$

$$s.t. \sum_{i=1}^n Q_i \geq BAU \text{ Total Emissions } 2020 - (\text{admitted } 2020 / 2050 \text{ benchmark}$$

*emission level for 450 / 500 / 550 ppm )*

**$P$**  - shadow price of the abatement of 1t CO<sub>2</sub>e

**$Q_i$** - emission reduction of a given country  $i$  in Mmt CO<sub>2</sub>e

**$a, b$**  - technology coefficients

# The model: General assumptions

- **Countries:** United States, Canada, Japan, European Union, Australia & New Zealand, Former Soviet Union, Eastern Europe, India, China, Indonesia, Higher Income East Asia, Mexico, Central & South America, Middle East, Africa and Rest of World
- **Sectors:** Agriculture, Services, Energy-Intensive Products, Other Industries Products, Transportation, Household Transportation, Other HH Consumption,
- **Technologies: Electricity Generation** - Fossil, Hydro, Nuclear, Solar and Wind, Biomass, Coal with CCS, Adv. gas without CCS, Gas with CCS
- **Gases:** estimations in CO<sub>2</sub>e as included - carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, sulphur dioxide, nitrogen oxides, black carbon, organic carbon, ammonia, carbon monoxide and non-methane volatile organic compounds
- **BAU emissions at 2020, 2050:** issued from EPPA 4's projections
- **Global market for Carbon Emission Reductions**  
**=> Unconstrained flows and a global market price**
- **Population projections issued from World Bank (2009)**

# The model: Assumptions on Global reductions constraint for 2020

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- **450 ppm**

CO<sub>2</sub>e, 12.5% of average reduction of Annex I emissions compared to their emissions in 1990 (IPCC recommendations are 25- 40%)

- **500 ppm**

CO<sub>2</sub>e, 20% of average reduction of Annex I emissions compared to their emissions in 1990 (IPCC recommendations are 10-30%)

- **550 ppm**

CO<sub>2</sub>e, 32,5% of average reduction of Annex I emissions compared to their emissions in 1990 (IPCC recommendations are 0-25%)

# The model: Assumptions on Global reductions constraint for 2050

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- **450 ppm**

CO<sub>2</sub>e, 70% of reductions by 2050 compared to global emissions in 2005 (Stern Review: The Economics of Climate Change (2006))

- **500 ppm**

CO<sub>2</sub>e, 50% of reductions by 2050 compared to global emissions in 2005 (Stern Review: The Economics of Climate Change (2006))

- **550 ppm**

CO<sub>2</sub>e, 25% of reductions by 2050 compared to global emissions in 2005 (Stern Review: The Economics of Climate Change (2006))

# Results and Comparison with the literature (1)

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- POLES, Criqui and Mima, (2009)

## Scenarios:

- ✓ “Muddling Through”: no world coordination on abatement actions
  - ✓ “Europe Alone” : EU- leading role;  
ROW- “muddling through”
  - ✓ “Global Regime” all the world regions participating
- ⇒ stabilization profile below 450 ppm CO<sub>2</sub>
- ~ 500 ppm CO<sub>2</sub>e by 2050
  - ~ global reduction of 50% of 2000 CO<sub>2</sub> emissions in 2050
- ⇒ 2 possibilities for burden sharing
- major implication Annex I countries (80% of global reductions); non-Annex I countries the residual part
  - global trading system or a world carbon tax

**Aim of the article:** define the impact of those economic policies on EU's energy consumption profile and fossil fuel dependence

# Results and Comparison with the literature (2)

- **EPPA 4, Jacoby et alii, ( 2008)**

**Scenarios:**

- ✓ **Allocation Rule**

- “**30-70**” (non- Annex I and Annex I countries repartition)

- “**Pop based**” (allocations based on countries` population, as a share of world total population in 2000)

- “**GDP based**” (allocations based on inverse share of year 2000 GDP per capita)

- ✓ **Full compensation for developing countries’** (all costs associated with emissions mitigation)

- “ **Full comp-equal alloc**” (an equal repartition in accordance with the year 2000 emissions)

- “**Full comp-equal cost**” (or as equal percentage costs)

- ✓ **Partial Participation of Developing Countries**

- “**3 % cost cap**” (compensation so that no developing country region’s welfare costs exceeds 3%)

- “**Direct mitigation costs**” (compensation for direct costs of participation but not for indirect costs (i.e terms of trade effects))

# Results: Carbon prices

CO<sub>2</sub>e Price evolution through the different scenarios (in 2000 US\$/tCO<sub>2</sub>e)

	450ppm	500 ppm (2050/ 2005)	550ppm	500ppm Criqui and Mima (2009) (2050/2000)	500 ppm (2050/ 2000)
Price 2020	<b>91,8</b>	<b>70,21</b>	<b>61,445</b>	-	
Price 2050	<b>160,7</b>	<b>131,7</b>	<b>101,82</b>	<b>380 (295*)</b>	<b>136,7</b>

\* Value in 2000 US\$. The conversion factor used is 1.287

# Results: Burden Sharing 2020

Region	2020					
	450 ppm		500ppm		550ppm	
	Qi Sc I	Qi Sc II	Qi Sc I	Qi Sc II	Qi Sc I	Qi Sc II
USA	4057	7691	3388	7523	3091	7423
CAN	1151	933	850	915	735	904
MEX	1253	535	866	475	734	439
JPN	698	1094	530	1033	463	996
ANZ	299	594	265	580	250	571
EUR	3850	4608	3084	4405	2755	4283
EET	912	1169	788	1123	732	1096
FSU	3313	3671	2785	3534	2549	3451
ASI	1693	1762	1282	1631	1117	1552
CHN	3521	2685	3167	1977	3008	1552
IND	1570	-330	1409	-990	1336	-1385
IDZ	277	41	248	-86	235	-162
AFR	1587	-345	1320	-948	1202	-1310
MES	773	1328	1567	1226	1242	1165
LAM	1947	1328	1622	1002	1478	806
ROW	277	415	248	19	235	-219

Decrease of the reduction effort: red

Rise of the reduction effort: blue

# Results: Burden Sharing 2050

Region	2050					
	450 ppm		500ppm		550ppm	
	Qi Sc I	Qi Sc II	Qi Sc I	Qi Sc II	Qi Sc I	Qi Sc II
USA	9742	12816	8863	12505	7848	12115
CAN	1571	1337	1441	1303	1281	1259
MEX	2548	1109	2327	1003	119	870
JPN	1369	2122	1210	2039	1027	1936
ANZ	667	929	600	902	523	869
EUR	11985	7721	9824	7400	7597	6999
EET	2082	1794	1799	1733	1481	1657
FSU	6561	5823	5461	5629	4293	5387
ASI	1292	3661	2361	3423	3958	3126
CHN	7250	9575	6694	8470	6057	7090
IND	3174	3475	2906	2209	2597	626
IDZ	239	476	221	251	202	-30
AFR	4483	3642	4019	2122	3485	223
MES	830	1612	746	1380	650	1089
LAM	5888	3830	4362	3220	3130	2456
ROW	3330	3094	2990	2239	2598	1170

Decrease of the reduction effort: red

Rise of the reduction effort: blue

# Results: Burden Sharing 2020

## Comparison with the literature

Region	Partial comp in Mmt CO2e			full comp in 2000 US\$billion	
	2020			2020	
	450 ppm	500ppm	550ppm	equal alloc	equal cost
USA	-3633,47	-4135,48	-4332,08	-196,7	-264,5
CAN	217,78	-64,38	-169,19	-20,0	4,5
MEX	718,02	391,38	295,02	16,4	14,6
JPN	-395,97	-502,59	-533,32	-44,8	-118,9
ANZ	-294,60	-314,63	-321,52	-18,5	-8,8
EUR	-757,71	-1320,69	-1527,89	-116,9	-86,3
EET	-257,02	-335,70	-364,16	-9,9	3,2
FSU	-358,36	-749,24	-901,99	-26,7	44,6
ASI	-68,77	-348,78	-434,53	-13,8	-14,9
CHN	836,05	1189,92	1456,32	73,9	74,4
IND	1899,62	2398,24	2721,98	51,8	52,3
IDZ	236,29	334,09	397,14	8,0	8,2
AFR	1932,61	2268,35	2511,81	81,2	79,3
MES	-555,67	340,14	76,75	119,4	116,5
LAM	618,73	619,87	671,50	62,7	61,3
ROW	-137,85	229,43	454,16	33,9	34,4
<b>Total</b>	12918,52	15542,90	17169,35		

# Results: Burden Sharing 2050

## Comparison with the literature

Region	Partial comp in Mmt CO <sub>2</sub> e			full comp in 2000 US\$billion	
	2050			2050	
	450 ppm	500ppm	550ppm	equal alloc	equal cost
USA	-3073,97	-3641,8	-4266,79	-1239,4	-1715,5
CAN	233,58	138,1	21,56	-148,8	2,1
MEX	1439,34	1324,4	-751,54	108,4	110,1
JPN	-752,76	-829,5	-908,61	-358,6	-942,1
ANZ	-261,87	-302,1	-346,06	-120,5	-78,6
EUR	4264,30	2424,5	598,17	-866,1	-985,3
EET	287,80	65,4	-176,45	-146,9	7,1
FSU	738,25	-168,0	-1093,67	-434,3	299,9
ASI	-2368,77	-1062,3	831,86	355,8	363,8
CHN	-2325,06	-1775,9	-1032,89	589,0	578,3
IND	-300,60	697,4	1971,09	176,4	189,5
IDZ	-237,63	-29,7	232,01	85,0	91,2
AFR	840,74	1896,9	3262,32	543,0	558,7
MES	-782,17	-633,2	-438,98	761,1	797,3
LAM	2057,92	1142,7	673,74	536,8	556,7
ROW	236,48	751,5	1428,29	159,1	167,0
Total	20201,24	16883,4	18034,04		

# Conclusions

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- China and India may not have the role of major recipients that they have actually
    - => more important role in the mitigation process; even import reduction units
    - => developing countries should not only count on financial flows of CDM-type in order to prepare themselves for a more constraining mitigation
    - => COP-15 meeting decision to create a Multilateral Climate Fund (substantial, new, additional, adequate, predictable and sustained public funding additional to and different from the ODA)
    - => private sector should also play a role (find the right incentives for benefiting from all positive spill-over effects)
  - Nowadays fast-growing major recipients of CDM (China and India) will be replaced by African and Latin American countries
  - China, India, Indonesia, Middle East Countries and Emerging Asian Economies wouldn't have improved enough their energy efficiency
    - => seem more on the top of the Kuznets curve than on its low side
- => on the half - way towards sustainable development**



**Thank you for your attention!**  
**[Iva.Hristova@dauphine.fr](mailto:Iva.Hristova@dauphine.fr)**