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IED
Institut für Umweltentscheidungen
Institute for Environmental Decision

The Economics of Climate Change

Lecture 6: International Environmental Agreements

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Discussion ctd: Equity

Table 1: Paths for Sharing the Emission Budget

Pattern	*Principle*	*Criterion*
Broadly Egalitarian I (Egalitarian)	Equal per Capita	EPC: proportionality to countries' 2006 population
	Equal Burdens	EB: proportionality to countries' 2006 GDP corrected by a factor equalising marginal abatement costs
	Equal Access	EA: proportionality to countries' 2006 population corrected by an energy services factor (heating/cooling needs)
Broadly Egalitarian II (Prioritarian)	Historical Responsibility	HR-EPC: proportionality to countries' 2006 population corrected by the historical responsibility factor (CO_2 1990–06 cumulative emissions)
		HR-GF: proportionality to countries' 2006 emissions corrected by the historical responsibility factor (CO_2 1990–06 cumulative emissions)
	Ability to Pay / Beneficiary Pays	ATP-BP: proportionality to countries' 2006 GDP corrected by the wealth factor (aggregate country's GDP)
Broadly Egalitarian III (Sufficientarian)	Survival/Luxury Emissions	S/L: proportionality to countries' 2006 population only for countries above the threshold of subsistence
Non-Broadly Egalitarian	Grandfathering	GF: proportionality to countries' 2006 emissions

Grasso, 2012

Table 3: UNFCCC Regions and Other Groupings of Countries:* Percentage and Number of Emission Rights (Er) (1 Er = 1 Mt = 0.001 Gt)

	EPC		*EB*		*EA*		*HR-EPC*		*HR-GF*		*ATP-BP*		*S/L*		*GF*	
	%	*Er*	*%*	*Er*	*%*	*Er*	*%*	*Er*	*%*	*Er*	*%*	*Er*	*%*	*Er*	*%*	*Er*
Annex I	0.195	128,425.3	0.621	408,261.2	0.198	130,021.8	0.191	125,517.6	0.582	382,634.8	0.590	387,580.1	0.383	193,060.7	0.509	334,770.9
Non-Annex I	0.805	528,674.7	0.379	248,838.8	0.802	527,078.2	0.809	531,582.4	0.418	274,465.2	0.410	269,519.9	0.616	310,539.5	0.491	322,329.1
Annex II	0.137	89,777.3	0.542	356,396.7	0.138	90,367.7	0.131	85,958.2	0.442	290,668.8	0.507	333,291.5	0.268	134,961.3	0.403	265,021.9
EITs	0.063	41,232.5	0.071	46,753.2	0.064	42,371.1	0.064	42,325.3	0.153	100,768.3	0.076	49,697.3	0.117	59,021.5	0.114	74,963.4
EU-27	0.076	49,990.3	0.221	145,270.7	0.076	50,257.7	0.079	52,011.1	0.186	122,142.6	0.242	158,781.2	0.150	75,150.2	0.145	95,208.4
G77 and China	0.767	503,669.3	0.324	213,180.0	0.764	502,319.0	0.769	505,429.1	0.355	233,474.1	0.343	225,678.9	0.546	275,930.8	0.434	285,063.5
G8	0.134	87,928.2	0.503	330,665.9	0.136	89,065.5	0.126	83,027.4	0.448	294,224.3	0.447	293,972.3	0.263	132,181.5	0.402	264,201.4
G20	0.624	410,200.4	0.790	519,345.6	0.624	409,888.7	0.604	396,683.7	0.750	492,531.0	0.731	480,020.3	0.767	386,311.4	0.779	511,916.0
G2 (China/US)	0.249	163,326.2	0.336	220,918.2	0.252	165,280.1	0.219	143,780.3	0.339	222,886.7	0.279	183,540.1	0.487	245,526.7	0.421	276,837.4
LDCs	0.118	77,367.9	0.012	7,876.9	0.117	76,749.0	0.125	81,827.7	0.005	3,327.0	0.016	10,641.6	0.000	74.2	0.006	3,858.8
OECD	0.181	119,088.2	0.618	406,108.7	0.182	119,482.1	0.177	116,576.7	0.512	336,763.2	0.586	385,102.2	0.356	179,024.2	0.465	305,285.3
OPEC	0.056	36,886.1	0.035	22,775.8	0.056	37,114.2	0.059	38,800.9	0.055	36,138.0	0.049	32,121.6	0.058	29,301.4	0.057	37,224.0
AOSIS	0.007	4,606.6	0.006	3,630.9	0.007	4,607.0	0.007	4,871.2	0.006	3,697.2	0.007	4,729.0	0.006	3,370.9	0.005	3,411.5

Source: Calculations from World Resources Institute-Climate Analysis Indicators Tool (CAIT) database. Available from: http://cait.wri.org/cait.php?page=notes&chapt=4 [Accessed 24 March 2011].

**For the definition of UNFCCC regions and groupings of countries, see the World Resources Institute-Climate Analysis Indicators Tool (CAIT) database.*

Grasso, 2012

Table 2: Top Twenty Emitters: Percentage and Number of Emission Rights (Er) (1 Er = 1 Mt = 0.001 Gt)

	EPC		EB		EA		HR-EPC		HR-GF		ATP-BP		S/L		GF	
	%	Er	%	Er	%	Er	%	Er	%	Er	%	Er	%	Er	%	Er
China	0.203	133,078.1	0.107	70,206.6	0.205	134,726.9	0.181	119,191.8	0.143	94,033.5	0.097	63,891.7	0.397	200,055.1	0.218	143,455.1
USA	0.046	30,248.1	0.229	150,711.7	0.046	30,553.2	0.037	24,588.5	0.196	128,853.3	0.182	119,648.4	0.090	45,471.6	0.203	133,382.3
Russia	0.022	14,603.4	0.033	21,587.0	0.023	15,243.5	0.022	14,352.1	0.073	47,796.5	0.032	21,159.8	0.044	21,953.1	0.057	37,314.1
India	0.170	111,663.5	0.048	31,743.9	0.165	108,615.8	0.173	113,419.0	0.042	27,766.8	0.047	30,650.4	exempt	exempt	0.047	30,766.1
Japan	0.020	13,034.7	0.071	46,944.1	0.020	13,121.3	0.020	13,085.6	0.053	35,118.5	0.067	44,297.3	0.039	19,595.0	0.044	28,836.2
Germany	0.013	8,413.0	0.048	31,529.8	0.013	8,537.5	0.013	8,567.6	0.040	26,095.2	0.046	30,453.4	0.025	12,647.3	0.030	19,468.3
Canada	0.005	3,296.3	0.021	13,782.2	0.005	3,405.1	0.005	3,412.4	0.023	15,245.3	0.021	13,664.6	0.010	4,955.3	0.019	12,705.4
UK	0.009	6,143.9	0.036	23,632.3	0.009	5,972.3	0.010	6,350.2	0.025	16,326.9	0.035	23,094.8	0.018	9,236.1	0.019	12,606.0
Korea (South)	0.007	4,926.7	0.021	13,655.1	0.007	4,833.9	0.008	5,121.5	0.019	12,410.6	0.021	1,3541.1	0.015	7,406.3	0.018	11,637.6
Iran	0.011	7,047.9	0.012	8,066.5	0.011	7,100.0	0.011	7,355.8	0.015	9,655.0	0.012	8,064.2	0.021	10,595.0	0.017	10,914.1
Italy	0.009	5,978.8	0.030	19,869.4	0.009	5,988.2	0.009	6,207.6	0.020	13,242.4	0.030	19,525.4	0.018	8,987.8	0.017	10,907.2
Mexico	0.016	10,516.6	0.024	16,069.7	0.016	10,248.6	0.017	10,954.7	0.017	11,001.1	0.024	15,879.5	0.031	15,809.5	0.016	10,197.6
Australia	0.003	2,081.1	0.012	7,883.2	0.003	2,061.7	0.003	2,171.5	0.015	9,816.5	0.012	7,883.0	0.006	3,128.5	0.014	9,229.1
France	0.009	6,209.9	0.034	22,609.4	0.010	6,244.4	0.010	6,463.5	0.018	11,546.1	0.034	22,128.5	0.019	9,335.3	0.014	8,981.8
Indonesia	0.034	22,500.1	0.013	8,806.5	0.035	22,887.2	0.036	2,3541.8	0.012	7,914.6	0.013	8,794.6	exempt	exempt	0.013	8,330.0
Brazil	0.029	19,059.5	0.030	19,478.2	0.029	19,007.6	0.030	1,9916.4	0.013	8,805.7	0.029	19,152.0	exempt	exempt	0.013	8,216.8
Spain	0.007	4,427.2	0.022	14,601.6	0.007	4,415.2	0.007	4,628.2	0.013	8,517.2	0.022	14,459.8	0.013	6,655.4	0.012	8,196.0
Saudi Arabia	0.004	2,358.5	0.001	599.1	0.004	2,395.8	0.004	2,468.0	0.012	7,821.7	0.009	6,006.9	0.007	3,545.5	0.012	8,172.9
South Africa	0.007	4,783.7	0.008	4,971.5	0.007	4,724.8	0.008	4,997.6	0.014	8,966.5	0.008	4,992.3	0.014	7,191.2	0.012	8,052.7
Ukraine	0.007	4,805.4	0.005	3,340.6	0.007	4,917.3	0.008	4,999.0	0.018	11,916.0	0.005	3,362.5	0.014	7,223.9	0.011	7,329.2
Total	*0.632*	*415,176.5*	*0.807*	*530,088.4*	*0.632*	*415,000.2*	*0.611*	*401,792.7*	*0.780*	*512,849.6*	*0.747*	*490,650.2*	*0.781*	*393,791.9*	*0.805*	*528,698.6*

Source: Calculations from World Resources Institute – Climate Analysis Indicators Tool (CAIT) database. Available from http://cait.wri.org/cait.php?page=notes&chapt=4 [Accessed 24 March 2011].

Repetition: Public Goods

- Sum of individual distributions of the public good does yield the social optimum

$$\underbrace{\max_{Q} \sum_{i=1}^{n} u(Q) - c(Q)}_{\text{Social Optimum over aggregate Q}} \neq \underbrace{\sum_{i=1}^{n} (\max_{q_i} [u_i(q_i + \sum_{k \neq i} (q_k^*)) - c_i(q_i)]}_{\text{Sum of individual net utilities from providing share } q_i}$$

$$\text{where } Q = \sum_i q_i$$

- Incentive for „Free-Riding“
- Result: Underprovision of Public Goods
- Problem of „collective action“

The Prisoners‘ Dilemma -
collectively versus individually best strategies

player 1 \ player 2	confess	not confess
confess	(4,4)	(1,5)
not confess	(5,1)	(2,2)

A simple coalition game

- Let there be i=1,…,N identical countries.
- Each country has two choices: abate or pollute
- Abatement is privately costly; polluting is collectively damaging
- Let emissions be given by qi,
- which may be 0 or 1
- Individual payoff of country i is thus:

$$\Pi_i = q_i - \gamma Q, \text{ where } Q = \sum_i q_i$$

- $0<\gamma<1$ is the (constant) marginal damage of aggregated emissions.

A simple coalition game

- Nash Equilibrium: $q_i=1$
- Pareto Optimum: $q_i=0$
- New Assumption: possibility of formation of a group n≤N countries acting in concert to provide abatement.
- Two stage game:
  1. Stage: Determination of coalition membership
  2. Stage: Emissions game determining Q
- First stage: Announcement game, where countries announce «in» or «out» of a single coalition.
- Hence, Two groups:
  1. Members of coalition
  2. Fringe (all players not in the coalition)

A simple coalition game

- Payoff of a member of coalition: $\Pi_c(n)$
- Payoff of fringe: $\Pi_f(n)$
- Members of coalition will always choose $q_i=1$
- Coalition will always choose abatement if

$$\Pi_c(n) = -\gamma Q = -\gamma(N-n) \geq 1-\gamma N$$

- Hence, coalition members will always chose pollute if

$$n < 1/\gamma$$

A simple coalition game

1. Definition: A coalition of size n is (potentially) internally stable if

$$\Pi_c(n) > (\geq)\Pi_f(n-1)$$

2. Definition: A coalition of size n is externally stable if

$$\Pi_f(n) > \Pi_c(n+1)$$

3. Definition: A coalition of size n is stable if it is externally and internally stable.

- In words:

  The coalition is internally stable if no individual wishes to leave to join the fringe; it is externally stable if no fringe member wants to join the coalition.

A simple coalition game

- Definition 4: Define I(x) as the smallest integer greater than or equal to x.
- Equilibrium number of members of the coalition is

$$n^* = I(1/\gamma) > 0$$

- Hence, allowing for the formation of a coalition :
  - (weakly) increases aggregate abatement
  - (weakly) increases aggregate welfare
  - reduces the problem of the public good game
- Note: A stable coalition will always be second-best, compared to the first-best social optimum, where all members abate.

Performance (IAM-based) and stability for some coalitions with transfers

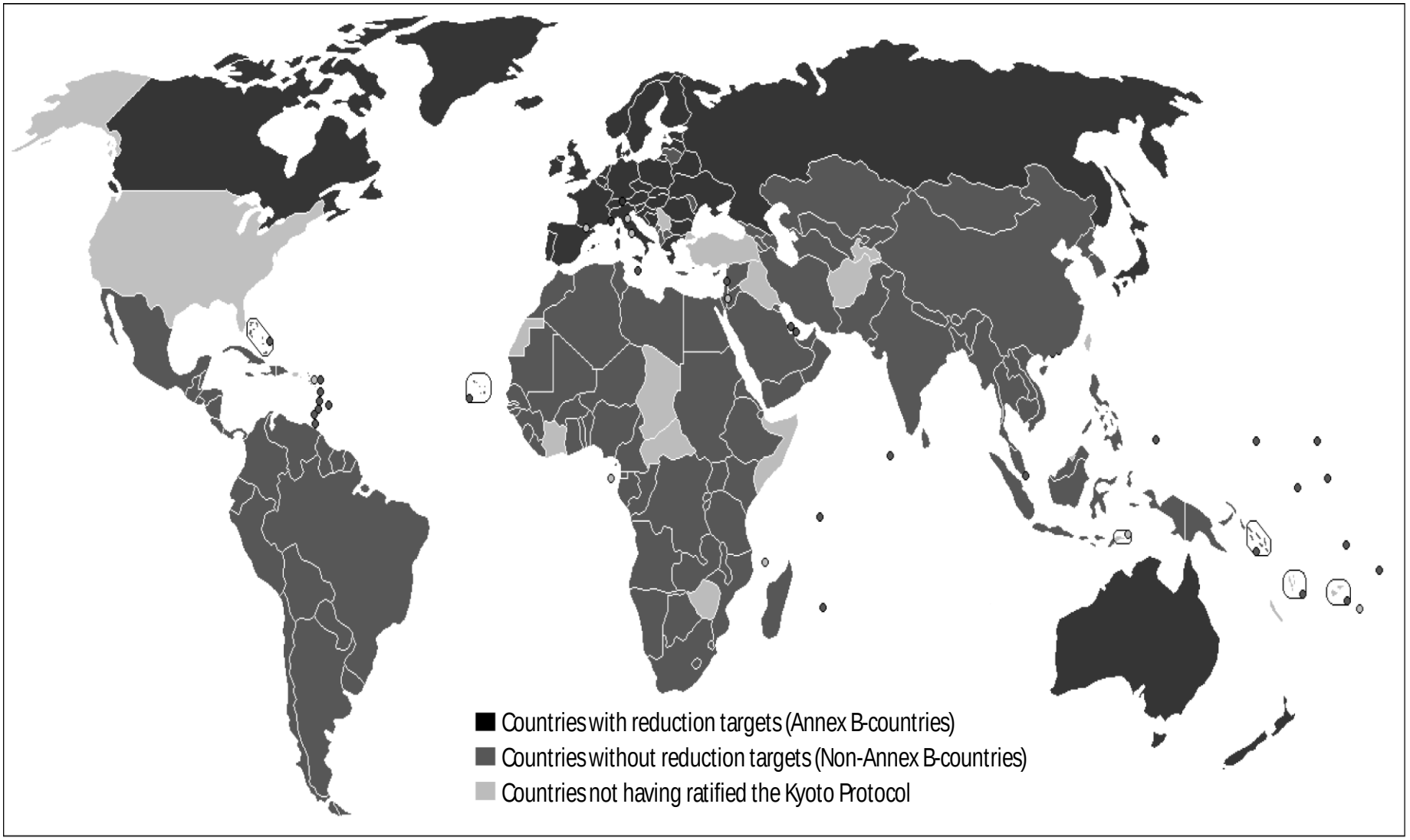
PANE	Welfare index (%)	Environmental index (%)	Stability
NASH	0	0	--
Annex B without USA	2	1	Potentially Internally Stable (PIS)
Annex B	8	3	PIS
USA+China	20	15	PIS
China+FSU+RoW	24	49	Not PIS
USA+Japan+China +FSU+RoW	92	80	PIS
USA+EU+China+RoW	97	92	Not PIS
Pareto	100	100	--

Brechet and Eyckmans (2009)

Kyoto Protocol - The only game in town

- Protocol to the UNFCCC, adopted in 1997
- 35 countries (Annex I-countries) are required to reduce greenhouse gas emissions (6 gases) below specific levels specified in the treaty.
- The **individual reduction targets** for Annex I Parties are listed in the Kyoto Protocol's Annex B.
- Targets adds up to a total cut in greenhouse-gas emissions of at least 5% from 1990 levels in the first Commitment Period 2008-2012.
- Inclusion of market-based Mechanisms
- Only countries that have ratified the Protocol are bound by the treaty (The USA have not ratified, Canada withdrew in 2011).

Kyoto Boundaries until 2012



Kyoto targets till 2012

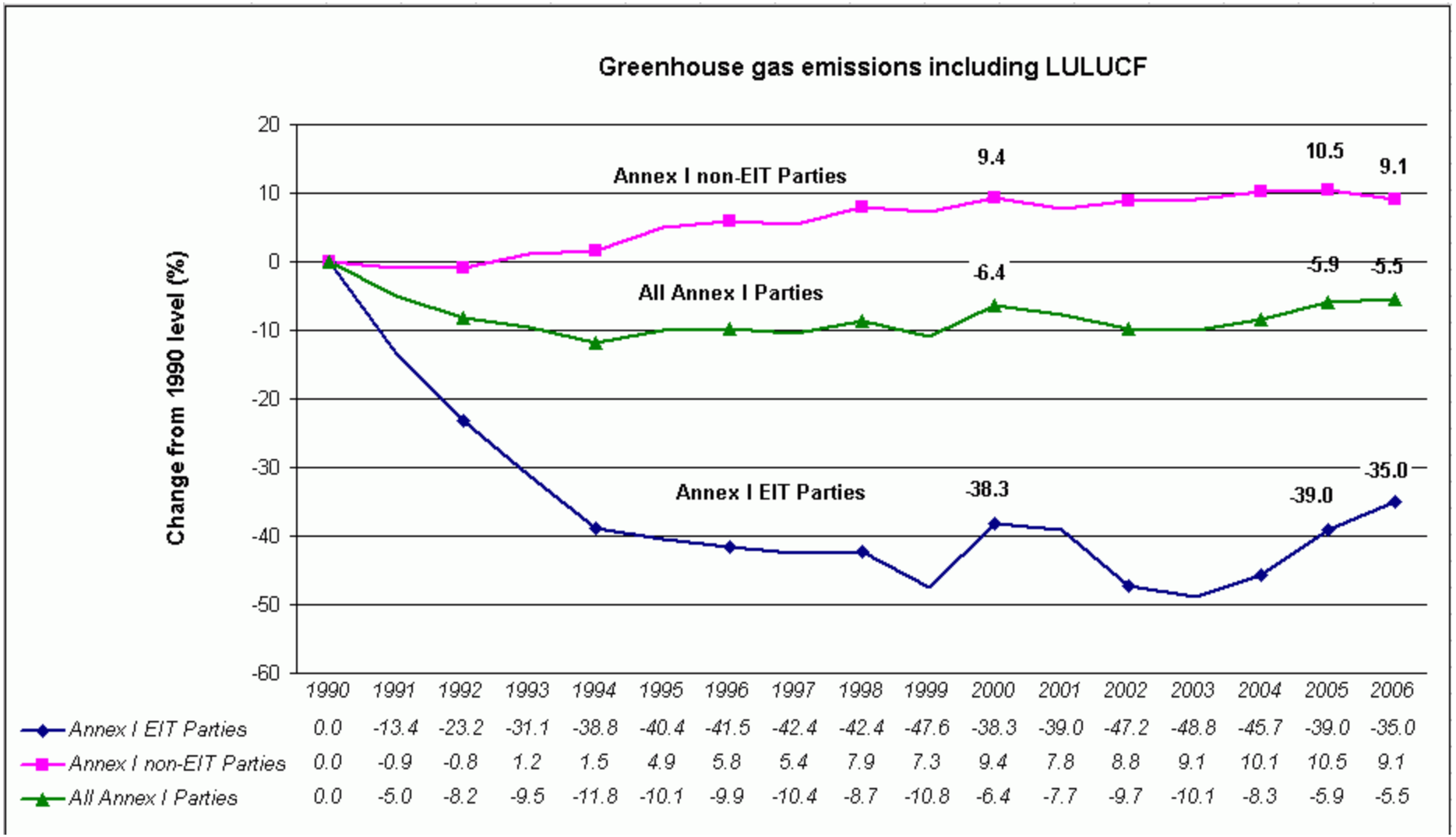
Annex B: -5% emission reductions on average in 2008-2012 as compared to 1990

Country	Target
EU, Switzerland	-8%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russia, Ukraine	0
Norway	+1%
Australia	+8%
Iceland	+10%
USA	-7%

Kyoto – Timetables and Enforcement

- Targets to be reached within Five-year „Commitment Periods“ (CP).
- First Commitment Period: 2008-2012
- Second Commitment Period: 2013-2020
- A country that does not meet its target has to overfulfill the next target by the respective shortcoming, plus 30%.
- Hence, enforcement of the Protocol is dependent on its continuation.

The problem of «Hot Air» in CP 1

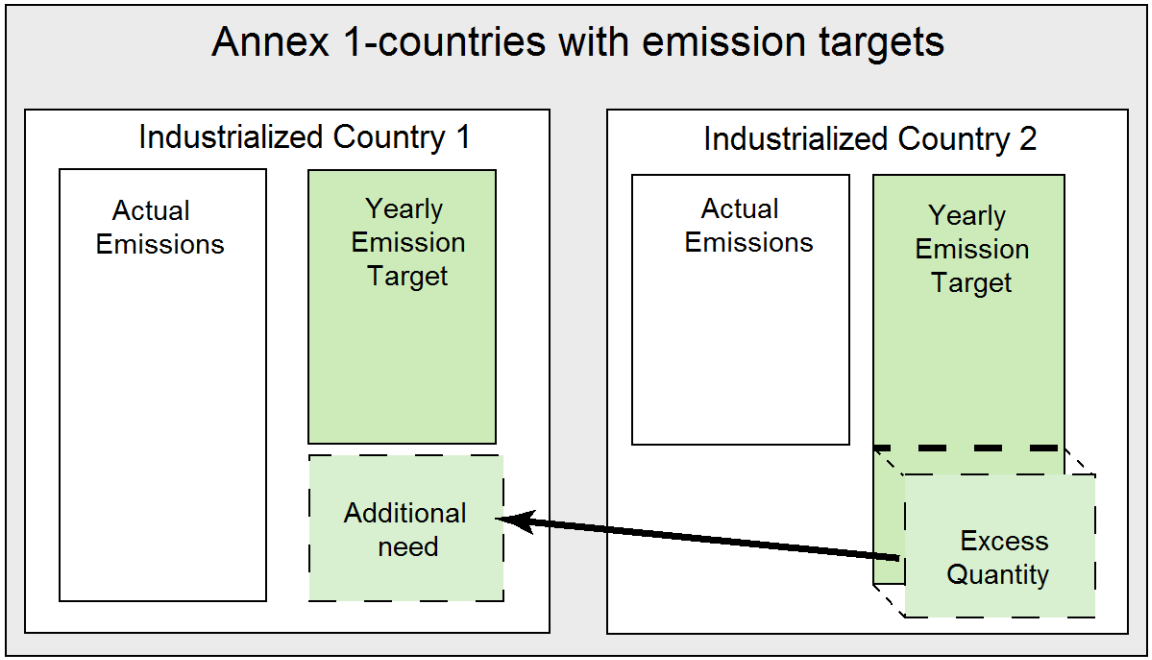


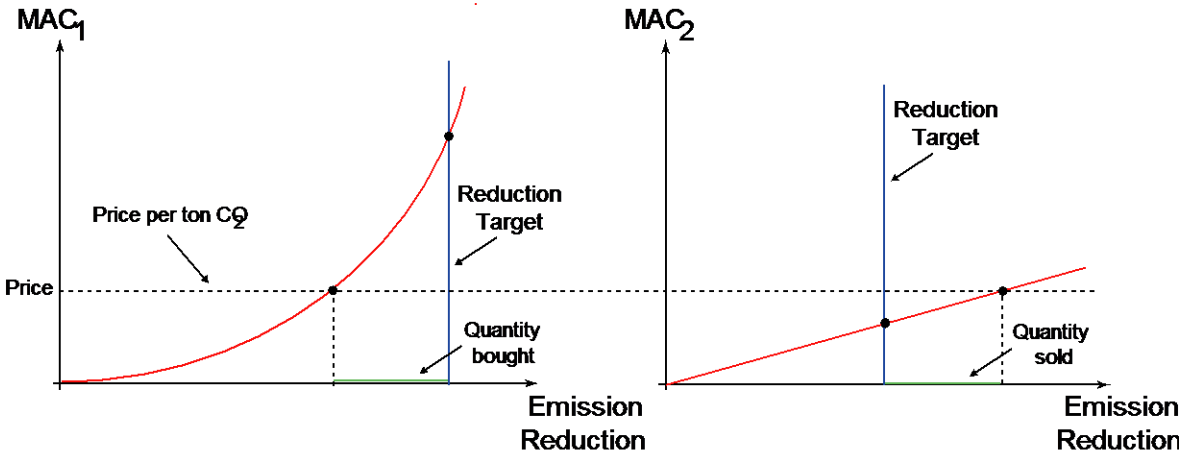
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Annex I EIT Parties	0.0	-13.4	-23.2	-31.1	-38.8	-40.4	-41.5	-42.4	-42.4	-47.6	-38.3	-39.0	-47.2	-48.8	-45.7	-39.0	-35.0
Annex I non-EIT Parties	0.0	-0.9	-0.8	1.2	1.5	4.9	5.8	5.4	7.9	7.3	9.4	7.8	8.8	9.1	10.1	10.5	9.1
All Annex I Parties	0.0	-5.0	-8.2	-9.5	-11.8	-10.1	-9.9	-10.4	-8.7	-10.8	-6.4	-7.7	-9.7	-10.1	-8.3	-5.9	-5.5

Flexible Mechanisms

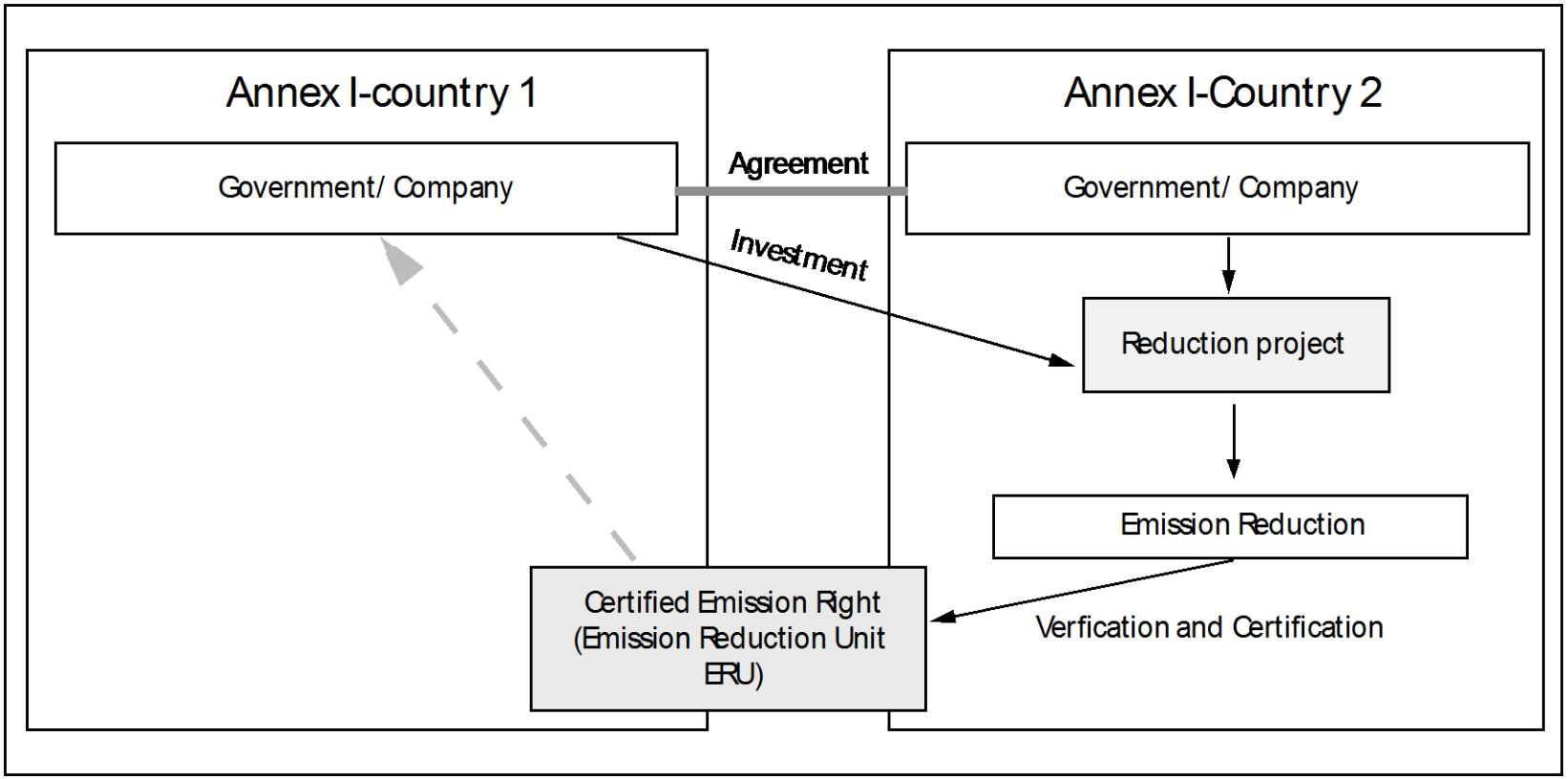
1. Bubble Building (e.g. EU)
2. Kyoto Emissions Trading
   - between Annex I-Countries
3. Joint Implementation
   - Reduction projects between Annex I- countries
4. Clean Development Mechanism
   - Reduction projects in Developing Countries

Kyoto Emissions Trading

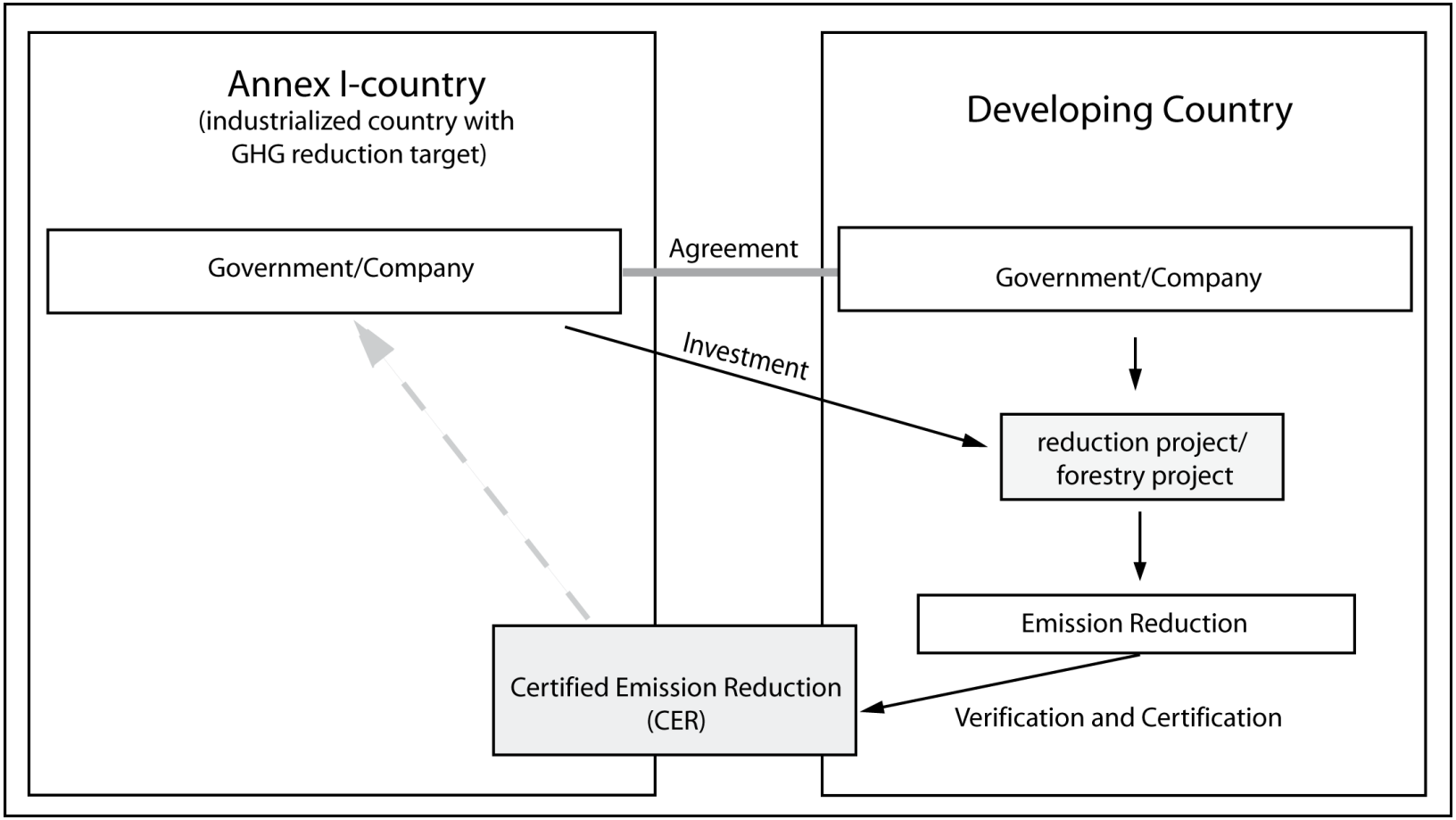




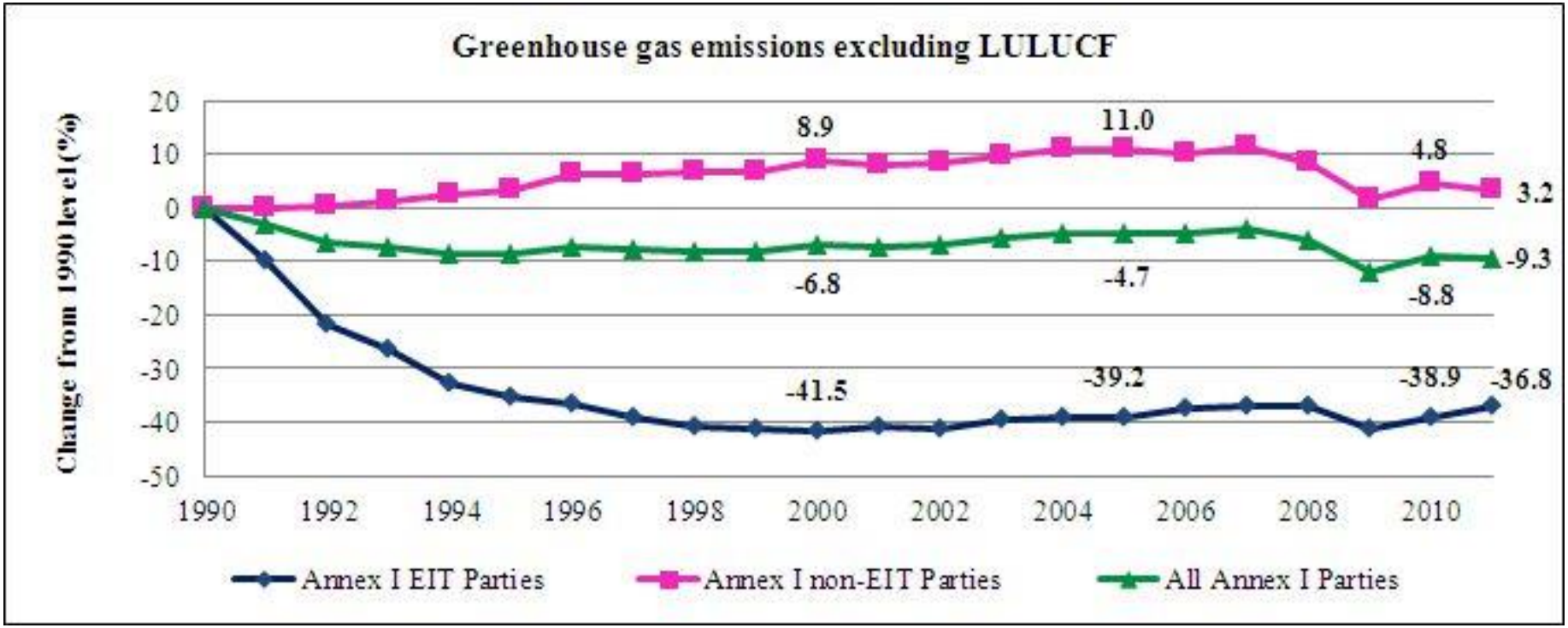
Joint Implementation



Clean Development Mechanism



Performance of international Climate Policy by 2012



Post 2012: Input from Science

Box 13.7 The range of the difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group[a]

Scenario category	Region	2020	2050
A-450 ppm CO_2-eq[b]	Annex I	–25% to –40%	–80% to –95%
	Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
B-550 ppm CO_2-eq	Annex I	-10% to -30%	-40% to -90%
	Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East
C-650 ppm CO_2-eq	Annex I	0% to -25%	-30% to -80%
	Non-Annex I	Baseline	Deviation from baseline in Latin America and MIddle East, East Asia

IPCC 2007

- On the Proposals from Social Sciences on future schemes, see IPCC, 2007, Report on Mitigation, Chapter 13 .

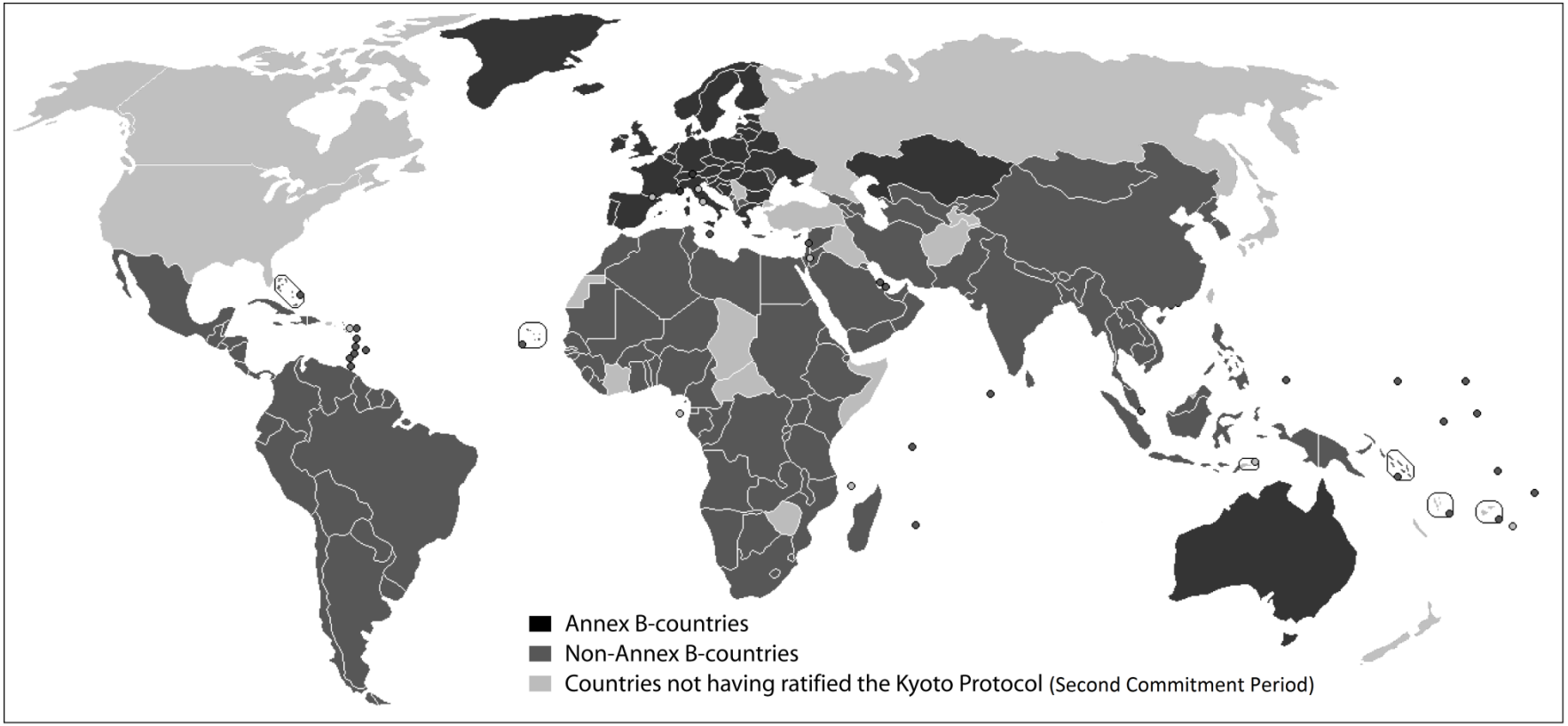
The situation in 2012

The Economist (2012)

Kyoto second Commitment Period

- The second commitment period will be for eight years, commencing on January 1, 2013 and conclude on December 31, 2020.
- 37 parties have agreed to binding emissions reduction targets for the second commitment period,
- Countries with binding targets in the second commitment period have agreed to review those targets by 2014

Participation Kyoto Protocol (Second Commitment Period)



ET in the Negotiations

- Combined with individual reduction targets Kyoto ET can also be viewed as a system of side-payments.
- Countries with lower interest in the treaty can be *"bribed in"* through the accordance of laxer targets and receive rents from selling certificates.
- Side-payment Mechanism less visible to the voter than direct transfers.

- **But: Concessions to some countries were too large in 2012 in order to ensure a large coalition!**